

THURSDAY, FEBRUARY 7, 1895.

ARGON.

THE scene in the theatre of the University of London on Thursday last was in many respects unique. It will certainly be historical. It was unique in that the Royal Society had formally invited members of two other scientific bodies to attend the meeting, and had left the comparative seclusion of Burlington House to meet, in Burlington Gardens, an audience numbering at least eight hundred. It was the first of a series of discussion meetings to which, we suppose, similar invitations will be issued; but it will be long before the same eagerness to obtain a ticket is displayed—long before those who gain admission, will listen to so much worth hearing.

The previous history of the subject to be "discussed" is known to most of our readers. Lord Rayleigh has for some years been engaged on one of the most difficult of physical measurements, namely, the determination of the densities of some of the more permanent gases. In the case of nitrogen, he was confronted with the fact that if obtained from chemical compounds, it was about one half per cent. lighter than if extracted from the atmosphere. This result he published in the spring of last year, and the cause of the discrepancy was a subject of general conversation in scientific circles. Lord Rayleigh himself discussed it with some of his chemical friends. Prof. Ramsay was interested, and since last Thursday he has confided to an interviewer some details as to the part he played in solving the problem. It appears that he asked Lord Rayleigh's permission to investigate the matter, that using a chemical method he succeeded in separating a heavier constituent from atmospheric nitrogen, and that on writing to Lord Rayleigh, he learned that he, too, had achieved the same result by a process of "sparking."

The fact of the discovery was announced in a semi-public way at the meeting of the British Association at Oxford. Of course it attracted great attention, and curiosity was further stimulated by the silence of the discoverers during the five succeeding months. Towards the end of last year it was announced that they would give their results to the world in January. On Thursday last the promise was fulfilled, and all that is known of "Argon" was told to all.

Three papers were read, which showed that the period of silence had been devoted to strenuous work. It was proved beyond possibility of doubt or question that the atmosphere contains a hitherto unknown constituent. It has been separated from the air by atmolysis, by red-hot magnesium, and by "sparking." Its density has been determined to be about 197. It is very soluble in water, and it has been proved that the nitrogen extracted from rain-water is twice as rich in argon as that which exists in the air.

Mr. Crookes has found that the new substance has two spectra, marked by red and blue lines respectively. Both he and Prof. Schuster certify that the principal lines are identical in the case of two specimens obtained by different methods. The properties at very low tempera-

tures have been determined by Prof. K. Olszewski, of Cracow. The critical temperature is -121°C ., the critical pressure 50.6 atmospheres. The liquid boils under a pressure of 740.5 m.m. at $-186^{\circ}.9$, having at the boiling point a density of about 1.5. The melting point is about $-189^{\circ}.6$, and it has been frozen into a white solid resembling ice. Last, but not least, the ratio of the specific heats of the gas is approximately 1.66, and all attempts to induce it to enter into chemical combination with other substances have up to the present entirely failed.

After this torrent of well-established facts, it cannot reasonably be doubted that Lord Rayleigh and Prof. Ramsay have really discovered a substance, which, though existing in enormous quantity, has hitherto defied detection. Lord Rayleigh's work first showed that there was something to explain; the patience and masterly skill which he displayed throughout years devoted to weary weighings, must command universal admiration. As has been well said, the result is "the triumph of the last place of decimals," that is, of work done so well that the worker knew that he could not be wrong. Prof. Ramsay, too, is to be congratulated in that when this preliminary stage had been accomplished, his energy and skill enabled him to take such a share in the hunt after the unknown cause of the difficulty, that he rightly ranks as a co-discoverer of the new gas.

In scientific investigations, however, the answer to one question always suggests others, and interest in a discovery quickly precipitates into interest in its results. Seldom have a series of facts and figures raised more important issues. The ratio of the specific heats is 1.66, which points to the conclusion that the substance is monatomic. If it is monatomic, it must be an element or a mixture of elements. If it is a single element, its atomic weight must be about 40, and in that case no place is ready for it in Mendeléeff's table. The easiest way out of the difficulty is to suppose that argon is a mixture, and the authors point out that there is evidence for and against this view; "for, owing to Mr. Crookes observations of the dual character of its spectrum; against, because of Prof. Olszewski's statement that it has a definite melting point, a definite boiling point, and a definite critical temperature and pressure; and because on compressing the gas in presence of its liquid, pressure remains sensibly constant until all gas has condensed to liquid. The latter experiments are the well-known criteria of a pure substance, the former is not known with certainty to be characteristic of a mixture." The question is to be further investigated, but at present the authors conclude that the balance of evidence is in favour of simplicity.

On this hypothesis a very awkward question is no doubt raised. The periodic classification of the elements cannot, and ought not, to be abandoned at the first challenge, and till further evidence is forthcoming a heavy strain is thrown on the link of the chain of argument which connects the ratio of the specific heats with the monatomicity of the gas.

On the other hand, the conclusion that if the ratio of the specific heats is 1.66 the gas can be diatomic, is directly contrary to all analogy. Merely to say that mercury is monatomic, that Kundt found that the

ratio of the specific heats is one and two-thirds, and that therefore a similar relation must hold for argon, is to understate the case. Taking the very outside values, no diatomic gas has a ratio greater than about 1.42; and to place among these a substance for which the ratio is 1.66, would be entirely opposed to all the other indications of a theory which, though admittedly only approximate, nevertheless in all other cases accords fairly with the conceptions of the chemist. The behaviour of mercury vapour suggests that there are two classes of phenomena which occur within the molecule—a coarser group with which the ordinary mechanical theory of gases is concerned, and a more refined type detected by the spectroscope. It is the former, and not the latter, which are of the same order as the chemical facts which lead to conclusions as to the number of atoms in the molecule.

Thus, in the case of mercury vapour, the mechanical theory of gases ignores the vibrations, whether mechanical or electrical, which produce the spectrum, and gives the precise value of the ratio of the specific heats which corresponds to three degrees of freedom. Whether we frame a mental picture of a Boscovitch point, or are content with the more usual contradictory image of a smooth sphere, perfectly elastic, and yet incapable of internal vibrations, is for the present purpose comparatively unimportant. It is impossible to connect the conception of three degrees of freedom with anything that does not behave as one single thing, incapable of being set in rotation, and incapable of internal vibration. That such a thing may have structure is not denied. It is only affirmed that as far as the phenomena under investigation are concerned, structure is not recognisable. It is not denied that it may be subject to internal changes. It is only affirmed that these changes are of different order from the causes which affect the behaviour of the molecule in what may be called the pressure-producing machinery of a gas. Where the ordinary dynamical theory stops, there, and there precisely, chemical analysis stops also. The chemical facts which prove that mercury is monatomic have nothing to do with its spectrum. The arguments used would be valid if it had no spectrum at all. Analysis recognises no structure in the indivisible molecule of mercury. In chemistry, and in the approximate theory of gases, "monatomic" means—in this case, at all events—the same thing.

Next take the case of the diatomic gases.

The results of the dynamical theory can be most easily represented if we suppose the atoms to be smooth spheres, which may, if it is desired, be regarded as mere geometrical surfaces surrounding Boscovitch centres.

The theory shows that unless the two atoms when united can be fairly represented by a single point or a single smooth sphere, the ratio of the specific heats ought not to be greater, but may be less, than 1.4. This value would correspond to the case of two smooth spheres the surfaces of which were maintained in contact, or to two points maintained at a certain fixed distance apart, but otherwise free. Smaller values would indicate greater internal freedom.

The gases may be divided into two classes, viz. firstly, O_2 , N_2 , H_2 , CO, NO and HCl, and secondly, Cl_2 ,

Br_2 and I_2 . The mean of the ratios of the specific heats for the first six is, according to Masson,¹ 1.399. The corresponding figure deduced from Regnault's experiments is 1.410. The highest value obtained from Regnault is 1.42 in the case of HCl, but Masson's value for the same gas is only 1.392, the mean being 1.406. In the cases of Cl_2 , Br_2 and I_2 the values are lower, lying between 1.293 and 1.323. The larger values thus in some cases slightly exceed, but are in all cases very close to, the limit fixed by the theory on the assumption that the dual character of the molecule can be recognised by it. The smaller values fall well within the limit.

The ratio of the specific heats has not been directly determined for many substances, but it can be calculated by well-known formulæ for all gases of which the specific heat at constant pressure is known, and though the values thus obtained are only approximate, they are sufficient to prove that the molecules of the more complex gases have always more than the minimum number of degrees of freedom which are consistent with the idea of their being built of smooth spheres constrained to remain in contact, and equal in number to the number of atoms within the molecule. Whereas, if argon is a diatomic substance, the molecule has fewer degrees of freedom than the theory indicates, and is thus the single exception to a universal rule. In that event it is not too much to say that the result will indicate a connection between its atoms of a kind absolutely different from that in any other known substance. In all other cases the approximate dynamical theory is in close agreement with the view that molecular structures made up of the union of two or more like or unlike things, have a more or less irregular form, and are capable of rotation. If argon is not monatomic, this rule will for the first time be broken. Quite apart from the absolute validity of the theoretical grounds on which it is based, and regarded only as suggested and not as completely justified by theory, it is nevertheless an empirical generalisation which up to the present has stood every test.

It is not sufficient to explain the difficulty by saying that the bonds between the constituents of the argon molecules must be very strong, for we have already assumed that the tie which unites the centres of the hydrogen or oxygen atoms is proof against the collisions which occur in the gas—*i.e.* is or the purposes of the approximate theory infinitely strong. It is further necessary that the molecule must be incapable of rotation, that the two points must coincide, or the two spheres be crushed out of shape, so that the surface is spherical. Such violent assumptions would be quite unjustifiable unless we are driven to them by facts which cannot be disputed. Until it is directly proved that argon is diatomic, we must agree with the discoverers that the weight of evidence is in favour of the molecule being indivisible. Whether in the future other and more convincing evidence will be adduced on the other side, the future alone can show. The courts of science are always open, and every litigant has an unrestricted right of moving for a writ of error.

See K. Strecker, *Wied. Ann.* 13, 1881, p. 41.

A TEXT-BOOK OF BOTANY.

Lehrbuch der Botanik. By Drs. E. Strasburger, F. Noll, H. Schenck, and A. F. W. Schimper. (Jena: Fischer, 1894.)

THIS book is intended for the use of students in the German *Hochschulen*; throughout it is written in a manner which is at once interesting and exact. According to the usual plan adopted in text-books of the kind, it is divided into two parts—the first dealing with general botany, and the second with special botany. In a general introduction a short *résumé* is given of the theories of descent and of natural selection, with a view to their bearing on the subject of the natural boundary between the animal and vegetable kingdoms.

The first division of the first part is devoted to the general morphology of plants. It is written by Prof. Strasburger. This whole subject he treats from a phylogenetic point of view, and so renders, what is in many botanies little more than a list of difficult names and their explanations, extremely interesting and suggestive reading. A good example of this will be found in his account (p. 26) of the leafy stipules of *Lathyrus aphaca*. In this connection it may be noticed that having once described the more important forms, he does not enlarge on the very various shapes and modifications assumed by leaves, stems, &c., as is often done in text-books, where the writers often appear to glory in the number of curious terms they collect descriptive of the forms of the members of plants—terms which, if it is necessary for the student to learn, might be more easily mastered if printed as a kind of botanical vocabulary or glossary, instead of rendering such an attractive subject as vegetable morphology a monotonous exercise of the memory. In the portion devoted to anatomy and histology we find the structure of the cell and its contents extremely lucidly described. The digression on p. 45, with regard to some of the properties of protoplasm and the effect of high temperatures and of reagents upon it, might have, perhaps, come more appropriately in the part of the book allotted to physiology. In the account of the systems of tissues in vascular plants, and their morphology, we are furnished with the results of recent work in this direction, of which so much is due to the author's own researches. With regard to the origin of these tissues, he disputes the theory according to which the meristematic apex of the stems and roots of phanerogamic plants is differentiated into three distinct initial layers. He urges that the arrangement of the cells in these regions is rather due to mechanical causes, and that the terms Dermatogen, Plerome, and Periblem should be used simply to facilitate the description of certain cell-layers in the vegetative cone, without involving the idea of the presence of distinct Histogens, as they have been called. Throughout this whole portion on general morphology, we feel that the space has been too limited, and we wish that the author had not restricted himself to the 126 pages allotted, but had allowed himself to enter more fully on the numerous points of interest in this subject which he, perhaps beyond all others, is capable of discussing.

The same remark may also apply to Dr. Noll's part on physiology. It is throughout too much abbreviated.

Apart from this defect, which is involved in the nature of the book, it is very attractively written, and by its logical arrangement and clear descriptions does much to atone for the necessary crowding of facts. The chapter on the phenomena of movement in plants strikes us as suffering the least from the condensed nature of the writing, and seems to be a good account of both earlier and recent researches on the subject.

The special botany is the work of Dr. Schenck and Prof. Schimper. The classification adopted is that proposed by Braun, and elaborated by Eichler and others. Little need be said of this portion, except that much trouble appears to have been taken to make the descriptions, so far as possible, include the results of modern work. At the end of the book there is a list of medicinal and of poisonous plants, as well as a very complete index. It is to be regretted that the authors have not given some references to the literature of the subjects of which they treat, so that the student might be helped to pursue more fully his studies in the directions he desired. The book is throughout profusely illustrated by means of extremely good figures, many of which are tastefully coloured. The figures are, to a large extent, new, and those which are not specially designed for the book are well selected, in part, from Prof. Strasburger's other works and, in part, from sources which are not commonly familiar to English readers, so that in this way the value of the book is enhanced. With regard to the coloured figures, they have this novelty—that they are inserted in the text, and are not in the form of separate plates. H. H. D.

A NEW POPULAR BOOK ON BRITISH BUTTERFLIES AND MOTHS.

Butterflies and Moths (British). By W. Furneaux, F.R.G.S., author of "The Out-door World, or Young Collector's Handbook." With twelve coloured plates, and numerous illustrations in the text. (London: Longmans, Green, and Co., 1894.)

THE success of Mr. Furneaux's "Out-door World" was sufficiently marked to induce the publishers to make it the first of a series of popular illustrated works on British Natural History, to be called "The Out-door World Library." Of this series, the volume before us forms the second; and we observe that others are projected, on British Birds, Mammals and Reptiles, Pond-Life, &c.

This is pre-eminently a beginner's book, written in a popular style throughout, and it has also been nicely printed and illustrated, so as to make it as attractive-looking as possible. Hence the practical part of the subject is dealt with at length, while questions of a purely academic nature, such as synonymy, are wisely omitted almost entirely. English names are given the most prominent place; but the scientific names used in South's List are added in brackets.

The book is divided into four parts: Structure and Life-history of the Lepidoptera; Work at home and in the field; British Butterflies; and Common British Moths. The appendices include a list of British *Macro-Lepidoptera* according to South's "Synonymic List," as far as the end of the *Geometridæ* (the English names here being in brackets), and a Lepidopterist's Calendar.

The introductory chapters are very good, and the woodcuts are clear and instructive, especially that of the neurulation of a butterfly, on p. 9. We could have wished that Mr. Furneaux had had space to treat of such important subjects as neurulation and the scaling of the wings more fully. The early stages of *Lepidoptera* are also discussed and illustrated; and we notice that our author calls the head of a caterpillar the "first segment." We know that some hypercritical authors object to the head of an insect being called a segment, because it is morphologically considered to be made up of so many "somites." But to refuse to allow the head of an insect to be called the first segment (in the case of caterpillars, at least) appears to us as absurd as it would be to object to the skull being spoken of collectively, because it is morphologically regarded as composed of a number of modified vertebrae. On the other hand, we think that Mr. Furneaux has been injudicious in calling the five membranous pairs of legs of a caterpillar "claspers," a term properly applicable to the last pair only. We think the usual distinction made between the last pair and the others should be preserved in speaking of them, though the term by which the other legs are generally known (prolegs) is perhaps not quite correct.

The directions for collecting and preserving appear to have been written by an experienced practical collector, with his heart in his work. However, when insects are set flat, the groove is generally made deeper than is shown in the illustrations on p. 123. The advice to start at once with a cabinet, spaced out for all species, may be very good for those who can afford to buy a large cabinet off-hand; but many of Mr. Furneaux's readers will certainly find it too costly, and we fear that any beginner who commences in such a manner will find his patience exhausted at his slow progress, and might give up the study of insects prematurely in disgust.

No technical characters are given for species, genera, or even families; and, strangely enough, the Seraphims (*Lobophora*) are said to differ from the Pugs (*Eupithecia*) by their "covering their hind-wings when at rest"; no mention being made of the curious appendages to the hind-wings of the males in *Lobophora*, which gives them the appearance of having six wings, and has suggested the name of "Seraphims."

Generally speaking, however, the accounts of the various species discussed (all the butterflies and a good series of representative moths, at least among the *Macro-Lepidoptera*) are very good. Here and there, however, we meet with a doubtful statement, as that "the Black-veined White is hardly to be distinguished from the Common Large White on the wing." Those accustomed to see both would hardly confound them, nor would the former frequent open ground at a distance from trees.

The numerous woodcuts are of unequal merit, but a fair standard of excellence is maintained throughout, and most of them are easily recognisable. The coloured plates, though recognisable too, are, we regret to say, not up to the standard of the woodcuts. Sometimes the colour is inaccurate, as in the case of the Purple Emperor, which has been represented as lilac rather than blue. It is, of course, a difficult insect to figure, but has been represented better in many popular books of late years. In the first two plates, an attempt has

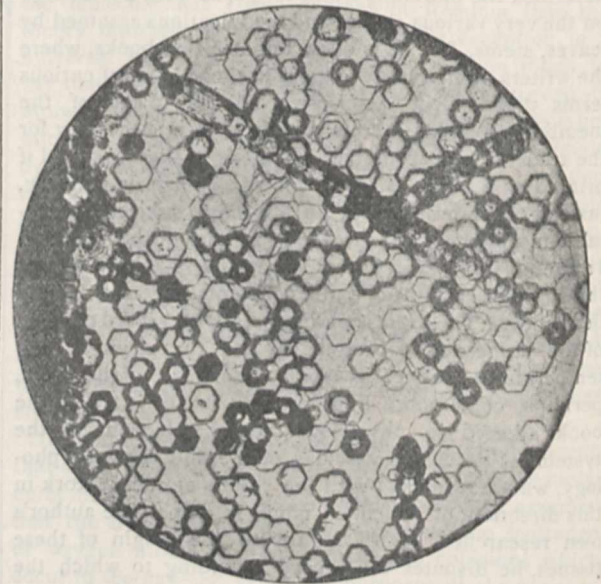
been made to throw up the colour of the insects (mostly whites and yellows) by shading. This has given rise to the appearance of an ugly smoky rim round the figures; and the experiment has been wisely abandoned in the remaining plates. We regret this the more, as the desired effect has been admirably attained by using a tinted background in Prof. Aurivillius' recent work on the butterflies and moths of Northern Europe; and we should like to see this improvement introduced into other books of a similar kind.

W. F. KIRBY.

OUR BOOK SHELF.

Die Resultate der Aetzmethode in der krystallographischen Forschung, an einer Reihe von krystalisirten Körpern dargestellt. Von Dr. H. Baumhauer. Mit 21 Textfiguren und einer Mappe mit 48 Mikrogrammen auf 12 Tafeln in Lichtdruck. Pp. 131. (Leipzig: Wilhelm Engelmann, 1894.)

It has long been known that the action of a reagent upon a smooth plane surface of a mineral substance may reveal details of structure previously invisible, and that such a mode of investigation has been extremely useful in the case of meteoric iron; indeed, the method is particularly valuable in that case by reason of the fact



that the structure thus revealed is different from the structure of terrestrial iron.

The researches of Leydolt, Baumhauer, and others, have shown us that the figures produced by reagents on the faces of the crystals which are met with among minerals, or are artificially prepared by the chemist, though dependent on the kind and strength of the reagent, are yet characterised by a symmetry which conforms with that of the crystalline structure; further, the etched figures serve to indicate by their forms the particular kind of symmetry (holosymmetry, hemisymmetry, tetartosymmetry, twinning) belonging to the crystalline structure, in many cases where other characters, physical or morphological, are insufficient for the purpose; they are especially useful in the investigation of isomorphism.

The etched figures can be observed, for instance, in the case of a crystal of which the opacity renders investigation by means of transmitted polarised light impossible; and, even in the case of a transparent

crystal, they often serve to determine the particular type of symmetry to which the structure belongs when polarised light may merely indicate whether the crystal is optically isotropic, uniaxial, or biaxial. Dr. Baumhauer has done a great service by preparing for publication a series of magnified photographs of the figures produced by etching different faces of crystals of the following substances:—Fluor, Blende, Cryolite, Apatite, Nepheline, Datolite, Zinnwaldite, Leucite, Boracite, Dolomite, Magnesite, Chalybite, Nickel sulphate, Strychnine sulphate.

The figure on the previous page shows the hexagonality of the depressions which, after etching, are seen on a basal plane of a crystal of Apatite.

These beautifully executed photographs are accompanied by detailed descriptions (85 pp.), and by a sketch of the history and development of the methods (46 pp.). Dr. Baumhauer has done such excellent work in this branch of science, that he is particularly qualified to select and describe examples which illustrate the potentiality of this mode of investigating crystalline structure. The photographs are mounted on twelve separate plates, so that they may be conveniently used in the classroom.

Summer Studies of Birds and Books. By W. Warde Fowler. Pp. 288. (London: Macmillan and Co., 1895.)

Forest Birds; their Haunts and Habits. By Harry F. Witherby. Pp. 98. (London: Kegan Paul, Trench, Trübner, and Co., 1894.)

It would be difficult to find a worthier disciple of Gilbert White than Mr. Warde Fowler. Many of White's most exact and enduring observations were made on birds, and the "Natural History of Selborne" has furnished his imitators with descriptions of the characteristics of the Stone-curlew, the Ring-ousel, the House-martin, the Sand-martin, the Goat-sucker, and many more of the birds of which he recorded the habits and movements. But Mr. Fowler's writings are not mere paraphrases of his prototype's. He is gifted with the "nice observation and discernment" required by every student of nature; and he can express himself in attractive language— attractive because it is unaffected, and because it is devoid of thin sentiment and gush. The result is that the papers reprinted in this volume are really valuable contributions to ornithology. To remark that there is not a dull page in the book may be a trite saying; nevertheless, so far as we are concerned, it is a true one in this case. What could be more readable than the chapters on the birds of the Engstlen Alp, and the birds of Wales; and where will you find a better example of careful and painstaking observation than is afforded by the account of the Marsh Warbler in Oxfordshire and Switzerland? The chapter on the songs of birds is most interesting; that descriptive of Aristotle's writings on birds, (in which fact and fiction are given equal prominence), should be read by all naturalists; and the biography of Gilbert White shows that the author is saturated with the spirit of the naturalist whose work has had such a wide influence upon natural history during the last hundred years.

Little more need be said about this charming book. So many volumes on popular natural history have lately appeared, that the subject has probably begun to pall upon the public taste. Mr. Warde Fowler's work, however, is so full of interest; it breathes out the air of the fields and streams so pleasantly, that it carries its own welcome to the heart of every lover of nature.

The second of the two books of which the titles are given above, is of quite a different character from the first. It is remarkably well illustrated, is daintily bound, and is nicely printed, and therefore it forms an attractive volume, so far as appearances go. But the text is

dull; for the author, while possessing the essential love of nature, lacks the words with which to express it eloquently. To him, "the Stock Dove is fourteen inches in length from the tip of the beak to the end of the tail, and its stretch of wing is twenty-six inches. Its general colour is bluish-grey. The head, wings, and back are of this colour, and the tail is the same, but tipped with leaden grey." There is much more of the same kind in the book; and we confess that after reading Mr. Warde Fowler's smooth phrases, Mr. Witherby's composition appears spiritless. The illustrations, however, are good enough to make up for deficiencies of the text, and for their sake alone, the book is worth buying.

LETTERS TO THE EDITOR.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. No notice is taken of anonymous communications.]

On the Age of the Earth.

IN reference to Lord Kelvin's letter (NATURE, January 3, p. 227), he will, no doubt, presently communicate with you on the results of measurements which he is making on conductivity and temperature in rocks. I do not wish to forestall him by referring at present to his more recent correspondence with me. Three weeks ago I sent him the solution of the problem of a cooling sphere whose conductivity k and volumetric capacity c are any functions whatsoever of the temperature v , but which are always proportional to one another. As Mr. Heaviside had been writing to me, and had shown me that under certain circumstances the differential equation became linear, and as I had used his operators much as he himself uses the ν , I cannot say to what extent I can claim credit for the work. I now venture to send you the more general case.

If

$$\int c \cdot dv = u \dots \dots \dots (1)$$

so that u is the total amount of sensible heat in unit volume. The general equation is

$$\frac{d}{dx} \left(k \frac{dv}{dx} \right) + \frac{d}{dy} \left(k \frac{dv}{dy} \right) + \frac{d}{dz} \left(k \frac{dv}{dz} \right) = \frac{du}{dt} \dots \dots (2)$$

Now let $k = \kappa c$ where κ is a constant, then

$$k = \kappa \frac{du}{dv} \text{ as } c = \frac{du}{dv}$$

and the equation becomes

$$\frac{d^2 u}{dx^2} + \frac{d^2 u}{dy^2} + \frac{d^2 u}{dz^2} = \frac{1}{\kappa} \frac{du}{dt} \dots \dots (3)$$

Any of the many problems that have been worked out on the distribution of u may be translated into temperature problems. Thus in a body before $t = 0$ let $u = u_1$ a constant everywhere, and after $t = 0$ let the surface have everywhere a constant $u = u_0$. Let the solution be

$$u = (u_1 - u_0)F(x, y, z, t) \dots \dots (4)$$

In the body before $t = 0$ let $v = v_1$ a constant everywhere, and after $t = 0$ let the surface have everywhere $v = v_0$ a constant, then if v is the temperature anywhere

$$\int c \cdot dv = (u_1 - u_0) \int (x, y, z, t) \dots \dots (5)$$

so that a table of the values of $\int c \cdot dv$ enables the temperature at any place to be calculated.

If $\frac{du}{dt}$ the rate of increase of u normally inward from the surface at any place, has been calculated, say that it is

$$\frac{du}{dt} = (u_1 - u_0)F(x, y, z, t) \dots \dots (6)$$

as

$$\frac{du}{dn} = \frac{du}{dv} \cdot \frac{dv}{dn} = c \frac{dv}{dn}$$

$$\frac{dv}{dn} = g = \frac{u_1 - u_0}{c_0} F(x, y, z, t) \dots (7)$$

where g is the temperature gradient inwards from the surface, and c_0 is the value of c at the surface.

If c and k are constant everywhere, say c_0 and k_0 , let us call the surface gradient g_0 ; then as $u = c_0 v + C$

$$\frac{g}{g_0} = \frac{1}{c_0} \frac{u_1 - u_0}{v_1 - v_0}$$

for the same place at the same time after cooling began.

As an example, let

$$k = k_0(av + 1),$$

and

$$c = c_0(av + 1),$$

and measure v on the Centigrade scale, c_0 and k_0 are the actual capacities and conductivities at $0^\circ C.$,

$$u = c_0(\frac{1}{2}av^2 + v + C),$$

so that

$$\frac{g}{g_0} = \frac{\frac{1}{2}av_1^2 + v_1}{v_1} = \frac{1}{2}av_1 + 1.$$

Thus if c and k increase s per cent. per 100 degrees Centigrade, and if $v_1 = 4000$, as

$$a = 10^{-4}s, \frac{g}{g_0} = \frac{s}{5} + 1.$$

In the cooling of Lord Kelvin's infinite mass with a plane face the time which elapses until a particular surface gradient is reached is inversely proportional to the square of the gradient. If the time taken on the assumption of constant c and k be called t_0 , and if the time taken on the assumption that c and k increase s per cent. for 100 degrees is t , then

$$t/t_0 = \left(\frac{s}{5} + 1\right)^2$$

Suppose

$$s = 50,$$

then

$$t/t_0 = 121.$$

So that Lord Kelvin's age of the Earth would be multiplied by 121.

It must be understood that my conclusions (NATURE, January 3, p. 224) are really independent of whether R. Weber's results are correct or not. Lord Kelvin has to prove the impossibility of the rocks inside the earth being better conductors (including convective conduction in case of liquid rock in crevices) than the surface rocks. If, however, Weber's results, as quoted by me, are trustworthy, the above solution is what I take Lord Kelvin to refer to in the first paragraph of his published letter. In considering all such measurements as those of R. Weber, it must be remembered that the rocks at twenty miles deep are not merely at a high temperature, but also under great pressure.

January 30.

JOHN PERRY.

Oceanic Temperatures at Different Depths.

THE question of the persistence or otherwise of the temperature of different strata of water beneath the surface of the oceans, is one upon which so few observations have been made, that it will probably be interesting to students of oceanic phenomena to publish in NATURE the results obtained at one spot in the Atlantic, at periods extending over as much as twenty-one years.

At a position about 200 miles west-south-west from Cape Palmas, in Africa, where the depth of water is about 2500 fathoms, and where on the surface the Guinea current is running to the eastward, the *Challenger* in 1873 and 1876, the *Buccaneer* in 1886, and the *Waterwitch* in 1894, have all obtained serial temperatures; the first three to a depth of 200 fathoms, the last to 150 fathoms.

The result is given in the following table, and illustrated by the diagram.

Comparison of Ocean Temperatures obtained at Different Times in or near the same position, viz. $5^\circ 48' N.$, $14^\circ 20' W.$

Depth in fathoms.	Challenger temperatures, 19/8/73.	Challenger temperatures, 10/4/76.	Buccaneer temperatures, 5/1/86.	Waterwitch temperatures, 22/9/94.
Surface	79.2	83.5	85.5	80.0
10	—	83.2	82.5	78.0
20	—	70.0	79.6	—
25	72.6	—	69.0	75.2
30	—	62.6	65.9	69.2
40	—	60.0	60.8	62.8
50	62.5	59.2	58.8	60.2
60	—	58.5	—	—
70	—	57.8	—	—
75	58.8	—	—	58.8
80	—	57.1	—	—
90	—	56.5	—	—
100	56.2	55.9	56.1	57.0
110	—	55.2	—	—
120	—	54.6	—	—
125	54.1	—	—	—
130	—	54.0	—	—
140	—	53.3	—	—
150	52.2	52.7	—	52.5
160	—	52.1	—	—
170	—	51.4	—	—
180	—	50.8	—	—
190	—	50.1	—	—
200	48.3	49.5	49.0	—

Exact Positions and Observation Spots.

Ship	Date	Lat. $^\circ$	Long. $^\circ$
Challenger	19/8/73	5 48 N.	14 20 W.
Challenger	10/4/76	5 28	14 38
Buccaneer	5/1/86	5 48	14 20
Waterwitch	22/9/94	5 48	14 22

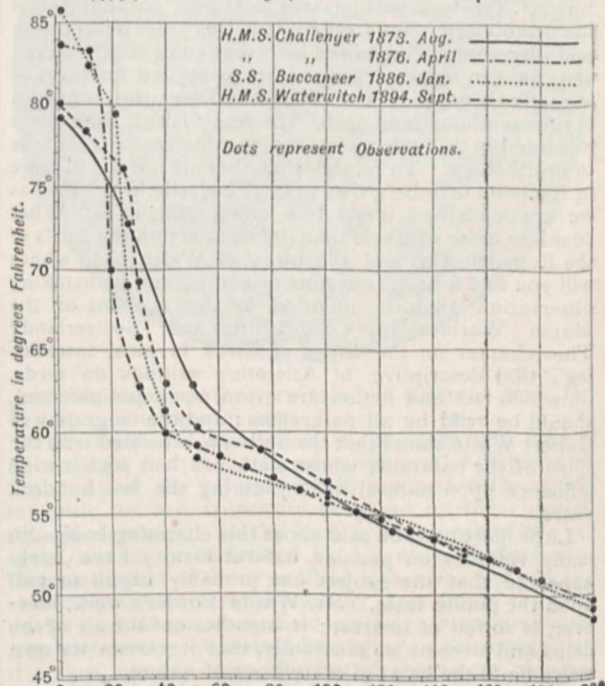


Diagram showing temperature at different depths obtained at various epochs in Lat. $5^\circ 48' N.$, Long. $14^\circ 20' W.$

It will be observed that the temperatures at the surface vary by $6^\circ.3 F.$; at a depth of 20 fathoms, by $9^\circ.6$; at 40 fathoms,

by about 6°; at 50 fathoms, by 3°·7; while at 100 fathoms, three of the results are within 0°·3 of one another, the fourth being 1°·1 above the lowest. From 100 to 200 fathoms, the temperatures, diminishing in the same ratio, differ by about the same amount.

It is difficult to say exactly what value can be placed on each individual observation. Many small errors may creep in; errors of reading, errors from movement of the indices, errors from insufficient time being given for the instrument to take up the true temperature, &c.

These should not, however, reach a degree in any instance, and it is pretty plain that below 100 fathoms the temperature at this spot remains fairly equable. This confirms the general view held by those who have studied the results obtained from observations at different depths, in different parts of the ocean.

While from one point of view it is unfortunate that the observations have been taken in different months, on the other hand, the variation in the surface temperature at different seasons of the year is given full value in the comparison.

January 26. W. J. L. WHARTON.

"The Bird-Winged Butterflies of the East."

PERMIT me to add a few notes supplementary to the very interesting and able article, by my friend Mr. Kirby, entitled "The Bird-Winged Butterflies of the East," which appeared in your issue of January 10, p. 254.

(1) If the male of either of the two species of my genus *Aethoptera* is examined in the proper light and position, a long pupæ-form stigma, composed of raised scent-producing scales, will be very readily seen, of a more slender character, but in nearly the same relative position on the hind margin of the anterior wing, as in the males of the genus *Ornithoptera*, or, as Mr. Kirby prefers to call it, *Troides*. As I have pointed out in part viii. of my "Icones Ornithopterorum," this stigmatic sexual brand, being a densely black mark surrounded by the general velvet black of the wing, is very likely to be overlooked by a casual observer in some positions, while it is really very prominent in others; and I have called special attention to the lovely arrangements by which the latter result is attained; and a reference to the plates containing the figures of these species will suffice to show how very obtrusive the mark is, and how much more beautiful the insect becomes by the magical play of opalescent tints on the black which encloses the stigma, as the insect is moved into different positions against or opposite the light. To simply look at the insect as it stands in a cabinet drawer, is to miss all this glory and its *raison d'être*. As in all the species of *Ornithoptera*, the female possesses no such organ.

(2) *Æ. (?) Tithonus* (De Haan), as quoted by Mr. Kirby, is (as he evidently suspect) not a member of the genus *Aethoptera* at all, but belongs to the first genus of the true *Ornithoptera*, viz. *Schoenbergia* (sub genus of Pagenstecher, and genus of Rippon); and I have no doubt that the female butterfly supposed to be its mate, is rightly assigned to it, as it is singularly like the female of *Sch. Paradisca* of Staudinger, and also co-generic with the large form described by M. Ch. Oberthür under the name *O. Goliath*. Neither in *Sch. Paradisca* or *Sch. Tithonus* is the male furnished with a pupæ-form sexual mark as in *Ornithoptera* and *Aethoptera*, nor with an abdominal marginal pouch or fold concealing the *androconia*, as in the males of *Pompeoptera*, or as Mr. Kirby calls them, *Ornithoptera* and *Trogonoptera*.

(3) I am compelled to regard the *Ornithoptera* as being naturally divided into three sub-groups of unequal extent (so far as our present material indicates): (1) The African or *Acræoid* *Ornithoptera*, containing one genus (*Drurya*), and two species, *D. Antimachus* (Drury), and *D. Zalmoxis* of Hewitson; (2) the Oriental or true *Ornithoptera*, with the five genera *Schoenbergia*, *Ornithoptera*, *Aethoptera*, *Trogonoptera*, and *Pompeoptera*; (3) the South and Central American *Ornithopterina*, containing the numerous black and red, and black and green, and olive black *Papilio*s, which are usually allowed to follow the true *Ornithoptera* in our systematic catalogues. The males of many of these possess an abdominal marginal fold concealing the *androconia*, an organ not found, as far as I am aware, on the abdominal margin of any other section of the *Papilionidæ*—though the sexual stigma can be found on the anterior wings of several males, as in *P. Ulysses* for example, though differing in form and position.

(4) My reasons for not adopting Hubner's name *Troides* in place of *Ornithoptera* for the *Priamus* group will be found by referring to "Icones Ornithopterorum." At the same time, I

quite understand, and to some extent sympathise, with the severe and uncompromising application of the law of priority in nomenclature for which Mr. Kirby and several other naturalists contend.

(5) The wonderful iridescence of the yellow hind wings of *Pompeoptera Magellanus*, ♂, may be seen equally displayed on the under surface also.

Finally, I may safely say that the males of *Aethoptera* and *Schoenbergia* are probably the most perfectly beautiful of the butterflies of the world.

ROBERT H. F. RIPPON.

Upper Norwood, S.E., January 19.

Thirst-endurance in some Vertebrates.

WHEN an example of great ability to endure thirst is desired, the camel is usually suggested. Hibernating animals also are put forward in instance of existence without water for long periods. The camel carries a supply with it, so that what is most wonderful in its case is the tank. Torpid animals need little or no moisture beyond that in their systems, and, besides, they benefit from dampness around them. Better examples abound on the arid plains near the Rocky Mountains and the Sierras, in the innumerable active, noisy little rodents, miles away from streams or pools, and out of possible reach of water by burrowing. Any one who observes these creatures in their haunts in midsummer, will be pretty sure to inquire, like one of my companions, "What do those little wretches get to drink, anyhow?" The only reply appears to be, "They drink water when they get it, and do without at other times." For weeks and months, when the vegetation is shrivelled and parched, and the sands are at their hottest, these squirrels and their neighbours, with thickening blood, wait for the rain, that the currents in their veins may be thinned and quickened. But one need not go so far for a much better instance than the camel. The common mouse endures thirst quite as well as its allies in the desert. This has been proved repeatedly by mice kept here as a reserve supply of food for a lot of reptiles. Reducing the allowance of water prevented the foul odour by which mice are generally attended; this led to keeping some of them entirely without water, to note the effect. Last winter, a few were kept in a warm room more than three months before being fed to the snakes. On the first of last October, several were put aside to have no drink; at the time of writing, three months and a half later, they are eating heartily of the driest of maize and grass seeds, on which alone they have been fed, and they act as if able to endure the experiment a month or two longer.

S. GARMAN.

Cambridge, Mass., U.S.A., January 17.

Electroscopes in Lecture.

THE electroscope which Prof. Lodge proposes to use to indicate positive and negative potentials by different movements of the leaves (see p. 320), has the disadvantage that (assuming the case to be charged negatively), if too large a negative charge be given to the gold leaves they will diverge, and the inference will be that the potential is zero or positive, neither of which is the truth. For the purpose Prof. Lodge has in view, a Bohnenberger's electroscope would indicate more clearly positive, negative, or zero potential. Instead of the two dry piles, the inner and outer coatings of a charged insulated Leyden jar connected to two knobs, one on each side of the single gold leaf, might be substituted.

J. REGINALD ASHWORTH.

The Owens College, Manchester.

Snake Cannibalism.

THE notice in NATURE, January 31, p. 321, on the above-mentioned subject, calls to my mind the following passage in Rénan's "Averroës," Paris, 1867, p. 310. He refers to the pre-Raphælite pictures representing allegorically the "Seven Liberal Arts," and adds: "Dans une fresque récemment découverte à Puy . . . La Logique tient en main un lézard ou un scorpion. Dans un tableau d'Angelico elle tient deux serpents qui se dévorent." I have not succeeded in finding any further statement about this picture in the books on Art within my reach, nevertheless this may prove an interesting addition to the growing literature on cannibal snakes.

C. R. OSTEN SACKEN.

Heidelberg, February 3.

PIERRE DUCHARTRE.

AS announced in our issue of November 8, 1894, the *doyen* of French botanists died on the 5th of that month, "having passed away without suffering, at the advanced age of eighty-three." Pierre Duchartre was pre-eminently a practical botanist, whose teachings were largely based upon actual knowledge, acquired by observation and experiment. Almost before the foundation of the present German school of botanists, of whom Sachs was one of the earliest exponents, Duchartre published (1867) the first edition of his well-known and highly esteemed "Éléments de Botanique." It was the result of thirty years' study and investigation; his first paper having appeared as early as 1836. It is true that Sachs's "Handbuch der Experimental Physiologie der Pflanzen" preceded it by one year; but for some years Duchartre's book held its own, not only in France but also in this country. As we learn from a sketch of his life by Mr. Gaston Bonnier,¹ Duchartre commenced his botanical studies under exceptionally difficult conditions, even for that period; but by great industry and perseverance he soon gained for himself a name and position which he maintained till the last. In 1843 he took up his abode in Paris, where he spent the last fifty years of his life, engaged in teaching, writing, and original research. In 1861 he replaced Payer at the Académie des Sciences, and succeeded him in the Botanical chair at the Sorbonne. For many years Duchartre was one of the principal supporters of the Société Nationale d'Horticulture, and he was seven times elected President of the Société Botanique de France, of which he was one of the founders. He was also President of the Société Nationale d'Agriculture, and the Académie des Sciences. Physiology and organology, including teratology, were his principal branches of study; but his very numerous contributions to botanical and horticultural literature cover a much wider field. Systematic botany, however, received comparatively little attention from him; a monograph of the Aristolochiaceæ being his chief work in this direction. His last work was a summary, from the German, of Engler's additions to Hehn's book on the native countries of cultivated plants. It appeared in the *Journal* of the French Horticultural Society a month before his death.

H.

NOTES.

THE remains of the late Prof. Cayley were interred at Cambridge on Friday, and, notwithstanding the inclemency of the weather, snow having fallen heavily during the night, the proceedings were attended by a large number of persons. We are indebted to the *Times* for the following account of the funeral:—The body was brought from Garden House at two o'clock to Trinity College, and was met at the great gate by a procession numbering about 300 gentlemen, among them being many notable men of science. The pall-bearers were the Vice-Master of Trinity (Mr. Aldis Wright), Dr. Glaisher, the Right Hon. George Denman, Prof. Jebb, M.P., Prof. Sir Robert Ball, Prof. J. J. Thomson, Lord Kelvin, and Prof. Sir G. G. Stokes. The choir headed the procession. Then came the officiating clergy—the Master of Trinity, the Bishop of Durham, and the Rev. R. St. John Parry, senior dean. Following the mourners came the Fellows of Trinity College—Mr. J. Prior, Dr. Jackson, Mr. H. M. Taylor, Mr. B. E. Hammond, Dr. Kirkpatrick, Dr. Stanton, the Rev. A. H. F. Boughey, Dr. Verrall, Mr. W. W. R. Ball, Mr. R. D. Hicks, Mr. R. T. Glazebrook, Mr. F. J. H. Jenkinson, Dr. Postgate, Mr. Fraser, Mr. J. G. Fraser, Mr.

¹ "La Vie et la Carrière Scientifique de M. Duchartre," *Revue Générale de Botanique*, Décembre 1894.

J. D. Duff, Mr. A. N. Whitehead, Dr. Sidgwick, Mr. J. N. Langley, Mr. S. M. Leathes, Rev. C. Platts, Mr. C. Williams, Mr. A. A. Bevan, Mr. G. T. Walker, Mr. W. C. Whetham, Mr. G. A. Davies, Mr. Capstick, Mr. Innes, Mr. Nicholson, Mr. Cowell, Mr. Moore, and Mr. Wyse. Then came the Vice-Chancellor of the University and the representatives of the German and United States Embassies—viz. H.S.H. Prince Hermann von Schoenburg-Waldenburg for the German Ambassador, and Mr. D. D. Wells on behalf of the United States Ambassador. Baron d'Estournelles de Constant had intended to be present as representative of the French Ambassador, but was prevented at the last moment. The heads of Houses included the Masters of Peterhouse, Clare, Caius, St. Catharine's, Jesus, Christ's, St. John's, Emmanuel, Sidney Sussex, Downing, and Ayerst Hall, the President of Queens', and the Principal of Ridley Hall. The Royal Society was represented by Lord Rayleigh and Prof. Michael Foster; the Royal Astronomical Society by Mr. Knobel; the Mathematical Society by Major MacMahon, Mr. Kempe, Prof. Elliott, and Prof. Henrici; the Cambridge Philosophical Society by Mr. Larmor and Mr. Newall. The attendance likewise included Profs. J. R. Lumby, H. B. Swete, E. C. Clark, A. Macalister, T. M'Kenny Hughes, W. J. Lewis, H. E. Ryle, E. B. Cowell, J. E. B. Mayor, J. A. Ewing, W. W. Skeat, Sir G. M. Humphrey, and C. S. Roy; the Public Orator, the Registrar, Dr. Routh, and many others. An impressive service was held in the chapel of Trinity College. The concluding portion of the service took place at the Mill Road Cemetery, the Bishop of Durham committing the body to the grave.

We are glad to see that the Duke of Argyll has recovered sufficiently from his illness to remove from the residence of Lord Kelvin to Inverary Castle.

THE very extensive and valuable botanical library of the late Prof. N. Pringsheim has been presented to the German Botanical Society, of which he was President, together with a sum of 25,000 marks for its maintenance.

THE Berlin correspondent of the *British Medical Journal* reports that a gift of 1,500,000 marks (£75,000) has come to the German Royal Academy of Sciences from a widow lady, Frau Wenzel. The sum is to remain as a foundation, and the interest used to assist scientific inquiries of importance.

THE death is announced of Dr. Lombard, the author of a standard work on Climatology from a medical point of view, and in 1882 the President of the International Congress of Hygiene at Geneva. An eminent German engineer—Hermann Gruson—has also just died, at Magdeburg.

REUTER'S correspondent at Christiania reports that earthquake shocks were felt at Christiansund, Molde, Aalesund, and Bergen between 12.15 and 12.43 on the morning of Tuesday, February 5, causing windows to rattle and disturbing furniture. The direction of the vibrations was from south-east to north-west.

A DEPUTATION from the recent Indian Medical Congress has (says the *Lancet*) waited upon Sir Anthony MacDonnell, controlling the Home Department, to urge upon the Government of India the extension of facilities for the study of preventive medicine and the prosecution of scientific research in that country. Sir Anthony MacDonnell, in his reply, assured the deputation of his interest in the objects in view, and announced that, in addition to the bacteriological laboratory at Agra, a similar institution for experimental research was to be established at Lahore.

THE United States Government has established an additional wind signal, to be known as the "Hurricane Signal," to be used in addition to the storm signals previously shown. The

signal consists of two red flags with black centres, shown one above the other, and will be used to announce the expected approach of tropical hurricanes, and also of those extremely severe and dangerous storms which occasionally move across the Lakes and the northern Atlantic shore. Whenever instructions are received to show this signal at any station, every effort has to be made to distribute the information, and all vessels have to be notified that it is dangerous to leave port.

THE Academy of Natural Sciences of Philadelphia, acting on the report of the Committee on the Hayden Memorial Geological Award, have voted the Hayden medal, and the accumulated interest on the fund, to Prof. G. A. Daubrée. The recipient in 1893 was Prof. Huxley. Prof. Daubrée was born in Metz, June 25, 1814, and is therefore now in his eighty-second year. He graduated from the *École Polytechnique* in 1834, and immediately received a commission to assist in the geological exploration of Algeria. He was called to the chair of Geology in Strasburg in 1839, and was Dean of its Scientific Faculty in 1852. He was appointed Engineer-in-Chief in 1855. In 1861, upon the death of the distinguished Cordier, he was selected to replace him in the Museum of Natural History, and as Professor of Mineralogy in the *École des Mines*, as well as in the *Académie des Sciences* in Paris. His writings have been numerous, original, and important, and his researches into the intricate causes of crystalline structure, and in the domain of experimental geology, are of exceptional value.

By the death of Dr. F. Buchanan White, which took place on December 3, 1894, at Perth, in his fifty-third year, Scotland has lost one of her most active naturalists. His special branches were entomology and botany. Dr. White was one of the founders of the Perthshire Society of Natural Sciences, of the Scottish Cryptogamic Society, and of the East of Scotland Union of Naturalists' Societies; and was the originator and first editor of the *Scottish Naturalist*. He left, at the time of his death, a nearly completed "Flora of Perthshire." The *Entomologist's Monthly Magazine* notes that his friends are endeavouring to raise a fund to erect a memorial to him. It is proposed to place a mural brass tablet in St. Ninian's Cathedral, and also to procure an enlarged photograph, to be hung in the lecture room of the Perthshire Society of Natural Science. Any who wish to contribute to this memorial may send subscriptions to either Vincent L. Rorison, Dean of St. Andrews, The Deanery, Perth; or Henry Coates, President of the Perthshire Society of Natural Science, Pitcullen House, Perth.

DR. HERMANN WEBER, a Fellow of the Royal College of Physicians and Surgeons, gave, last December, the sum of £2500 in trust for the purpose of founding a prize to be called the "Weber-Parkes" prize, to be given at intervals for the best essay on tubercular consumption. It has now been resolved that the prize be awarded triennially to the writer of the best essay upon some subject connected with the etiology, prevention, pathology, or treatment, of tuberculosis, especially with reference to pulmonary consumption in man; that, in making the award, the College have regard to careful collection of facts and original research; that the value of the prize be 150 guineas, or such sum as the interest accrued on the capital, after payment of expenses, will permit; that a bronze medal be awarded to the holder of the prize, and a similar medal, to be distinguished as the "second medal," to the essayist who comes next in order of merit. The competition will be open to members of the medical profession in all countries, the essays to be type-written, and, if written in a foreign language, to be accompanied by a translation in English. It is a condition of the competition that each prize essay shall become the property of the College, though the College may grant its author permission to publish it.

ON Friday last, a deputation from the British Medical Association and the Ophthalmological Society waited upon Mr. Bryce, President of the Board of Trade, to urge the adoption of more precise tests for eyesight in the examination for the mercantile marine and railway servants. Dr. Macnamara, in introducing the deputation, said that railway and merchant marine authorities did not insist upon proper precautions being taken to exclude men with imperfect eyesight from being employed as signalmen, and in the movement of trains and vessels. Dr. Argyll Robertson held it was necessary that the tests should be adequate and uniform, that they should be skilfully employed, and that they should be applied at regular intervals. The tests should elicit three conditions: (1) the acuteness of vision possessed by the applicant; (2) the state of refraction of the candidate's eye; and (3) his acuteness of colour perception. Mr. Bryce, in the course of his reply, said he was glad to gather from what had been said by members of the deputation, that the tests embodied in the Board's circular of last September, to be applied to masters and mates, were recognised as being satisfactory, except in regard to the question of refraction. He was perfectly certain, however, that if the railway companies' examinations did not cover this defect, they would soon take steps to apply the test for it. But the Board of Trade had no statutory powers as regarded the companies in this matter, neither had they any power to apply the tests to all persons entering the merchant service.

IN June of last year, the Society for the Preservation of the Monuments of Ancient Egypt discussed the importance of having a thorough survey made of the Nile Valley from the First to the Second Cataract—that is to say, of the district which will be partially converted into a high reservoir when the dam at Assouan, even in its reduced proportions, is constructed. A draft scheme for such an archaeological survey has been drawn up by the Committee appointed to decide upon the regions to be investigated and the work to be done. A list has been compiled to show the most important antiquities along the Nile Valley which require examination and copying. The Committee propose that the survey should commence with a preliminary reconnaissance, providing a general map and maps of sites, to be followed by plans of the buildings and special inquiries indicated in subsequent sections. It is probable that, under the special circumstances of the case, if the maps and plans referred to cannot be prepared for publication in Egypt, application to the Board of Agriculture might secure their multiplication and reduction by the Ordnance Survey. Such a course would secure perfect reproduction and a great economy. It is proposed that illustrations, other than plans, should be based on photographs, to be subsequently processed in printer's ink. This would secure permanency and great economy, and avoid all the expenses of hand illustration, which alone was available in the expeditions of 1789 and 1844. The Committee suggest that a non-commissioned officer of the Royal Engineers, who has passed through the Photographic School at Chatham, should be attached to one of the companies of Royal Engineers stationed in Egypt, and be employed in obtaining the photographs. It is understood that the preliminary reconnaissance is now about to commence, under the direction of the Public Works, Irrigation, and Archæological Departments of the Egyptian Government, very much in accordance with the detailed scheme, printed copies of which have been forwarded to Egypt.

A PAPER on boiler explosions, read at the Institution of Civil Engineers on January 29, by Mr. William H. Fowler, presents some points of interest. The theories, such as "deferred ebullition," "disassociation of water," "spheroidal condition," which have been propounded to account for

such explosions, are well known. Mr. Fowler showed that it was the hot water, rather than the steam, in the boiler which formed the source of destructive energy. In regard to the causes of boiler explosions, there is nothing occult or mysterious. They can, as a rule, be traced by patient investigation to the operation of simple and well-known facts. Thus when a boiler-shell is normally in a state of high tension, if once a rupture takes place by the action of static stresses on a locally weak spot, the stored-up energy is capable not only of tearing the boiler to pieces, but of producing all the other destructive effects observed in connection with such disasters. Prominent among the principal causes of explosions is the corrosion of the boiler-shell. Some explosions have their origin in the stresses arising from expansion and contraction due to the action of the fire. As an illustration of the stresses set up by unequal expansion and contraction in a boiler, a case was mentioned in which an explosion occurred two hours after the fires were drawn. A frequent source of boiler explosions in the past is the practice of cutting large openings in boiler-shells, without providing compensating strengthening-rings. Overheating from shortness of water is a common cause of boiler explosions, but the operation of this cause is different from the reason formerly assigned to it. Explosions are not the result of turning cold water on to red-hot plates. What takes place is that the overheated plates become gradually softened, with the result that they bulge downwards and are rent at the ordinary working pressure: explosions of this kind are of a relatively mild character. Many explosions arise from excessive pressure in consequence of the defective action of the safety-valve. This may occur in a variety of ways, but the type of valve loaded with a spring-balance is the most prolific source. Finally, explosions sometimes arise from faulty material and construction. As a result of using iron of poor quality with punched holes, incipient flaws are occasionally set up in the seams, and several cases have occurred in which these inherent defects were so situated as to forbid detection when the boiler was put together, and were only revealed by the explosion. These defects show the value in connection with new work of a careful hydraulic test.

THE barometer has been very high over north-west Europe during the past week, and the type of weather over these islands has been anti-cyclonic, with strong easterly winds or gales at several places on our coasts. In the neighbourhood of London the maximum day temperatures have not exceeded 35° , and at night sharp frosts have occurred. In the suburbs a reading of 15° has been recorded, and a few miles distant the temperature fell several degrees lower, with a radiation temperature of $6^{\circ}5$, while over the midland districts of England the thermometer in the shade has fallen 24° below the freezing point. The *Weekly Weather Report* published by the Meteorological Office states that during the week ending the 2nd inst. the absolute shade minima recorded were— 2° at Llandoverly on January 28, 1° at Braemar on January 30, and 2° at Hillington on January 27. Over the whole country the temperature ranged from 8° to 13° below the mean for the week. Snow has fallen at many places in different parts of the kingdom.

THE beautiful Alpine phenomenon which the Swiss call "Alpenglühén," is not a simple red glow of the snowy peaks at sunset, but is sometimes intermittent, the glow returning once or twice after it has apparently died away. Dr. J. Am-ler, in a recent communication to the Swiss Natural Science Society, explains this repetition by taking into account the various deviations undergone by the sun's rays in passing through the rapidly cooling atmosphere. Since the air is colder in the higher, and warmer in the lower strata, the solar rays undergo a kind

of total reflection which makes them pass upwards again, so that when the sun has reached a certain position they will no longer strike the summits. This is the end of the first glow. As the lower air cools, the rays become once more rectilinear, and the second glow sets in. When the sun sinks still lower, its rays are thrown down upon the glaciers by ordinary refraction. This refraction may be intensified by warm air from below reaching the upper regions of the air, which would give rise to the third glow. But the latter is only rarely observed.

IT is gratifying to learn that the Italian Government has appointed a commission to study the violent earthquake which occurred in South Italy on November 16. In the meantime, Prof. Tacchini has established one result of great interest and, possibly, of much practical importance (*R. Accad. dei Lincei, Rend.* iii. 1894, pp. 365-357). The earthquake was registered at Rome by three pendulums in the Collegio Romano. The maximum displacement occurred at 5h. 55m. p.m. Greenwich mean time; but the first movement was registered by the great seismometergraph (length 16m., mass 200 kg.) at 5h. 52m. 25s., by another (length 6m., mass 100 kg.) at 5h. 52m. 30s., and by a third still less delicate (length $1\frac{1}{2}$ m., mass 10 kg.) at 5h. 53m. 20s. Now a clock was stopped at the observatory of Messina at 5h. 52m., there being no slight shock previously, and the maximum disturbance was registered at the same moment at the observatory of Catania. It may be inferred, therefore, that before the great shock took place, there was a microseismic motion insensible to man and to ordinary apparatus. But, if an instrument as delicate as that at Rome had been installed at Messina, the beginning of the motion would have been recorded $2\frac{1}{2}$ minutes before the occurrence of the sensible shock.

WE learn from the *Journal of Botany*, that a "Flora of Berkshire," by Mr. Druce, will shortly be published.

THE constant communication kept up by the central authorities at Kew with the directors of the various colonial botanic gardens, is bearing fruit in the numerous botanical publications which proceed from the Colonies. We have on our table the *Bulletin of Miscellaneous Information* from the Royal Botanic Garden, Trinidad, for January 1895; the *Agricultural Journal* of the Leeward Islands for October 1894; and *Notes on Antigua Grasses*, by Mr. C. A. Barber, Superintendent of Agriculture for the Leeward Islands; all containing notes and information of value for the dwellers in the Tropics.

FIVE *Bulletins* of the University of Wisconsin have come to us. One, the first of a Science Series, is on the speed of the liberation of iodine in mixed solutions of potassium chlorate, potassium iodide, and hydrochloric acid, the author thereof being Mr. H. Schlundt. His experiments show that the speed of the reaction increases to a marked degree with temperature. The presence in the mixture of an excess of one or more of the components also increases the speed, and an increase in the degree of concentration acts in the same manner. The presence of hydrobromic acid accelerates the reaction; and, to a less extent, hydrochloric, nitric, and sulphuric acids. Organic acids, however, and boric acid, do not increase the speed. The four remaining *Bulletins* referred to belong to the Engineering Series. In one, Mr. L. F. Loree traces the development of railroads from 1825 to the present time, chiefly dealing with the construction of the permanent way. Some practical hints in dynamo design are given by Mr. Gilbert Wilkes in the second of the series. The next, by Mr. C. T. Purdy, refers to the steel construction of buildings; and the fourth, by Mr. A. V. Abbott, deals with telephones and switchboards.

TWO further communications concerning the new iodine bases are contributed by pupils of Prof. Victor Meyer to the current issue of the *Berichte*. In the first, Mr. John McCrae

describes the base and its salts derived from toluene, analogous to the compounds previously described by Prof. Meyer and Herr Hartmann derived from benzene. In the second memoir, Mr. Wilkinson describes a further series derived from para-chloro-iodo-benzene, C_6H_4ClI . The formation of both series occurs precisely as in the case of the benzene derivatives. The base derived from toluene was prepared from the para iodide of toluene as starting point. Its composition is $(C_6H_4 \cdot CH_3)_2I \cdot OH$, iodine apparently acting, as in the bases previously described, in a trivalent capacity, and forming the central element around which the two toluene radicles and the hydroxyl are grouped. The base itself has only been obtained in aqueous solution, but many of the salts crystallise well, and are consequently readily isolated. The iodide, $(C_6H_4 \cdot CH_3)_2I \cdot I$, is precipitated as a white powder, extremely sensitive to light, and melting at 146° . The corresponding chloride and bromide both crystallise from water in needles which melt at almost the same temperature in the neighbourhood of 178° . The bichromate is a particularly beautiful salt, crystallising from hot water in large orange-red plates. It is likewise explosive, detonating when heated. The nitrate, $(C_6H_4 \cdot CH_3)_2I \cdot NO_3$, is very soluble in water, and melts at 139° . The per-iodide is a remarkable compound, $(C_6H_4 \cdot CH_3)_2I_3$, obtained by addition of two further atoms of iodine to the ordinary iodide above mentioned. It crystallises in dark red needles, endowed with a very brilliant lustre, and melting at 156° . In addition to these salts, double salts with the chlorides of gold, platinum and mercury are described, all of which crystallise well and exhibit definite melting points. The base of the series described by Mr. Wilkinson possesses the composition $(C_6H_4Cl)_2I \cdot OH$, being derived from para chloro-iodo-benzene by reactions analogous to those by means of which the base above described was obtained, and similar to those previously described by Prof. Meyer. The iodide, chloride, bromide, nitrate and chromate, as well as double salts with the chlorides of mercury and platinum, have been obtained in well-defined crystals. Hence it would appear that the reactions discovered by Prof. Meyer and Herr Hartmann, between iodosobenzene and silver oxide, and between sulphuric acid and iodosobenzene, which resulted in the preparation of the first iodonium bases, are of pretty general application in the benzene series. These remarkable compounds containing iodine as the grouping element must now, therefore, be regarded as thoroughly well established, and the older idea as to the nature of the iodine atom must give place to a fuller conception of the capabilities of that element.

THE additions to the Zoological Society's Gardens during the past week include a Chacma Baboon (*Cynocephalus porcaricus*) from South Africa, presented by Captain Webster; a White-throated Capuchin (*Cebus hypoleucus*) from Central America, presented by Mr. H. W. Manning; a Senegal Parrot (*Picocephalus senegalus*) from West Africa, presented by Miss Alice Firman.

OUR ASTRONOMICAL COLUMN.

NEW STARS AND NEBULÆ.—The first number of the *Astro-physical Journal* has come to hand. It is practically a continuation of *Astronomy and Astro-Physics* in a slightly different form, and is now published by the Chicago University Press. Among the contributions to the journal is a paper, by Prof. W. W. Campbell, on some interesting and significant changes which have occurred recently in the spectrum of Nova Aurigæ. The intensities of the two lines at $\lambda 4360$ and $\lambda 5750$ appear to have decreased very materially. When Prof. Campbell observed the Nova spectrum in 1892, these two lines were stronger in the Nova than in the nebulæ in the spectra of which they were seen and photographed. Observing last November, however, he found that this condition of things was reversed, the lines

appearing relatively fainter in the Nova than in the nebulæ. As is now very well known, the spectra of nebulæ differ both as regards the number and intensity of the lines. The recent observations of the Nova seem to show that the spectrum is not only nebular, but it is approaching the average type of nebular spectrum. Prof. Campbell thus sums up the bearing of spectroscopic observations upon theories proposed to account for the genesis of new stars:—

“The Harvard College Observatory has shown that both Nova Aurigæ and Nova Normæ at discovery possessed substantially identical spectra of bright and dark lines, similarly and equally displaced. Both diminished in brightness and both assumed the nebular type of spectrum. The new star of 1876 in Cygnus probably had nearly an identical history: passing from a bright star with a spectrum of bright and dark lines, to a faint object with a spectrum consisting of one bright line (undoubtedly the nebular line $\lambda 5010$, or the two nebular lines $\lambda 5010$ and $\lambda 4960$ combined). We may say that only five ‘new stars’ have been discovered since the application of the spectroscope to astronomical investigations, and that three of these have had substantially identical spectroscopic histories. This is a remarkable fact. We cannot say what the full significance of this fact is. One result, however, is very clear: the *special* theories propounded by various spectroscopists to account for the phenomena observed in Nova Aurigæ must unquestionably give way to the more *general* theories.”

THE DESIGNATION OF COMETS.—A uniform system of cometary notation is certainly needed. The *Observatory* points out that though the small letters *a, b, c, &c.*, are now generally used to denote the order of discovery, and Roman numerals I, II, III, &c., to indicate the order of perihelion passage, astronomers are not agreed whether to write Comet *a* 1894, Brooks's Comet, or Comet Brooks. It is therefore suggested, and the suggestion deserves to be acted upon, that in the future the order shall be letter, year, Roman numeral, discoverer. The full name of the comet would then run as follows:—Comet *a* 1892, I. (Swift): and if any part of the name be quoted, this order should be preserved. Those who have had to search for observation of comets in astronomical publications, will welcome the system of uniformity in indexing, proposed by our contemporary.

THE NEW CONSTITUENT OF THE ATMOSPHERE.¹

I. Density of Nitrogen from Various Sources.

In a former paper² it has been shown that nitrogen extracted from chemical compounds is about $\frac{1}{2}$ per cent. lighter than “atmospheric nitrogen.”

The mean numbers for the weights of gas contained in the globe used were as follows:—

From nitric oxide	...	...	...	2'3001
From nitrous oxide	...	...	...	2'2990
From ammonium nitrite	...	...	...	2'2987

while for “atmospheric nitrogen” there was found—

By hot copper, 1892	...	...	...	2'3103
By hot iron, 1893	...	...	...	2'3100
By ferrous hydrate, 1894	...	...	...	2'3102

At the suggestion of Prof. Thorpe experiments were subsequently tried with nitrogen liberated from *urea* by the action of sodium hypobromite. The hypobromite was prepared from commercial materials in the proportions recommended for the analysis of urea. The reaction was well under control, and the gas could be liberated as slowly as desired.

In the first experiment the gas was submitted to no other treatment than slow passage through potash and phosphoric anhydride, but it soon became apparent that the nitrogen was contaminated. The “inert and inodorous” gas attacked vigorously the mercury of the Töpler pump, and was described as smelling like a dead rat. As to the weight, it proved to be in excess even of the weight of atmospheric nitrogen.

The corrosion of the mercury and the evil smell were in great

¹ Abstract of a paper by Lord Rayleigh, Sec. R.S., and Prof. William Ramsay, F.R.S., read before the Royal Society, at a special meeting, on January 31.

² Rayleigh, “On an Anomaly encountered in Determinations of the Density of Nitrogen Gas,” *Roy. Soc. Proc.* vol. lv. p. 340, 1894.

degree obviated by passing the gas over hot metals. For the fillings of June 6, 9, and 13 the gas passed through a short length of tube containing copper in the form of fine wire heated by a flat Bunsen burner, then through the furnace over red-hot iron, and back over copper oxide. On June 19 the furnace tubes were omitted, the gas being treated with red hot copper only. The mean result, reduced so as to correspond with those above quoted, is 2.2985.

Without using heat, it has not been found possible to prevent the corrosion of the mercury. Even when no urea is employed, and air simply bubbled through, the hypobromite solution is allowed to pass with constant shaking over mercury contained in a U tube, the surface of the metal was soon fouled.

Although the results relating to urea nitrogen are interesting for comparison with that obtained from other nitrogen compounds, the original object was not attained on account of the necessity of retaining the treatment with hot metals. We have found, however, that nitrogen from ammonium nitrite may be prepared without the employment of hot tubes whose weight agrees with that above quoted. It is true that the gas smells slightly of ammonia, easily removable by sulphuric acid, and apparently also of oxides of nitrogen. The mean result from three fillings is 2.2987.

It will be seen that, in spite of the slight nitrous smell, there is no appreciable difference in the densities of gas prepared from ammonium nitrite with and without the treatment by hot metals. The result is interesting as showing that the agreement of numbers obtained for chemical nitrogen does not depend upon the use of a red heat in the process of purification.

The five results obtained in more or less distinct ways for chemical nitrogen stand thus:—

From nitric oxide	2.3001
From nitrous oxide	2.2990
From ammonium nitrite purified at a red heat	2.2987
From urea	2.2985
From ammonium nitrite purified in the cold	2.2987
Mean	2.2990

These numbers, as well as those above quoted for "atmospheric nitrogen," are subject to a deduction of 0.0006 for the shrinkage of the globe when exhausted.¹ If they are then multiplied in the ratio of 2.3108 : 1.2572, they will express the weights of the gas in grams per litre. Thus, as regards the mean numbers, we find as the weight per litre under standard conditions of chemical nitrogen 1.2505, that of atmospheric nitrogen being 1.2572.

It is of interest to compare the density of nitrogen obtained from chemical compounds with that of oxygen. We have $N_2 : O_2 = 2.2984 : 2.6276 = 0.87471$; so that if $O_2 = 16$, $N_2 = 13.9954$. Thus, when the comparison is with chemical nitrogen, the ratio is very nearly that of 16 : 14; but if "atmospheric nitrogen" be substituted, the ratio of small integers is widely departed from.

To the above list may be added nitrogen prepared in yet another manner, whose weight has been determined subsequently to the isolation of the new dense constituent of the atmosphere. In this case nitrogen was actually extracted from air by means of magnesium. The nitrogen thus separated was then converted into ammonia by action of water upon the magnesium nitride, and afterwards liberated in the free state by means of calcium hypochlorite. The purification was conducted in the usual way, and included passage over red hot copper and copper oxide. The following was the result:—

Globe empty, October 30, November 5 ...	2.82313
Globe full, October 31	0.52395
Weight of gas	2.29918

It differs inappreciably from the mean of other results, viz. 2.2990, and is of special interest as relating to gas which at one stage of its history formed part of the atmosphere.

Another determination, with a different apparatus, of the density of "chemical" nitrogen from the same source, magnesium nitride, which had been prepared by passing "atmospheric" nitrogen over ignited magnesium, may here be recorded. The sample differed from that previously mentioned, inasmuch as it had not been subjected to treatment with red-

hot copper. After treating the nitride with water, the resulting ammonia was distilled off, and collected in hydrochloric acid; the solution was evaporated by degrees, the dry ammonium chloride was dissolved in water, and its concentrated solution added to a freshly-prepared solution of sodium hypobromite. The nitrogen was collected in a gas-holder over water which had previously been boiled, so as, at all events, partially to expel air. The nitrogen passed into the vacuum globe through a solution of potassium hydroxide, and through two drying-tubes, one containing soda-lime, and the other phosphoric anhydride.

At 18.38° C. and 754.4 mm. pressure, 162.843 c.c. of this nitrogen weighed 0.18963 gram. Hence,

Weight of 1 litre at 0° C. and 760 mm. pressure = 1.2521 gram.

The mean result of the weight of 1 litre of "chemical" nitrogen has been found to equal 1.2505. It is therefore seen that "chemical" nitrogen, derived from "atmospheric" nitrogen, without any exposure to red hot copper, possesses the usual density.

Experiments were also made, which had for their object to prove that the ammonia produced from the magnesium nitride is identical with ordinary ammonia, and contains no other compound of a basic character. For this purpose the ammonia was converted into ammonium chloride, and the percentage of chlorine determined by titration with a solution of silver nitrate which had been standardised by titrating a specimen of pure sublimed ammonium chloride. The silver solution was of such a strength that 1 c.c. precipitated the chlorine from 0.001701 gram of ammonium chloride.

(1) Ammonium chloride from orange-coloured sample of magnesium nitride contained 66.35 per cent. of chlorine.

(2) Ammonium chloride from blackish magnesium nitride contained 66.35 per cent. of chlorine.

(3) Ammonium chloride from nitride containing a large amount of unattacked magnesium contained 66.30 per cent. of chlorine.

Taking for the atomic weights of hydrogen H = 1.0032, of nitrogen N = 14.04, and of chlorine Cl = 35.46, the theoretical amount of chlorine in ammonium chloride is 66.27 per cent.

From these results—that nitrogen prepared from magnesium nitride, obtained by passing "atmospheric" nitrogen over red-hot magnesium has the density of "chemical" nitrogen, and that ammonium chloride, prepared from magnesium nitride, contains practically the same percentage of chlorine as pure ammonium chloride—it may be concluded that red-hot magnesium withdraws from "atmospheric nitrogen" no substance other than nitrogen capable of forming a basic compound with hydrogen.

II. Reasons for suspecting a hitherto Undiscovered Constituent in Air.

When the discrepancy of weights was first encountered, attempts were naturally made to explain it by contamination with known impurities. Of these the most likely appeared to be hydrogen, present in the lighter gas in spite of the passage over red-hot cupric oxide. But inasmuch as the intentional introduction of hydrogen into the heavier gas, afterwards treated in the same way with cupric oxide, had no effect upon its weight, this explanation had to be abandoned, and finally it became clear that the difference could not be accounted for by the presence of any known impurity. At this stage it seemed not improbable that the lightness of the gas extracted from chemical compounds was to be explained by partial dissociation of nitrogen molecules N_2 into detached atoms. In order to test this suggestion both kinds of gas were submitted to the action of the silent electric discharge, with the result that both retained their weights unaltered. This was discouraging, and a further experiment pointed still more markedly in the negative direction. The chemical behaviour of nitrogen is such as to suggest that dissociated atoms would possess a high degree of activity, and that even though they might be formed in the first instance their life would probably be short. On standing they might be expected to disappear, in partial analogy with the known behaviour of ozone. With this idea in view, a sample of chemically prepared nitrogen was stored for eight months. But at the end of this time the density showed no sign of increase, remaining exactly as at first.¹

¹ Rayleigh, "On the Densities of the Principal Gases," *Roy. Soc. Proc.* vol. liii. p. 134, 1893.

¹ *Roy. Soc. Proc.* vol. lv., p. 344, 1894.

Regarding it as established that one or other of the gases must be a mixture, containing, as the case might be, an ingredient much heavier or much lighter than ordinary nitrogen, we had to consider the relative probabilities of the various possible interpretations. Except upon the already discredited hypothesis of dissociation, it was difficult to see how the gas of chemical origin could be a mixture. To suppose this would be to admit two kinds of nitric acid, hardly reconcilable with the work of Stas and others upon the atomic weight of that substance. The simplest explanation in many respects was to admit the existence of a second ingredient in air from which oxygen, moisture, and carbonic anhydride had already been removed. The proportional amount required was not great. If the density of the supposed gas were double that of nitrogen $\frac{1}{2}$ per cent. only by volume would be needed; or if the density were but half as much again as that of nitrogen, then 1 per cent. would still suffice. But in accepting this explanation, even provisionally, we had to face the improbability that a gas surrounding us on all sides, and present in enormous quantities, could have remained so long unsuspected.

The method of most universal application by which to test whether a gas is pure or a mixture of components of different densities is that of diffusion. By this means Graham succeeded in effecting a partial separation of the nitrogen and oxygen of the air, in spite of the comparatively small difference of densities. If the atmosphere contain an unknown gas of anything like the density supposed, it should be possible to prove the fact by operations conducted upon air which had undergone atomolysis. This experiment, although in view from the first, was not executed until a later stage of the inquiry (§ 6), when results were obtained sufficient of themselves to prove that the atmosphere contains a previously unknown gas.

But although the method of diffusion was capable of deciding the main, or at any rate the first question, it held out no prospect of isolating the new constituent of the atmosphere, and we, therefore, turned our attention in the first instance to the consideration of methods more strictly chemical. And here the question forced itself upon us as to what really was the evidence in favour of the prevalent doctrine that the inert residue from air after withdrawal of oxygen, water, and carbonic anhydride, is all of one kind.

The identification of "phlogisticated air" with the constituent of nitric acid is due to Cavendish, whose method consisted in operating with electric sparks upon a short column of gas confined with potash over mercury at the upper end of an inverted U tube.¹

Attempts to repeat Cavendish's experiments in Cavendish's manner have only increased the admiration with which we regard this wonderful investigation. Working on almost microscopic quantities of material, and by operations extending over days and weeks, he thus established one of the most important facts in chemistry. And what is still more to the purpose, he raises as distinctly as we could do, and to a certain extent resolves, the question above suggested. The passage is so important that it will be desirable to quote it at full length.

"As far as the experiments hitherto published extend, we scarcely know more of the phlogisticated part of our atmosphere, than that it is not diminished by lime-water, caustic alkalies, or nitrous air; that it is unfit to support fire, or maintain life in animals; and that its specific gravity is not much less than that of common air: so that though the nitrous acid, by being united to phlogiston, is converted into air possessed of these properties, and consequently, though it was reasonable to suppose, that part at least of the phlogisticated air of the atmosphere consists of this acid united to phlogiston, yet it was fairly to be doubted whether the whole is of this kind, or whether there are not in reality many different substances compounded together by us under the name of phlogisticated air. I therefore made an experiment to determine whether the whole of a given portion of the phlogisticated air of the atmosphere could be reduced to nitrous acid, or whether there was not a part of a different nature to the rest, which would refuse to undergo that change. The foregoing experiments indeed in some measure decided this point, as much the greatest part of the air let up into the tube lost its elasticity; yet as some remained unabsorbed, it did not appear for certain whether that was of the same nature as the rest or not. For this purpose I diminished a similar mixture of dephlogisticated and common air, in the same manner as before, till it was reduced to a small

part of its original bulk. I then, in order to decompose as much as I could of the phlogisticated air which remained in the tube, added some dephlogisticated air to it, and continued the spark until no further diminution took place. Having by these means condensed as much as I could of the phlogisticated air, I let up some solution of liver of sulphur to absorb the dephlogisticated air; after which only a small bubble of air remained unabsorbed, which certainly was not more than $\frac{1}{16}$ of the bulk of the phlogisticated air let up into the tube; so, that if there is any part of the phlogisticated air of our atmosphere which differs from the rest, and cannot be reduced to nitrous acid, we may safely conclude that it is not more than $\frac{1}{16}$ of the whole."

Although Cavendish was satisfied with his result, and does not decide whether the small residue was genuine, our experiments about to be related render it not improbable that his residue was really of a different kind from the main bulk of the "phlogisticated air," and contained the gas now called argon.

Cavendish gives data¹ from which it is possible to determine the rate of absorption of the mixed gases in his experiment. This was about 1 c.c. per hour, of which two-fifths would be nitrogen.

III. Methods of Causing Free Nitrogen to Combine.

To eliminate nitrogen from air, in order to ascertain whether any other gas could be detected, involves the use of some absorbent. The elements which have been found to combine directly with nitrogen are: boron, silicon, titanium, lithium, strontium, barium, magnesium, aluminium, mercury, and, under the influence of an electric discharge, hydrogen in presence of acid, and oxygen in presence of alkali. Besides these, a mixture of barium carbonate and carbon at a high temperature is known to be effective. Of those tried, magnesium in the form of turnings was found to be the best. When nitrogen is passed over magnesium, heated in a tube of hard glass to bright redness, combustion with incandescence begins at the end of the tube through which the gas is introduced, and proceeds regularly until all the metal has been converted into nitride. Between 7 and 8 litres of nitrogen can be absorbed in a single tube; the nitride formed is a porous, dirty orange-coloured substance.

IV. Early Experiments on Sparking Nitrogen with Oxygen in presence of Alkali.

In our earliest attempts to isolate the suspected gas by the method of Cavendish, we used a Ruhmköuff coil of medium size actuated by a battery of five Grove cells. The gases were contained in a test-tube standing over a large quantity of weak alkali, and the current was conveyed in wires insulated by U-shaped glass tubes passing through the liquid round the mouth of the test-tube. With the given battery and coil a somewhat short spark or arc of about 5 mm. was found to be more favourable than a longer one. When the mixed gases were in the right proportion the rate of absorption was about 30 c.c. per hour, or thirty times as fast as Cavendish could work with the electrical machine of his day.

To take an example, one experiment of this kind started with 50 c.c. of air. To this oxygen was gradually added, until oxygen being in excess, there was no perceptible contraction during an hour's sparking. The remaining gas was then transferred at the pneumatic trough to a small measuring vessel, sealed by mercury, in which the volume was found to be 1.0 c.c. On treatment with alkaline pyrogallate, the gas shrank to 0.32 c.c. That this small residue could not be nitrogen was argued from the fact that it had withstood the prolonged action of the spark, although mixed with oxygen in nearly the most favourable proportion.

The residue was then transferred to the test-tube with an addition of another 50 c.c. of air, and the whole worked up with oxygen as before. The residue was now 2.2 c.c., and, after removal of oxygen, 0.76 c.c.

Although it seemed almost impossible that these residues could be either nitrogen or hydrogen, some anxiety was not unnatural, seeing that the final sparking took place under somewhat abnormal conditions. The space was very restricted, and the temperature (and with it the proportion of aqueous vapour) was unduly high. But any doubts that were felt upon this score were removed by comparison experiments in which the whole quantity of air operated on was very small. Thus, when

¹ "Experiments on Air," *Phil. Trans.* vol. lxxv. p. 372, 1785.

² *Phil. Trans.* vol. lxxviii. p. 271, 1788.

a mixture of 5 c.c. of air with 7 c.c. of oxygen was sparked for 1½ hours, the residue was 0.47 c.c., and after removal of oxygen 0.06 c.c. Several repetitions having given similar results, it became clear that the final residue did not depend upon anything that might happen when sparks passed through a greatly reduced volume, but was in proportion to the amount of air operated upon.

No satisfactory examination of the residue which refused to be oxidised could be made without the accumulation of a larger quantity. This, however, was difficult of attainment at the time in question. It was thought that the cause probably lay in the solubility of the gas in water, a suspicion since confirmed. At length, however, a sufficiency was collected to allow of sparking in a specially constructed tube, when a comparison with the air spectrum, taken under similar conditions, proved that, at any rate, the gas was not nitrogen. At first scarcely a trace of the principal nitrogen lines could be seen, but after standing over water for an hour or two these lines became apparent.

V. Early Experiments on Withdrawal of Nitrogen from Air by means of Red-hot Magnesium.

A preliminary experiment carried out by Mr. Percy Williams on the absorption of atmospheric nitrogen, freed from oxygen by means of red-hot copper, in which the gas was not passed over, but simply allowed to remain in contact with the metal, gave a residue of density 14.88. This result, although not conclusive, was encouraging; and an attempt was made, on a larger scale, by passing atmospheric nitrogen backwards and forwards over red-hot magnesium from one large gas-holder to another to obtain a considerable quantity of the heavier gas. In the course of ten days, about 1500 c.c. were collected and transferred gradually to a mercury gas-holder, from which the gas was passed over soda lime, phosphoric anhydride, magnesium at a red-heat, copper oxide, soda-lime, and phosphoric anhydride into a second mercury gas-holder. After some days the gas was reduced in volume to about 200 c.c., and its density was found to be 16.1. After further absorption, in which the volume was still further reduced, the density of the residue was increased to 19.09.

On passing sparks for several hours through a mixture of a small quantity of this gas with oxygen, its volume was still further reduced. Assuming that this reduction was due to the further elimination of nitrogen, the density of the remaining gas was calculated to be 20.0.

The spectrum of the gas of density 19.09, though showing nitrogen bands, showed many other lines which were not recognisable as belonging to any known element.

VI. Proof of the Presence of Argon in Air by means of Atmolysis.

It has already (§ II.) been suggested that if "atmospheric nitrogen" contains two gases of different densities, it should be possible to obtain direct evidence of the fact by the method of atmolysis. The present section contains an account of carefully conducted experiments directed to this end.

The atmolysing apparatus was prepared (after Graham) by combining a number of "churchwarden" tobacco pipes. At first twelve pipes were used in three groups, each group including four pipes connected in series. The three groups were then connected in parallel, and placed in a large glass tube closed in such a way that a partial vacuum could be maintained in the space outside the pipes by a water pump. One end of the combination of pipes was open to the atmosphere; the other end was connected to a bottle aspirator, initially full of water, and so arranged as to draw about 2 per cent. of the air which entered the other end of the pipes. The gas collected was thus a very small proportion of that which leaked through the pores of the pipes, and should be relatively rich in the heavier constituents of the atmosphere. The flow of water from the aspirator could not be maintained very constant, but the rate of 2 per cent. was never much exceeded.

The air thus obtained was treated exactly as ordinary air had been treated in determinations of the density of atmospheric nitrogen. Oxygen was removed by red-hot copper, followed by cupric oxide, ammonia by sulphuric acid, moisture and carbonic acid by potash and phosphoric anhydride.

In a total weight of approximately 2.3 grams the excess of weight of the diffused nitrogen over ordinary atmospheric nitrogen was in four experiments, 0.0049, 0.0014, 0.0027, 0.0015.

The mean excess of the four determinations is 0.00262 gram,

or, if we omit the first, which depended upon a vacuum weighing of two months old, 0.00187 gram.

The gas from prepared air was thus in every case denser than from unprepared air, and to an extent much beyond the possible errors of experiment. The excess was, however, less than had been expected, and it was thought that the arrangement of the pipes could be improved. The final delivery of gas from each of the groups in parallel being so small in comparison with the whole streams concerned, it seemed possible that each group was not contributing its proper share, and even that there might be a flow in the wrong direction at the delivery end of one or two of them. To meet this objection, the arrangement in parallel had to be abandoned, and for the remaining experiments eight pipes were connected in simple series. The porous surface in operation was thus reduced, but this was partly compensated for by an improved vacuum. Two experiments were made under the new conditions, in which the excess was I., 0.0037; II., 0.0033.

The excess being larger than before is doubtless due to the greater efficiency of the atmolysing apparatus. It should be mentioned that the above recorded experiments include all that have been tried, and the conclusion seems inevitable that "atmospheric nitrogen" is a mixture, and not a simple body.

It was hoped that the concentration of the heavier constituent would be sufficient to facilitate its preparation in a pure state by the use of prepared air in substitution for ordinary air in the oxygen apparatus. The advance of 3½ milligrams on the 11 milligrams, by which atmospheric nitrogen is heavier than chemical nitrogen, is indeed not to be despised, and the use of prepared air would be convenient if the diffusion apparatus could be set up on a large scale and be made thoroughly self-acting.

VII. Negative Experiments to prove that Argon is not derived from Nitrogen from Chemical Sources.

Although the evidence of the existence of argon in the atmosphere, derived from the comparison of densities of atmospheric and chemical nitrogen and from the diffusion experiments (§ VI.), appeared overwhelming, we have thought it undesirable to shrink from any labour that would tend to complete the verification. With this object in view, an experiment was undertaken and carried to a conclusion on November 13, in which 3 litres of chemical nitrogen, prepared from ammonium nitrite, were treated with oxygen in precisely the manner in which atmospheric nitrogen had been found to yield a residue of argon. The gas remaining at the close of the large scale operations was worked up as usual with battery and coil until the spectrum showed only slight traces of the nitrogen lines. When cold, the residue measured 4 c.c. This was transferred, and after treatment with alkaline pyrogallate to remove oxygen, measured 3.3 c.c. If atmospheric nitrogen had been employed, the final residue should have been about 30 c.c. Of the 3.3 c.c. actually left, a part is accounted for by an accident, and the result of the experiment is to show that argon is not formed by sparking a mixture of oxygen and chemical nitrogen.

In a second experiment of the same kind 5660 c.c. of nitrogen from ammonium nitrite was treated with oxygen. The final residue was 3.5 c.c., and was found to consist mainly of argon.

The source of the residual argon is to be sought in the water used for the manipulation of the large quantities of gas (6 litres of nitrogen and 11 litres of oxygen) employed. When carbonic acid was collected in a similar manner and subsequently absorbed by potash, it was found to have acquired a contamination consistent with this explanation.

Negative experiments were also carried out, absorbing nitrogen by means of magnesium. In one instance 3 litres of nitrogen prepared from ammonium chloride and bleaching-powder was reduced in volume to 4.5 c.c., and on sparking with oxygen its volume was further reduced to about 3 c.c. The residue appeared to consist of argon. Another experiment, in which 15 litres of nitrogen from ammonium nitrite was absorbed, gave a final residue of 3.5 c.c. Atmospheric nitrogen, in the latter case, would have yielded 150 c.c., hence less than ¼th of the normal quantity was obtained. It should be mentioned that leakage occurred at one stage, by which perhaps 200 c.c. of air entered the apparatus; and besides, the nitrogen was collected over water from which it doubtless acquired some argon. Quantitative negative experiments of this nature are exceedingly difficult, and require a long time to carry them to a successful conclusion.

VIII. Separation of Argon on a Large Scale.

To prepare argon on a large scale, air is freed from oxygen by means of red-hot copper. The residue is then passed from a gas-holder through a combustion tube, heated in a furnace, and containing copper, in order to remove all traces of oxygen; the issuing gas is then dried by passage over soda-lime and phosphorus pentoxide, after passage through a small U tube containing sulphuric acid, to indicate the rate of flow. It then enters a combustion-tube packed tightly with magnesium turnings, and heated to redness in a second furnace. From this tube it passes through a second index tube, and enters a small gas-holder capable of containing 3 or 4 litres. A single tube of magnesium will absorb from 7 to 8 litres of nitrogen. The temperature must be nearly that of the fusion of the glass, and the current of gas must be carefully regulated, else the heat developed by the union of the magnesium with nitrogen will fuse the tube.

Having collected the residue from 100 or 150 litres of atmospheric nitrogen, which may amount to 4 or 5 litres, it is transferred to a small gas-holder connected with an apparatus, whereby, by means of a species of a self-acting Sprengel's pump, the gas is caused to circulate through a tube half filled with copper and half with copper oxide; it then traverses a tube half filled with soda-lime and half with phosphorus pentoxide; it then passes a reservoir of about 300 c.c. capacity, from which, by raising a mercury reservoir, it can be expelled into a small gas-holder. Next it passes through a tube containing magnesium turnings heated to bright redness. The gas is thus freed from any possible contamination with oxygen, hydrogen, or hydrocarbons, and nitrogen is gradually absorbed. As the amount of gas in the tubes and reservoir diminishes in volume, it draws supplies from the gas-holder, and finally, the circulating system is full of argon in a pure state. The circulating system of tubes is connected with a mercury pump, so that, in changing the magnesium tube, no gas may be lost. Before ceasing to heat the magnesium tube the system is pumped empty, and the collected gas is restored to the gas-holder; finally, all the argon is transferred from the mercury reservoir to the second small gas-holder, which should preferably be filled with water saturated with argon, so as to prevent contamination from oxygen or nitrogen; or, if preferred, a mercury gas-holder may be employed. The complete removal of nitrogen from argon is very slow towards the end, but circulation for a couple of days usually effects it.

The principal objection to the oxygen method of isolating argon, as hitherto described, is the extreme slowness of the operation. In extending the scale we had the great advantage of the advice of Mr. Crookes, who not long since called attention to the flame rising from platinum terminals, which convey a high tension alternating electric discharge, and pointed out its dependence upon combustion of the nitrogen and oxygen of the air.¹ The plant consists of a De Meritens alternator, actuated by a gas engine, and the currents are transformed to a high potential by means of a Ruhmkorff or other suitable induction coil. The highest rate of absorption of the mixed gases yet attained is 3 litres per hour, about 3000 times that of Cavendish. It is necessary to keep the apparatus cool, and from this and other causes a good many difficulties have been encountered.

In one experiment of this kind, the total air led in after seven days' working, amounted to 7925 c.c., and of oxygen (prepared from chlorate of potash), 9137 c.c. On the eighth and ninth days oxygen alone was added, of which about 500 c.c. was consumed, while there remained about 700 c.c. in the flask. Hence the proportion in which the air and oxygen combined was as 79:96. The progress of the removal of the nitrogen was examined from time to time with the spectroscope, and became ultimately very slow. At last the yellow line disappeared, the contraction having apparently stopped for two hours. It is worthy of notice that, with the removal of the nitrogen, the arc discharge changes greatly in appearance, becoming narrower and blue rather than greenish in colour.

The final treatment of the residual 700 c.c. of gas was on the model of the small scale operations already described. Oxygen or hydrogen could be supplied at pleasure from an electrolytic apparatus, but in no way could the volume be reduced below 65 c.c. This residue refused oxidation, and showed no trace of the yellow line of nitrogen, even under favourable conditions.

¹ *Chemical News*, vol. lxx. p. 301, 1892.

When the gas stood for some days over water, the nitrogen line reasserted itself in the spectrum, and many hours' sparking with a little oxygen was required again to get rid of it. Intentional additions of air to gas free from nitrogen showed that about 1½ per cent. was clearly, and about 3 per cent. was conspicuously, visible. About the same numbers apply to the visibility of nitrogen in oxygen when sparked under these conditions, that is, at atmospheric pressure, and with a jar connected to the secondary terminals.

IX. Density of Argon prepared by means of Oxygen.

A first estimate of the density of argon prepared by the oxygen method was founded upon the data already recorded respecting the volume present in air, on the assumption that the accurately known densities of atmospheric and of chemical nitrogen differ on account of the presence of argon in the former, and that during the treatment with oxygen nothing is oxidised except nitrogen. Thus, if

- D = density of chemical nitrogen.
- D' = " atmospheric nitrogen,
- d = " argon,
- a = proportional volume of argon in atmospheric nitrogen,

the law of mixtures give

$$ad + (1 - a)D = D',$$

or

$$d = D + (D' - D)/a.$$

In this formula D' - D and a are both small, but they are known with fair accuracy. From the data already given

$$a = \frac{65}{0.79 \times 7925},$$

whence if (on an arbitrary scale of reckoning) D = 2.2990, D' = 2.3102, we find d = 3.378. Thus if N₂ be 14, or O₂ be 16, the density of argon is 20.6.

A direct determination by weighing is desirable, but hitherto it has not been feasible to collect by this means sufficient to fill the large globe employed for other gases. A mixture of about 400 c.c. of argon with pure oxygen, however, gave the weight 2.7315, 0.1045 in excess of the weight of oxygen, viz. 2.6270. Thus, if a be the ratio of the volume of argon to the whole volume, the number for argon will be

$$2.6270 + 0.1045/a.$$

The value of a, being involved only in the excess of weight above that of oxygen, does not require to be known very accurately. Sufficiently concordant analyses by two methods gave a = 0.1845; whence for the weight of the gas we get 3.193, so that, if O₂ = 16, the density of the gas would be 19.45. An allowance for residual nitrogen, still visible in the gas before admixture of oxygen, raises this number to 19.7, which may be taken as the density of pure argon resulting from this determination.

X. Density of Argon prepared by means of Magnesium.

The density of the original sample of argon prepared has already been mentioned. It was 19.09; and, after sparking with oxygen, it was calculated to be 20.0. The most reliable results of a number of determinations give it as 19.90. The difficulty in accurately determining the density is to make sure that all nitrogen has been removed. The sample of density 19.90 showed no spectrum of nitrogen when examined in a vacuum tube. It is right, however, to remark that the highest density registered was 20.38. But there is some reason here to distrust the weighing of the vacuous globe.

XI. Spectrum of Argon.

The spectrum of argon, seen in a vacuum tube of about 3 mm. pressure, consists of a great number of lines, distributed over almost the whole visible field. Two lines are specially characteristic; they are less refrangible than the red lines of hydrogen or lithium, and serve well to identify the gas, when examined in this way. Mr. Crookes, who will give a full account of the spectrum in a separate communication, has kindly furnished us with the accurate wave-lengths of these lines, as well as of some others next to be described; they are respectively 696.56 and 705.64, 10⁻⁶ mm.

Besides these red lines, a bright yellow line, more refrangible than the sodium line, occurs at 603.84. A group of five bright

green lines occurs next, besides a number of less intensity. Of the group of five, the second, which is perhaps the most brilliant, has the wave-length 561'00. There is next a blue or blue violet line of wave-length 470'2; and last, in the less easily visible part of the spectrum, there are five strong violet lines, of which the fourth, which is the most brilliant, has the wave-length of 420'0.

Unfortunately, the red lines, which are not to be mistaken for those of any other substance, are not easily seen when a jar discharge is passed through argon at atmospheric pressure. The spectrum seen under these conditions has been examined by Prof. Schuster. The most characteristic lines are perhaps those in the neighbourhood of F, and are very easily seen if there be not too much nitrogen, in spite of the presence of some oxygen and water vapour. The approximate wave-lengths are—

487'91	Strong.
[486'07]	F.
484'71	Not quite so strong.
480'52	Strong.
476'50	} Fairly strong characteristic triplet.
475'53	
472'56	

It is necessary to anticipate Mr. Crookes' communication, and to state that when the current is passed from the induction coil in one direction, that end of the capillary tube next the positive pole appears of a redder, and that next the negative pole of a bluer hue. There are, in effect, two spectra, which Mr. Crookes has succeeded in separating to a considerable extent. Mr. E. C. Baly, who has noticed a similar phenomenon,¹ attributes it to the presence of two gases. The conclusion would follow that what we have termed "argon" is in reality a mixture of two gases which have as yet not been separated. This conclusion, if true, is of great importance, and experiments are now in progress to test it by the use of other physical methods. The full bearing of this possibility will appear later.

The presence of a small quantity of nitrogen interferes greatly with the argon spectrum. But we have found that in a tube with platinum electrodes, after the discharge has been passed for four hours, the spectrum of nitrogen disappears, and the argon spectrum manifests itself in full purity. A specially constructed tube with magnesium electrodes, which we hoped would yield good results, removed all traces of nitrogen, it is true; but hydrogen was evolved from the magnesium, and showed its characteristic lines very strongly. However, these are easily identified. The gas evolved on heating magnesium *in vacuo*, as proved by a separate experiment, consists entirely of hydrogen.

Mr. Crookes has proved the identity of the chief lines of the spectrum of gas separated from air-nitrogen by aid of magnesium with that remaining after sparking the air-nitrogen with oxygen in presence of caustic soda solution.

Prof. Schuster also has found the principal lines identical in the spectra of the two gases, as observed by the jar discharge at atmospheric pressure.

XII. Solubility of Argon in Water.

Determinations of the solubility in water of argon, prepared by sparking, gave 3.94 volumes per 100 of water at 12°. The solubility of gas prepared by means of magnesium was found to be 4.05 volumes per 100 at 13.9°. The gas is therefore about $2\frac{1}{2}$ times as soluble as nitrogen, and possesses approximately the same solubility as oxygen.

The fact that argon is more soluble than nitrogen would lead us to expect it in increased proportion in the dissolved gases of rain water. Experiment has confirmed this anticipation. "Nitrogen" prepared from the dissolved gases of water supplied from a rain-water cistern was weighed upon two occasions. The weights, corresponding to those recorded in § I., were 2.3221 and 2.3227, showing an excess of 24 milligrams above the weight of true nitrogen. Since the corresponding excess for "atmospheric nitrogen" is 11 milligrams, we conclude that the water "nitrogen" is relatively more than twice as rich in argon.

On the other hand, gas evolved from the hot spring at Bath,

and collected for us by Dr. A. Richardson, gave a residue after removal of oxygen and carbonic acid, whose weight was only about midway between that of true and atmospheric nitrogen.

XIII. Behaviour at Low Temperatures.¹

Preliminary experiments, carried out to liquefy argon at a pressure of about 100 atmospheres, and at a temperature of -90°, failed. No appearance of liquefaction could be observed.

Prof. Charles Olszewski, of Cracow, the well-known authority on the constants of liquefied gases at low temperatures, kindly offered to make experiments on the liquefaction of argon. His results are embodied in a separate communication, but it is allowable to state here that the gas has a lower critical temperature (-121°) and a lower boiling point (-187°) than oxygen, and that he has succeeded in solidifying argon to white crystals, melting at -189.6°. The density of the liquid is approximately 1.5, that of oxygen being 1.124, and of nitrogen 0.885. The sample of gas he experimented with was exceptionally pure, and had been prepared by help of magnesium. It showed no trace of nitrogen when examined in a vacuum tube.

XIV. Ratio of Specific Heats.

In order to decide regarding the elementary or compound nature of argon, experiments were made on the velocity of sound in it. It will be remembered that, from the velocity of sound in a gas, the ratio of specific heat at constant pressure to that at constant volume can be deduced by means of the equation

$$n\lambda = v = \sqrt{\left\{ \frac{e}{d} (1 + \alpha t) \frac{C_p}{C_v} \right\}},$$

when n is the frequency, λ the wave-length of sound, v its velocity, e the isothermal elasticity, d the density, $(1 + \alpha t)$ the temperature correction, C_p the specific heat at constant pressure, and C_v that at constant volume. In comparing two gases at the same temperature, each of which obeys Boyle's law with sufficient approximation, and in using the same sound, many of these terms disappear, and the ratio of specific heats of one gas may be deduced from that of the other, if known, by means of the proportion

$$\lambda^2 d : \lambda'^2 d' :: 1.41 : x,$$

where, for example, λ and d refer to air, of which the ratio is 1.41, according to observations by Röntgen, Wüllner, Kayser, and Jamin and Richard.

Two completely different series of observations, one in a tube of about 2 mm. diameter, and one in one of 8 mm., made with entirely different samples of gas, gave, the first, 1.65 as the ratio, and, the second, 1.61.

Experiments made with the first tube, to test the accuracy of its working, gave for carbon dioxide the ratio 1.276, instead of 1.288, the mean of all previous determinations; and the half wave-length of sound in hydrogen was found to be 73.6, instead of 74.5, the mean of those previously found. The ratio of the specific heats of hydrogen found was 1.39, instead of 1.402.

There can be no doubt, therefore, that argon gives practically the ratio of specific heats, viz. 1.66, proper to a gas in which all the energy is translational. The only other gas which has been found to behave similarly is mercury gas, at a high temperature.

XV. Attempts to induce Chemical Combination.

Many attempts to induce argon to combine will be described in full in the complete paper. Suffice it to say here, that all such attempts have as yet proved abortive. Argon does not combine with oxygen in presence of alkali under the influence of the electric discharge, nor with hydrogen in presence of acid or alkali also when sparked; nor with chlorine, dry or moist, when sparked; nor with phosphorus at a bright-red heat, nor with sulphur at bright redness. Tellurium may be distilled in a current of the gas; so may sodium and potassium, their metallic lustre remaining unchanged. It is unabsorbed by passing it over fused red-hot caustic soda, or soda-lime heated to bright redness; it passes unaffected over fused and bright red-hot potassium nitrate; and red-hot sodium peroxide does not combine with it. Persulphides of sodium and calcium

¹ *Proc. Phys. Soc.*, 1893, p. 147. He says:—"When an electric current is passed through a mixture of two gases, one is separated from the other and appears in the negative glow."

¹ The arrangements for the experiments upon this branch of the subject were left entirely in Prof. Ramsay's hands.

² Kundt and Warburg, *Pogg. Ann.* vol. cxxxv. pp. 337 and 527.

are also without action at a red heat. Platinum black does not absorb it, nor does platinum sponge, and wet oxidising and chlorinating agents, such as nitro-hydrochloric acid, bromine water, bromine and alkali, and hydrochloric acid and potassium permanganate, are entirely without action. Experiments with fluorine are in contemplation, but the difficulty is great; and an attempt will be made to produce a carbon arc in the gas. Mixtures of sodium and silica and of sodium and boracic anhydride are also without action, hence it appears to resist attack by nascent silicon and by nascent boron.

XVI. General Conclusions.

It remains, finally, to discuss the probable nature of the gas, or mixture of gases, which we have succeeded in separating from atmospheric air, and which we provisionally name *argon*.

The presence of argon in the atmosphere is proved by many lines of evidence. The high density of "atmospheric nitrogen," the lower density of nitrogen from chemical sources, and the uniformity in the density of samples of chemical nitrogen prepared from different compounds, lead to the conclusion that the cause of the anomaly is the presence of a heavy gas in air. If that gas possess the density 20 compared with hydrogen, "atmospheric" nitrogen should contain of it approximately 1 per cent. This is, in fact, found to be the case. Moreover, as nitrogen is removed from air by means of red-hot magnesium, the density of the remaining gas rises proportionately to the concentration of the heavier constituent.

Second. This gas has been concentrated in the atmosphere by diffusion. It is true that it has not been freed from oxygen and nitrogen by diffusion, but the process of diffusion increases, relatively to nitrogen, the amount of argon in that portion which does not pass through the porous walls. This has been proved by its increase in density.

Third. As the solubility of argon in water is relatively high, it is to be expected that the density of the mixture of argon and nitrogen, pumped out of water along with oxygen, should, after the removal of the oxygen, be higher than that of "atmospheric" nitrogen. Experiment has shown that the density is considerably increased.

Fourth. It is in the highest degree improbable that two processes, so different from each other, should manufacture the same product. The explanation is simple if it be granted that these processes merely eliminate nitrogen from an "atmospheric" mixture. Moreover, as argon is an element, or a mixture of elements, its manufacture would mean its separation from one of the substances employed. The gas which can be removed from red-hot magnesium in a vacuum has been found to be wholly hydrogen. Nitrogen from chemical sources has been practically all absorbed by magnesium, and also when sparked in presence of oxygen; hence argon cannot have resulted from the decomposition of nitrogen. That it is not produced from oxygen is sufficiently borne out by its preparation by means of magnesium.

Other arguments could be adduced, but the above are sufficient to justify the conclusion that argon is present in the atmosphere.

The identity of the leading lines in the spectrum, the similar solubility and the similar density, appear to prove the identity of the argon prepared by both processes.

Argon is an element, or a mixture of elements, for Clausius has shown that if *K* be the energy of translatory motion of the molecules of a gas, and *H* their whole kinetic energy, then

$$\frac{K}{H} = \frac{3(C_p - C_v)}{2C_v}$$

C_p and *C_v* denoting as usual the specific heat at constant pressure and at constant volume respectively. Hence if, as for mercury vapour and for argon (§ XIV.), the ratio of specific heats *C_p* : *C_v* be 1 $\frac{2}{3}$, it follows that *K* = *H*, or that the whole kinetic energy of the gas is accounted for by the translatory motion of its molecules. In the case of mercury the absence of interatomic energy is regarded as proof of the monatomic character of the vapour, and the conclusion holds equally good for argon.

The only alternative is to suppose that if argon molecules are di- or polyatomic, the atoms acquire no relative motion, even of rotation, a conclusion exceedingly improbable in itself and one postulating the sphericity of such complex groups of atoms.

Now a monatomic gas can be only an element, or a mixture of

elements; and hence it follows that argon is not of a compound nature.

From Avogadro's law, the density of a gas is half its molecular weight; and as the density of argon is approximately 20, hence its molecular weight must be 40. But its molecule is identical with its atom; hence its atomic weight, or, if it be a mixture, the mean of the atomic weights of that mixture, taken for the proportion in which they are present, must be 40.

There is evidence both for and against the hypothesis that argon is a mixture: for, owing to Mr. Crookes' observations of the dual character of its spectrum; against, because of Prof. Olszewski's statement that it has a definite melting point, a definite boiling point, and a definite critical temperature and pressure; and because on compressing the gas in presence of its liquid, pressure remains sensibly constant until all gas has condensed to liquid. The latter experiments are the well-known criteria of a pure substance; the former is not known with certainty to be characteristic of a mixture. The conclusions which follow are, however, so startling, that in our future experimental work we shall endeavour to decide the question by other means.

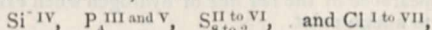
For the present, however, the balance of evidence seems to point to simplicity. We have therefore to discuss the relations to other elements of an element of atomic weight 40. We inclined for long to the view that argon was possibly one or more than one of the elements which might be expected to follow fluorine in the periodic classification of the elements—elements which should have an atomic weight between 19, that of fluorine, and 23, that of sodium. But this view is completely put out of court by the discovery of the monatomic nature of its molecules.

The series of elements possessing atomic weights near 40 are:—

Chlorine	35.5
Potassium	39.1
Calcium	40.0
Scandium	44.0

There can be no doubt that potassium, calcium, and scandium follow legitimately their predecessors in the vertical columns, lithium, beryllium, and boron, and that they are in almost certain relation with rubidium, strontium, and (but not so certainly) yttrium. If argon be a single element, then there is reason to doubt whether the periodic classification of the elements is complete; whether, in fact, elements may not exist which cannot be fitted among those of which it is composed. On the other hand, if argon be a mixture of two elements, they might find place in the eighth group, one after chlorine and one after bromine. Assuming 37 (the approximate mean between the atomic weights of chlorine and potassium) to be the atomic weight of the lighter element, and 40 the mean atomic weight found, and supposing that the second element has an atomic weight between those of bromine, 80, and rubidium, 85.5, viz. 82, the mixture should consist of 93.3 per cent. of the lighter, and 6.7 per cent. of the heavier element. But it appears improbable that such a high percentage as 6.7 of a heavier element should have escaped detection during liquefaction.

If it be supposed that argon belongs to the eighth group, then its properties would fit fairly well with what might be anticipated. For the series, which contains



might be expected to end with an element of monatomic molecules, of no valency, *i.e.* incapable of forming a compound, or, if forming one, being an octad; and it would form a possible transition to potassium, with its monovalence, on the other hand. Such conceptions are, however, of a speculative nature; yet they may be perhaps excused, if they in any way lead to experiments which tend to throw more light on the anomalies of this curious element.

In conclusion, it need excite no astonishment that argon is so indifferent to reagents. For mercury, although a monatomic element, forms compounds which are by no means stable at a high temperature in the gaseous state; and attempts to produce compounds of argon may be likened to attempts to cause combination between mercury gas at 800° and other elements. As for the physical condition of argon, that of a gas, we possess no knowledge why carbon, with its low atomic weight, should be a solid, while nitrogen is a gas, except in so far as we ascribe molecular complexity to the former and comparative molecular simplicity to the latter. Argon, with its compara-

tively low density and its molecular simplicity, might well be expected to rank among the gases. And its inertness, which has suggested its name, sufficiently explains why it has not previously been discovered as a constituent of compound bodies.

We would suggest for this element, assuming provisionally that it is not a mixture, the symbol A.

We have to record our thanks to Messrs. Gordon, Kellas, and Matthews, who have materially assisted us in the prosecution of this research.

ON THE SPECTRA OF ARGON.¹

Through the kindness of Lord Rayleigh and Prof. Ramsay I have been enabled to examine the spectrum of this gas in a very accurate spectrograph, and also to take photographs of its spectra in a spectrograph fitted with a complete quartz train. The results are both interesting and important, and entirely corroborate the conclusions arrived at by the discoverers of argon.

Argon resembles nitrogen in that it gives two distinct spectra according to the strength of the induction current employed. But while the two spectra of nitrogen are different in character, one showed fluted bands and the other sharp lines, the argon spectra both consist of sharp lines. It is, however, very difficult to get argon so free from nitrogen that it will not show the nitrogen flutings superposed on its own special system of lines. I have used argon prepared by Lord Rayleigh, Prof. Ramsay, and myself, and, however free it was supposed to be from nitrogen, I could always detect the nitrogen bands in its spectrum. These, however, soon disappear when the induction spark is passed through the tube for some time, varying from a few minutes to a few hours.

The pressure of argon giving the greatest luminosity and most brilliant spectrum is 3 mm. (The best pressure for nitrogen is 75 or 80 mm.) At this point the colour of the discharge is an orange-red, and the spectrum is rich in red rays, two being especially prominent at wave-lengths 696.56 and 705.64. On passing the current the traces of nitrogen bands soon disappear, and the argon spectrum is seen in a state of purity.

If the pressure is further reduced, and a Leyden jar intercalated in the circuit, the colour of the luminous discharge changes from red to a rich steel-blue, and the spectrum shows an almost entirely different set of lines. The two spectra, called for brevity red and blue, are shown on the large map, the upper spectrum being that of "blue" argon, and the lower one that of "red" argon. It is not easy to obtain the blue colour and spectrum entirely free from the red. It appears that a low electromotive force (3 cm. spark, or 27,600 volts) is required to bring out the red, and a high E.M.F. and a very hot spark for the blue. The red glow is produced by the positive spark, and the blue by the negative spark.

I have taken photographs of the two spectra of argon partly superposed. In this way their dissimilarity is readily seen.² In the spectrum of the blue glow I have counted 119 lines, and in that of the red glow 80 lines, making 199 in all. Of these 26 appear to be common to both spectra.

The disappearance of the red glow and the appearance of the blue glow in argon as the exhaustion increases also resembles the disappearance of the red line of hydrogen when exhaustion is raised to a high point.

I have prepared tubes containing other gases as well as nitrogen at different pressures, and have examined their spectra both by eye observations and by photography. The sharp line spectrum of nitrogen is not nearly so striking in brilliancy, number or sharpness of lines as are those of argon, and the most careful scrutiny fails to show any connection between the spectra. I can detect no lines in common. Between the spectra of argon and the band spectrum of nitrogen there are two or three close approximations of lines, but a projection on the screen of a magnified image of the two spectra partly superposed will show that two at least of these are not really coincidences.

I have found no other spectrum-giving gas or vapour yield spectra at all like those of argon, and the apparent coincidences in some of the lines, which on one or two occasions are noticed, have been very few, and would probably disappear on using a

higher dispersion. Having once obtained a tube of argon giving the pure spectra, I can make no alteration in it, other than what I have explained takes place on varying the spark or increasing the exhaustion, when the two spectra change from one to the other. As far, therefore, as spectrum work can decide, the verdict must, I think, be that Lord Rayleigh and Prof. Ramsay have added one, if not two, members to the family of elementary bodies.

The Two Spectra of Argon.

[Lines having intensities below 8 have been omitted.]

Blue.		Red.	
Wave-length.	Intensity.	Wave-length.	Intensity.
		705.64	10
		696.56	9
		640.7	9
603.84	8	603.8	8
		565.1	9
		561.0	9
		555.70	10
		549.65	8
		518.58	10
		516.5	9
514.0	10		
506.5	10		
500.7	9		
496.55	9		
493.8	10		
487.9	10		
		470.12	8
460.80	8		
450.95	8	450.95	9
442.05	10		
442.25	10		
439.95	10		
437.65	9		
436.90	9		
434.85	10		
433.35	9	433.35	9
		430.05	9
429.90	9		
		427.20	8
425.95	8	425.95	9
420.10	10	420.10	10
419.80	9	419.80	9
419.15	9	419.15	9
418.30	8	418.30	8
416.45	8		
415.95	10	415.95	10
410.50	8		
407.25	8		
404.40	8	404.40	9
401.30	8		
394.85	9	394.85	10
392.85	8		
		390.45	8
386.85	8		
385.15	10		
378.08	9		
376.60	8		
372.98	10		
358.70	10		
358.03	9		
357.50	9		
349.00	10		

The totals are:—

119 lines in the "blue" spectrum.

80 lines in the "red" spectrum.

199 total lines.

26 lines common to the two spectra.

¹ Abstract of a paper by Mr. William Crookes, F.R.S.

² Photographs of the different spectra of argon, and other gaseous spectra for comparison, were projected on the screen.

THE LIQUEFACTION AND SOLIDIFICATION OF ARGON.¹

Having been furnished, by Prof. Ramsay's kindness, with a sample of the new gas, argon, I have carried out experiments on its behaviour at a low temperature and at high pressures, in order to contribute, at least in part, to the knowledge of the properties of this interesting body.

Four series of experiments in all were carried out, two with the object of determining the critical temperature and pressure of argon, as well as measuring its vapour pressure at several other low temperatures, while two other series served to determine its boiling and freezing points under atmospheric pressure, as well as its density at its boiling point.

A detailed description of these experiments will be given in another place; I shall here give only a short description of the manner in which they were made.

For the first two experiments I made use of a Cailletet's apparatus. Its metallic manometer had been previously compared with the readings of a mercury manometer. As cooling agent I used liquid ethylene, boiling under diminished pressure. The glass tube of Cailletet's apparatus was so arranged that the portion immersed in the liquid ethylene had comparatively thin walls (not exceeding 1 mm.), so as to equalise the external and internal temperature as quickly as possible.

In both the other experiments the argon was contained in a burette, closed at both ends with glass stop-cocks. By connecting the lower end of the burette with a mercury reservoir, the argon was transferred into a narrow glass tube fused at its lower end to the upper end of the burette, and in which the argon was liquefied, and its volume in the liquid state measured. In these two series of experiments liquid oxygen, boiling under atmospheric or under diminished pressure, was employed as a cooling agent. I made use of a hydrogen thermometer in all these experiments to measure low temperatures.

Determination of the Critical Constants of Argon.

As soon as the temperature of liquid ethylene had been lowered to $-128^{\circ}6$, the argon easily condensed to a colourless liquid under a pressure of 38 atmospheres. On slowly raising the temperature of the ethylene, the meniscus of the liquid argon became less and less distinct, and finally vanished.

Seven determinations of the disappearance of the meniscus proved that the critical pressure was 50.6 atmospheres; but determinations of the critical temperature show slight differences.

quadruple walls, so as to isolate the liquid from external heat. After the liquid oxygen had been thus poured under atmospheric pressure, a great part of it evaporated, but there still remained about 70 c.c. boiling under atmospheric pressure. A calibrated tube, intended to receive the argon to be liquefied, and the hydrogen thermometer were immersed in the boiling oxygen. At this temperature ($-182^{\circ}71$) on admitting argon, no appearance of liquefaction could be noticed, even when compressed by adding a quarter of an atmosphere pressure to that of the atmosphere. This shows that its boiling point lies below that of oxygen. But on diminishing the temperature of the liquid oxygen below -187° , the liquefaction of argon became manifest. When liquefaction had taken place, I carefully equalised the pressure of the argon with that of the atmosphere, and regulated the temperature, so that the state of balance was maintained for a long time. This process gives the boiling point of argon under atmospheric pressure. Four experiments gave the numbers $-186^{\circ}7$, $-186^{\circ}8$, $-187^{\circ}0$, and $-187^{\circ}3$. The mean is $-186^{\circ}9$, which I consider to be the boiling point under atmospheric pressure (740.5 mm.).

The quantity of argon used for these experiments, reduced to normal temperature and pressure, was 99.5 c.c.; the quantity of liquid corresponding to that volume of gas was approximately 0.114 c.c. Hence the density of argon at its boiling point may be taken as approximately 1.5. Two other determinations of the density of liquid argon, for which I employed still smaller quantities of the gas, yielded rather smaller numbers. Owing to the small amount of argon used for these experiments, the numbers given cannot lay claim to great exactness; yet they prove that the density of liquid argon at its boiling point (-187°) is much higher than that of oxygen, which I have found, under similar conditions, to be 1.124.

By lowering the temperature of the oxygen to -191° by slow exhaustion, the argon froze to a crystalline mass, resembling ice; on further lowering temperature it became white and opaque. When the temperature was raised it melted; four observations which I made to determine its melting point gave the numbers: $-189^{\circ}0$, $-190^{\circ}6$, $-189^{\circ}6$, and $-189^{\circ}4$. The mean of these numbers is $-189^{\circ}6$; and this may be accepted as the melting point of argon.

In the following table I have given a comparison of physical constants, in which those of argon are compared with those of other so-called permanent gases. The data are from my previous work on the subject.

Name.	Critical temperature.	Critical pressure.	Boiling point.	Freezing point.	Freezing pressure.	Density of gas.	Density of Liquid at boiling point.	Colour of liquid.
	Below.	Atmos.			mm.			
Hydrogen (H ₂)	$-220^{\circ}0$	20.0	?	?	?	1.0	?	Colourless.
Nitrogen (N ₂)	$-146^{\circ}0$	35.0	$-194^{\circ}4$	$-214^{\circ}0$	60	14.0	0.885	"
Carbonic oxide (CO)	$-139^{\circ}5$	35.5	$-190^{\circ}0$	$-207^{\circ}0$	100	14.0	?	"
Argon (A ₁)	$-121^{\circ}0$	50.6	$-187^{\circ}0$	$-189^{\circ}6$	?	19.9	1.5	"
Oxygen (O ₂)	$-118^{\circ}8$	50.8	$-182^{\circ}7$	?	?	16.0	1.124	Bluish.
Nitric oxide (NO)	$-93^{\circ}5$	71.2	$-153^{\circ}6$	$-167^{\circ}0$	138	15.0	?	Colourless.
Methane (CH ₄)	$-81^{\circ}8$	54.9	$-164^{\circ}0$	$-185^{\circ}8$	80	8.0	0.415	"

The mean of the seven estimations of the critical temperature is -121° , and this may be taken as the critical temperature of argon.

The vapour pressures at ten temperatures from $-128^{\circ}6$ to $139^{\circ}1$ were also determined.

Determination of the Boiling and Freezing Points.

Two hundred cubic centimetres of liquid oxygen, prepared in my large apparatus,² was poured into a glass vessel with

¹ Abstract of a paper by Dr. K. Olszewski, Professor of Chemistry in the University of Cracow.

² *Bulletin international de l'Academie de Cracovie*, June 1890; also *Wiedemann's Beiblätter*, vol. 15, p. 29.

As can be seen from the foregoing table, argon belongs to the so-called "permanent" gases, and, as regards difficulty in liquefying it, it occupies the fourth place, viz. between carbon monoxide and oxygen. Its behaviour on liquefaction places it near to oxygen, but it differs entirely from oxygen in being solidifiable; as is well known, oxygen has not yet been made to assume a solid state.

The high density of argon rendered it probable that its liquefaction would take place at a higher temperature than that

³ I have re-determined the boiling point of oxygen, using large quantities of oxygen, and a hydrogen thermometer of much larger dimensions than previously. The registered temperature is 1.3 lower than that which I previously recorded.

at which oxygen liquefies. Its unexpectedly low critical temperature and boiling point seem to have some relation to its unexpectedly simple molecular constitution.

After the reading of the three foregoing papers, a discussion followed, of which we give the most important parts.

Dr. H. E. Armstrong said that the case for the existence of the new constituent was undoubtedly a very strong one, and would, no doubt, meet with very considerable criticism throughout the world. But, apart from the facts which were brought forward, there was a portion which was of a wildly speculative character: viz. the portion dealing with the probable nature of this new element. Apparently the authors were not entirely satisfied with the evidence to be adduced from the application of the Clausius method for the determination of the atomicity of the gas. It was quite conceivable that the condition which Prof. Ramsay pointed out as being the only alternative to the one which was apparently accepted by the authors of the communication, is a conceivable condition. It was quite likely that the two atoms existed so firmly locked in each other's embrace, that there was no possibility for them to take notice of anything outside, and that they were perfectly content to roll on together without taking up any of the energy that is put into the molecule. The spectroscopic evidence was not sufficient to justify the conclusion that the new gas was a mixture. The great difficulty in accepting the conclusion that the gas was an element having a molecular weight of 40, and an atomic weight of 20, arose from the difficulty of placing an element of that kind. All these matters, however, would have to be discussed later on more fully: they were matters which could only be discussed very gradually, as more was learned about the new substance.

Prof. A. W. Rüchler said that the one certain fact which came out indisputably from the facts described by Prof. Ramsay was, that in spite of the doubt which may have existed on the matter for the last few weeks or months, it was certain that they had now a new constituent of the atmosphere. It seemed to him that one of the most interesting results arrived at from the physical point of view was the fact that the gas was monatomic, arguing from the determination of the specific heats. The experiments carried out by Lord Rayleigh and Prof. Ramsay made it certain that the element had the particular ratio of specific heats mentioned. Well, then the question arose, What followed from this? In order that this ratio might be obtained it was necessary that the atom with which they were dealing should be regarded as spherical. In conclusion, he said that whatever the effect might be upon the great chemical generalisation of Mendeléeff, that was, after all, an empirical law based at present upon no dynamical foundation. If it held in its own right in this case, it would, of course, strengthen the belief in it, but, on the other hand, the law did not stand on the footing of these great mechanical generalisations which could not be upset without upsetting the whole of our fundamental notions of science.

Prof. Roberts Austen remarked that in the Bessemer process alone some ten tons of iron were put into a vessel called a converter. During the conversion no less than 100,000 cubic feet of air passed through the fluid iron. Therefore 1000 cubic feet of argon went somewhere. He had taken Bessemer-blown metal which had not been treated with ferro-manganese, and pumped out forty times its volume of gas, of which one-twentieth was nitrogen. In that nitrogen he had not been able to detect any argon that could not have come from the water which was necessarily used in the manipulation. It remained to be seen whether the argon found its way into the iron, and if it stayed there, whether certain peculiarities that made Bessemer metal different from other kinds of steel could be traced to some of this 1000 cubic feet of argon, which had either passed into the air or into the iron.

Lord Rayleigh, in the course of his remarks, referred to the argument in favour of the monatomicity of the gas. Of course, what was directly proved by the experiment was that the whole, or nearly the whole, of the energy put into the gas, when it was heated, was devoted to increasing the energy of its translatory motion, and that no margin remained over to be attributed to intermolecular or interatomic motion. At first sight it seemed rather a strange thing that there should be no rotation in the molecules of the gas. That condition was met by the suggestion which had been put forward, and which had also been communicated by Prof. Fitzgerald, in the following words: "The reason why the ratio of specific heats of 1.66 is supposed to prove monatomicity in a gas is because in a monatomic

gas there are no internal motions of any consequence. Now, if the atoms in a molecule are so bound together that hardly any internal motions exist, it would, so far as specific heat is concerned, behave like a monatomic element. That the atoms in argon may be very closely connected seems likely from its very great chemical inertness. Hence the conclusion from the ratio of its specific heats may be, not that it is monatomic, but that its atoms are so bound together in its molecule that the molecule behaves as a whole as if it was monatomic." It was difficult to conceive the possibility of such an eccentrically-shaped atom as that to move about without acquiring a considerable energy of rotation. He therefore thought that the only interpretation was that the gas was monatomic.

Lord Kelvin remarked as to the condition under which the ratio of the specific heats could be exactly 1.66, that he did not admit that a spherical atom could fulfil that condition. A spherical atom would not be absolutely smooth. In other words, it must be a Boscovitch point. In fact, the only kind of atom that could be conceived as giving, in the dynamical theory of heat, rigorously the ratio 1.66 for the specific heat, was the ideal Boscovitch mathematical point endowed with the property of inertia, and with the other property of acting upon neighbouring points with a force depending upon distance.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—A meeting was held on Monday last, in the rooms of the Regius Professor of Medicine, at the University Museum, and was attended by all the scientific professors and teachers of the University, with the exception of one or two, who, being unable to be present, expressed their concurrence by letter. It was unanimously resolved that a memorial connecting Sir Henry Acland's name in a permanent manner with the University Museum should be established. Sympathy was generally expressed with the scheme already before the public, but it was felt that a more distinctly personal memorial in the Museum was desirable. The future consideration of the proposal will be the subject of a second meeting to be held shortly.

Mr. A. Trevor Battye delivered a lecture before the Ashmolean Society, on Monday last, entitled "Ice-bound in Kolguev." The lecturer narrated his personal experiences, and gave an account of the manners and customs of the Samoyedi, illustrated by numerous lantern-slides and specimens, and he also described the ornithological features of the island.

The Sibthorpean Professor of Rural Economy, Mr. R. Warrington, F.R.S., gave his inaugural lecture to a large audience in the University Museum on Monday afternoon. The subject chosen was "The Present Relations of Agricultural Art and Natural Science." He deplored the want of really good agricultural and horticultural libraries.

CAMBRIDGE.—The election to the Sadlerian Professorship of Pure Mathematics, vacant by the death of Prof. Cayley, will be held on Monday, February 25, at 2.30 p.m. The names and testimonials of candidates are to be sent to the Vice-Chancellor by Monday, February 18. The electors are the Vice-Chancellor (Mr. Austen Leigh), Dr. Phear, Dr. Ferrers, Dr. Taylor, Sir G. G. Stokes, Sir R. S. Ball, and Prof. G. H. Darwin.

The Observatory Syndicate propose the appointment of a Second Assistant Observer, at a stipend of £100 a year. The appointment will be for five years, and will be made by the Director, with the consent of the Vice-Chancellor.

SCIENTIFIC SERIALS.

American Meteorological Journal, January.—Solar magnetism in meteorology, by Prof. F. H. Bigelow. This article contains some general remarks on the present state of the problems arising out of the relations that have been traced by the author's study of solar magnetism and its influences upon meteorological phenomena. Prof. Bigelow endeavours to show that the usually accepted mode of propagation of energy from the sun to the earth is not the only one that exists, and suggests that another possible mode is due to polarised solar magnetic force, such as surrounds a magnet. The progress of the investigation was made in three distinct stages: (1) the detection of the true period of the sun's rotation; (2) the determination of

the intensity of the solar magnetic field from meridian to meridian of the sun; (3) the discovery of the inversion of the solar magnetism in certain periods. The author expresses the opinion that the convectional hypothesis of cyclones is untenable, and endeavours to show, from an examination of the American meteorological curves for the years 1878-93, that the three systems—the one at the sun, that of the magnetic field in the northern hemisphere, and that of the American meteorological field—vary together in block from year to year.—Variations in the character of the seasons, by H. Gawthrop. The division of the year into four seasons is traditional, but when measured as phases of weather, it is not possible to fix these periods within definite limits. The author's investigation leads him to conclude that the primal cause for the variations in the character of the seasons must be traced back through all the effects of diurnal and seasonal insolation, and of the cyclonic storms in the lower atmosphere.

Wiedemann's Annalen der Physik und Chemie, No. 1, 1895.—Electromagnetic pulling force, by Max Weber. An iron wire whose length is very great in comparison with its thickness, experiences a pulling force proportional to the field intensity, its magnetisation, and its sectional area, when its end lies in a magnetic field, and its axis is parallel to the lines of force. If the lines of force are perpendicular to the axis of the wire, it also experiences a pulling force along its axis, which is, however, smaller in iron than the former force. The ratio of the pull along the lines of force to that across it is about 100 in moderate fields (such as $H = 100$), but with increasing strength of field it quickly decreases, and appears to approach unity.—Different forms of multiple resonance, by V. Bjerknes. The conclusion usually drawn from Sarasin and de la Rive's experiments with electric waves propagated along wires, that there are as many stationary wave systems as nodal systems are exhibited by the resonator, is erroneous. These periods are due to the resonator, which resonates to a simple sine oscillation at different points. The only reliable method is to study the wave systems with "indifferent" indicators, such as spark micrometers, electrometers, bolometers, and small thermo-couples. The difference between electric waves and light waves is that the latter are continually maintained, while the former are damped.—Total reflection of light in dense crystalline substances, by R. Camerer. The measurement of the index of refraction of substances of a crystalline structure by total reflection is attended with various difficulties. In some cases, there is no well-defined limit of total reflection, as in the case of paraffin or beeswax planed or cast on mercury. When the same substances are cast or pressed on the surface of the prism, two limits, polarised at right angles to each other, are observed. The author explains this by supposing that in the latter case the substances crystallise in a uniaxial form, with their optical axes perpendicular to the surface, while in the former case they are biaxial.—Elastic behaviour of zinc at different temperatures, by Erich Zimansky. It appears that the suddenness or otherwise of the cooling of cast zinc has no very decided influence upon its brittleness. It is not hardened by rapid cooling to anything like the extent that iron is.

Bulletin de la Société des Naturalistes de Moscou, 1894, No. 2.—On the Mastodons of Russia, and their relations to the Mastodons of other regions, by Mme. Marie Pavlova, being a summing up of her larger work, now ready for print. Its conclusions are: (1) It is the group *Mastodon Zygodon*, represented by *M. Borsoni*, *M. oblioticus*, and their varieties, which had a very great spreading in south-west Russia during the Miocene and the Pliocene periods. (2) None of these forms is specific to Russia, all having been widely spread in West Europe and North America. (3) The group of *M. Bunolophodon* is only known till now through a very limited number of specimens of *M. arvernensis*, while this group is widely represented in West Europe, Asia, and America. (4) The close resemblance between the Mastodons of Eurasia and America confirms once more the connection which existed between the two continents during the Tertiary period.—The Post-pliocene mammals of East Russia, by Prof. Stuckenberg (in French). They are: *Rhinoceros tichorhinus*, Fischer, and *Rh. Merckii*, Jaeger; *Elasmotherium Fischeri*, Desmarest, which has never been found in Perm, Ufa, Vjatka, Kazan, Nizhni Novgorod, and Simbirsk, but only further south, i.e. in Samara, Penza, and Saratoff; *Equus caballus*, very common—the fossil horses having already been made the subject of special studies by Mme.

Pavlova; *Cervus tarandus*, *C. slophus*, *C. alces* (*Alces palmata*), and *C. megaceros* (*Al. gaceros hibernicus*). Owen; *Antelope saiga*, Pallas; *Bos priscus*, and *Bos primigenius*, the latter very rare; *Ovibos moschatus*, Blainville (*O. fossilis*, Rütimeyer); *Sus*, sp.; *Elephas primigenius*, very common—some molars offering great divergences from the usual type—and another yet undetermined species of *Elephas*, of which one molar is kept in the museum of Kazan; though like as a whole to a mammoth tooth, it has well-defined peculiarities of structure; *Castor fiber*; *Ursus arctos*; and an undetermined species of *Canis*. All these remains have rarely been found *in situ*, but chiefly in remodelled river deposits.—The second part and conclusions of the work of B. Lwoff, on the embryology of mammals. The current theory of gastrulation is shown not to be supported by direct observation, and a new theory is proposed.—On the use of Bouguer's formula in the study of gravitation anomalies, by Prof. Th. Sloudsky (in French).—On some land shells collected by M. Kishtafowitch on the Vorobiev Hill, near Moscow, by Dr. Zickendrah. They belong to species now quite common in Middle Europe (*Hyalinia*, *Heix*, *Cionella*, *Pupa*, *Succinea*, &c.), and originate from the period when the Vorobievo plateau was covered with thick marshy forests; they can by no means be considered as belonging to any ice period.—Entomological and botanical notes from Sarepta, by Alex. Becker (in German).

SOCIETIES AND ACADEMIES.

LONDON.

Geological Society, January 9.—Dr. Henry Woodward, F.R.S., President, in the chair.—The formation of oolite, by E. B. Wethered. In previous communications the author has described pisolites formed by the growth of *Girvanella*, and some true oolitic granules having a like origin. He had previously expressed the opinion that all oolitic granules are of organic origin, and the facts described in the present paper give support to this view. He described the form of the granules, which frequently exhibit a series of concentric layers of calcium carbonate around a nucleus, and also dark striae and patches, the former placed more or less at right-angles to the nucleus. The concentric layers often exhibit an irregularity which the author maintained to be incompatible with their chemical origin. Again, granules are found made of calcium carbonate occurring in two forms—a clear crystalline portion representing the organic structural part, and an amorphous portion consisting of ordinary carbonate of lime, which is either infilling or secreted material, possibly both. In discussing the origin of the crusts around the nuclei the author treated of the radial structure which is so marked a feature in the crust of oolitic granules. This structure has the appearance of light and dark striae when seen by reflected light: the light are tubules which have grown at right-angles to the nucleus, while the dark are secondary formations. He referred to Rothpletz's description of the oolitic granules of the great Salt Lake, which are stated to have originated from the growth of lime-secreting algae, and thinks it possible that the fossil forms are of like origin, though not necessarily due to organisms allied to algae, and possibly even lower in the scale of life. In his opinion *Girvanella*—the first type of oolite-forming organism discovered—is simply a tubule. A long discussion followed the reading of the paper. The President thought that the author had placed evidence before the meeting sufficient to prove the organic origin of many of his oolitic granules. Mr. G. F. Harris believed that while most geologists would possibly agree as to the organic nature of the tubules in the pisolites referred to, they would not be unanimous in recognising the tubular structure in many of the oolitic granules shown. Many of the features presented by oolitic granules, and brought forward by the author as evidence of the organic origin of oolite, could be explained by the alteration effected in them since their original formation. Mr. E. T. Newton agreed with the author that the irregular tubules termed *Girvanella*, and seen sometimes within and sometimes on the outside of oolitic granules, were of organic origin, but he thought that the characteristic concentric and radiated structure of oolitic granules was entirely different, and not due to concentric tubules. Dr. G. J. Hinde did not think that the author was right in his interpretation of the concentric layers so common in ordinary oolitic grains as tubular forms of growth. In his (the speaker's) opinion these concentric lines might indicate

layers of growth, but they were not in any sense tubules. Mr. A. C. Seward expressed himself in agreement with the main contention in reference to the occurrence of organic tubular structures in the oolitic grains described by the author; but the explanation offered by the author with regard to the radiating structure seen in certain grains he regarded as unsatisfactory, their general appearance being much more suggestive of secondary changes in the oolitic grains, which had no direct connection with the *Girvanella*-tubules. Prof. Judd said that as far back as 1862 the eminent botanist Dr. Ferdinand Cohn had pointed out the important part played by algæ in the formation of the Sprudelstein of Carlsbad and other calcareous rocks. At a later date Bornet, the eminent French algologist, had insisted no less strongly on the work done in perforation and breaking-up calcareous fragments by other plants. The speaker was inclined to regard some of the structures (especially certain of the radial ones) as due to the action of destructive rather than to constructive organisms. Mr. H. B. Woodward referred to the modern formation of oolitic-grains in waters charged with bicarbonate of lime, whether in proximity to calcareous springs or coral reefs. He thought that the slides exhibited by the author did not show connection between the *Girvanella* and the concentric and radiate bands of oolitic-grains. Prof. Seeley believed that some of the photographs exhibited a structure which, although imperfectly preserved, might be compared with the sections of nullipores which the speaker brought before the British Association at Bath in 1888, as evidence that some grains of oolite are of organic origin. Mr. Rutley said that, with regard to the nuclear portions of some of the sections projected upon the screen, he considered that the author was probably correct in ascribing an organic origin to the interlacing tubular structures; but, so far as the peripheral portion of the oolitic bodies was concerned, he believed that it presented no appreciable difference from that of ordinary calcareous concretions of a purely inorganic origin: similar radiating and concentric structures being also met with in the sphaerulites frequently present in eruptive rocks. Prof. A. H. Green also spoke; and the author replied.—On the Lias Ironstone around Banbury, by Edwin A. Walford. The ferruginous limestone of the Middle Lias of the Banbury district occurs practically within a ten-mile circle around Banbury. The stone (the Marlstone of the Geological Survey) is an "oolitic" cyprid-limestone with much molluscan and crinoidal débris and some quartz-grains. The author described the lithological characters of the rock, and their variations, as traced laterally and vertically, giving a full description of its local development, with a detailed account of the sections in the principal exposures.—Notes on the geology and mineral resources of Anatolia (Asia Minor), by W. F. Wilkinson. The route traversed from northwards to southwards through the city of Broussa lay through a country composed of sedimentary rocks (largely limestones with some shales and conglomerates). In the mountains metamorphic rocks were met with, and also igneous rocks. The principal igneous rocks noticed are granites and serpentines; in the latter chrome iron-ore occurs, and is worked.

Physical Society. January 25.—Mr. Medley concluded the reading of a paper, by Prof. Ayrton and himself, on tests of glow-lamps, which was commenced at a former meeting. With the newer lamps employed in these tests, it was found that candle-power, current, and candles per watt, all rose as the lives of the lamps increased. The authors, being surprised at this result, took care to satisfy themselves that the effect observed was due neither to change in the resistance of their manganin potentiometer strip, nor to uncertainty of contact at the sockets of the lamps. Starting again with new lamps, they found that in all cases the light given out was greater after the lamps had been glowing for some time than it was when they were new. In the earlier tests a considerable falling off in candle-power had always taken place after the lamps had been running for some time. Further, while the globes of the earlier lamps were always much blackened, even after a run of a few hundred hours, and so became comparatively useless long before the filament broke, the Edison-Swan lamps now examined showed hardly any blackening, even when the filaments lasted over 1300 hours. The rise in candle-power was always accompanied by a rise in current, which was, however, proportionally much smaller, so that the consumption of power per candle was actually less after the lamp had been running fifty hours than it was at the beginning. Among the conclusions drawn by the

authors were the following: (a) When a group of Edison-Swan lamps, marked 100-8, are run at 100 volts, and each lamp as its filament breaks is replaced by a new one, it may be expected that the light given out will never subsequently be as small as when all the lamps were new; (b) an Edison-Swan lamp, marked 100-8, when run at 100 volts will give an average illumination of about 10 candles, and will absorb on an average power of about 4.3 watts per candle, so that such a lamp must be regarded as a 43-watt lamp, and not a 30-watt lamp, as is frequently stated; (c) the maximum rise of light recorded during the life of any lamp was 45 per cent.; (d) with lamps of the type examined, there is no point at which it becomes economical to discard a lamp before its filament actually breaks; (e) no marked economy can be gained by overrunning such lamps (*i.e.* by using pressures exceeding 100 volts). Prof. Ayrton mentioned that the improvement in glow-lamps after running for some time had been attributed to an improvement in the vacuum. Experiments made on new and used lamps by means of an induction coil showed that the more a lamp was used the better the vacuum became, but he (Prof. Ayrton), though at first inclined to adopt this explanation, had since found that though in all the lamps examined the progressive improvement of the vacuum was equally marked, the increase in candle-power varied between very wide limits, being very considerable in some lamps, and hardly perceptible in others. Prof. Rücker asked if it made any difference to the life of a lamp whether it were kept running continuously until the fibre broke, or were run for periods of a few hours, alternating with intervals of rest. The latter case would more nearly correspond with the conditions obtaining in practice. Prof. Ayrton replied that the lamps were kept running during the night, and were disconnected during the day.—A paper, by Prof. Anderson and Mr. J. A. McClelland, on the temperature of maximum density of water and its coefficient of expansion in the neighbourhood of this temperature, was read by the secretary, Mr. Elder. The dilatometer method was used, but the bulb of the instrument contained a quantity of mercury, determined by experiment, which for the range of temperature concerned was such as to secure the constancy of the remaining internal volume, occupied by water. The observed changes were thus the real, and not the apparent changes. The bulb was furnished with a graduated tube of small bore, bent twice at right angles, which served at the same time the purpose of a ground-glass stopper. (The joint was made water-tight by a little Canada balsam.) To determine the coefficient of expansion of the glass, the bulb and tube were filled with mercury at 0° C., and heated up to about 9.7° C., the necessary weighings being afterwards performed. The coefficient of expansion of mercury being known, the number of grams of mercury to be kept in the bulb during the experiments on water was calculated. The dilatometer was next filled with (thoroughly boiled) distilled water at about 8° C., the stopper-end of the graduated tube inserted, and the free end dipped under mercury, giving at 4° C. a column of mercury whose changes of level could be observed. A thermometer was placed with its bulb close to the middle part of that of the dilatometer; both being immersed in a water-bath which could be cooled by the addition of ice-cold water, or heated by radiation from surrounding objects. The thermometer used was graduated to tenths of a degree, and was compared with two similarly graduated ones by different makers. The two latter agreed very closely with one another, and one had a Kew certificate showing no error in the readings. Temperatures were written to the fourth decimal place, but accuracy to this extent was not claimed. Three sets of experiments were made, and for each a corresponding curve was drawn. In the first, the water was at atmospheric pressure; in the other two, at 1½ and 2 atmospheres respectively. Corresponding to these three pressures, the temperatures of maximum density found were 4°.1844 C., 4°.1823 C., and 4°.1756 C. The value 4°.1844 C., corresponding to atmospheric pressure, is greater than that generally received. Mr. Rhodes thought that sufficient precaution had not been taken to accurately calibrate the thermometers. He doubted whether temperatures read in the manner described could be relied upon to much less than 0.1. He did not see that any real advantage was gained by having mercury inside the dilatometer to compensate for the expansion of the glass. Mr. W. Watson thought that the mercury within the vessel would cause further uncertainty by tending to produce distortion of the glass. He pointed out

that in the case of water at maximum density, there would be practically no convection currents, so that equalisation of temperature would be very slow. As the bulb used was about 8 cm. in diameter, and all the experiments were made with the temperature rising, he thought that this would account for the high value obtained for the temperature of maximum density. Dr. Burton thought a distinct advantage was gained by compensating for the expansion of the glass. The values obtained in different experiments did not seem to be highly concordant. Prof. Rücker thought that the criticisms which had been passed were, for the most part, just. For such measurements as those recorded, it was not sufficient to know the corrections of the thermometer readings at a few isolated points; the portion of the stem over which the readings were taken must be carefully and minutely calibrated. The Kew certificate not only ignored errors of less than '05° (as mentioned by the author), but it only gave corrections for a small number of temperatures, separated by considerable intervals.

Linnean Society, January 17.—Mr. C. B. Clarke, F.R.S., President, in the chair.—Mr. George Murray exhibited lantern slides representing a new part of *Pachytheca*, consisting of a cup-shaped receptacle in which *Pachytheca* was found by Mr. John Storie, of Cardiff. The walls of the cup are composed of radiating chambers like those of *Acetabularia*, and in the centre there are traces of an axile structure. Mr. Murray considered that this discovery only made the interpretation of the nature of *Pachytheca* more difficult than ever.—Mr. Arthur Lister exhibited and made remarks upon a Landrail (*Crex pratensis*) which had been found, a few days previously, near Axminster, in Devonshire, where it had been killed by coming in contact with telegraph wires. The occurrence in midwinter of a bird which is a summer visitor to this country, seemed to him to be worth notice.—Mr. J. E. Harting exhibited specimens of northern sea-birds which had been driven upon the east coast of England during recent gales; amongst others, the Little Auk (*Mergulus alba*), of which great numbers had come ashore dead, or in an exhausted condition; the Little Gull (*Larus minutus*), obtained at Whitstable on January 5; and an example of Brünnich's Guillemot, *Uria brunnicchii*, Sabine (*Trans. Linn. Soc.* xii. p. 538), a species which, though abundant in Greenland, North-East Iceland, and Spitzbergen, is of such extremely rare occurrence on our coasts, that not more than two or three authenticated instances of its appearance here have been recorded. The specimen exhibited had been forwarded by Mr. W. J. Clarke, of Scarborough, near which sea-port it was shot on December 7, 1894.—A paper was then read by Mr. I. H. Burkill, on variations in the number of stamens and carpels. Of *Stellaria media* about 5700 flowers were examined, showing that towards the end of the life of the plant the number of stamens becomes reduced. *Ranunculus Ficaria* (nearly 800 flowers) showed that towards the end of the flowering period both stamens and carpels become reduced in number without their proportion being changed. Smaller numbers were examined of *Caltha palustris*, *Ranunculus arvensis*, *R. bulbosus*, *Thalictrum flavum*, *Bocconia cordata*, *Prunus Padus*, *Prunus Lauro-cerasus*, *Crataegus Oxyacantha*, *Rosa canina*, *Quercus Ilex*, and *Sagittaria montevidensis*, all of which showed, either in carpels or in stamens, a reduction in number towards the end of the flowering period. Of other influences besides age which affect the number of parts, temperature might be one, but nothing could be safely assumed.—Of a kindred nature was a paper by Mr. A. G. Tansley and Miss E. Dale, on variation in the floral symmetry of *Potentilla Tormentilla*, Necker. This paper, of which Mr. Tansley gave an abstract, was mainly a record of variations tending to alter the normal tetramerous actinomorphic symmetry of this flower. From his observations it appeared that independent variations of the epicalyx is considerable, but is probably mainly due to a tendency of its segments to revert to a primitively double condition. The residual independent variation is small, and roughly equal to that of the calyx and corolla. The number of stamens is more variable, and the carpels extremely so. Correlated variation of all the whorls is frequent, and produces deviating types of symmetry in about 3 per cent. of the flowers examined. The series of groups into which the various deviating types might be said to fall, illustrated the shifting of the centre of variation from the pentamerous type of allied flowers to the tetramerous type of *P. Tormentilla*.—A discussion followed, in which the President, Mr. H. N. Ridley, and others took part, and Mr. Tansley replied to the criticisms offered.

Chemical Society, January 17.—Dr. Armstrong, President, in the chair.—The following papers were read: Octacetylmaltose, by A. R. Ling and J. L. Baker. Herzfeld's description of octacetylmaltose is in many respects erroneous.—Action of diastase on starch, by A. R. Ling and J. L. Baker. The isomaltose obtained by Lintner by the action of diastase on starch is not a pure substance. From the product of hydrolysis of starch paste by diastase, a triosazone was isolated; one of the products of the action is therefore probably a triose $C_{18}H_{32}O_{16}$.—New derivatives from α -dibromocamphor, by M. O. Forster. Fuming nitric acid dissolves α -dibromocamphor with formation of a neutral substance $C_{10}H_{12}Br_2O_2$; this on alkaline reduction yields a monobromo-derivative $C_{10}H_{12}BrO_2$. The latter substance is converted into a nitro-derivative $C_9H_{12}BrNO_3$ by nitric acid.—Acid sulphate of hydroxylamine, by E. Divers. Crystalline hydroxylamine hydrogen sulphate is prepared by acting on hydroxylamine hydrochloride with the calculated quantity of sulphuric acid.—The hypophosphites of mercury and bismuth, by S. Hada. Hypophosphites of the composition $Hg_2H_2PO_2$, Hg_2NO_3 , H_2O and $Bi(H_2PO_2)_3$, H_2O have been prepared.—Kamala, part ii., by A. G. Perkin. The three acids previously obtained by the oxidation of rottlerine are now shown to be ortho- and para-nitrocinnamic acids and paranitrobenzoic acid. From the composition of its metallic derivatives rottlerine would seem to have the composition $C_{35}H_{20}O_7$.COOH; it yields a crystalline substance, rottlerone $C_{25}H_{26}O_6$, when boiled with sodium carbonate.—The action of aqueous potassium cyanide on gold and silver in presence of oxygen, by J. S. Maclaurin. The solution of gold or silver by potassium cyanide solution is dependent on the presence of oxygen, and the rate of solution is proportional to the quantity of oxygen present, and to the coefficient of viscosity of the solution.—The crystalline forms of the two dimethylpimelic acids, by W. J. Pope.—Oxidising action of ammonia solution on some metals, by W. R. Hodgkinson and N. E. Bellairs.—Action of magnesium on some phenylhydrazine compounds, by W. R. Hodgkinson and A. H. Coote. Complicated mixtures of products are obtained on boiling acetyl- or benzoyl-phenylhydrazine with magnesium filings.—Refraction equivalents of the elements and the periodic law, by R. M. Deeley.

PARIS.

Academy of Sciences, January 28.—M. Marey in the chair.—Preparation and properties of boride of iron, by M. Henri Moissan. A boride of iron of the composition FeB is obtained by heating together iron and boron, best in the electric furnace. It forms brilliant grey crystals which remain unaltered in air or dry oxygen. Its density is 7.15 at 18° C. Its chemical behaviour with ordinary reagents is fully described.—On Fourier's problem, by M. E. Le Roy.—On the exact levelling operations recently carried out in Russia, by General Venukoff. In a total of 1090 stations scattered throughout Russia, no altitude was determined greater than 338 metres. The most important result of the survey was the establishment of the identity of level of the Baltic, Black, and Azov Seas.—On the solution of solids in vapours, by M. P. Villard.—Action of an electric current on a number of metallic sulphides in the fused state, by M. Jules Garnier. Sulphur is gradually eliminated from the fused mass out of contact with air, the copper retaining a greater proportion of sulphur than iron and nickel in an ore containing the three sulphides.—On some properties of bismuth sulphide, by M. A. Diite. The production and properties of crystalline bismuth sulphide, made in the wet way, are described. A remarkable double compound with potassium sulphide, $Bi_2S_3 \cdot 4K_2S \cdot 4H_2O$, is obtained in very sharp and brilliant reddish-yellow, transparent rhombohedra from a solution of Bi_2S_3 in potassium sulphide. The crystals cannot be kept in a moist atmosphere, as water readily blackens them.—Influence of the surrounding medium on the transformation of amorphous zinc sulphide, by M. A. Villiers.—On carbonyl chlorobromide and dibromide, by M. A. Besson. The author obtains the substances $COClBr$ and $COBr_2$ by the interaction of $COCl_2$ and BBr_3 . They are both partially decomposed by distillation in air. They are very dilatible by heat, and possess very irritating vapours. In contact with mercury at 100° in sealed tubes they suffer total decomposition, but are only slowly acted on by cold water.—Mixed ether and ammonium derivative of hexamethyl-ramido-triphenylmethane, by M. A. Roessighe.—On acetic ethers from sugars, by M. C. Tanret. The author shows the various reactions given with different classes of sugars by acetic acid in presence of fused sodium acetate and of zinc chloride respectively. He describes three

pentacetyl compounds derived from glucose under the names α , β , and γ pentacetynes.—On hexa-methylene-amine, by M. Delépine. The molecular weight, determined by the cryoscopic method, requires the formula $C_6H_{12}N_4$. This result is fully confirmed by examination of its reactions and by the character of its nitroso-derivatives.—On the seeds of *Coula* from French Congo, by MM. H. Lecomte and A. Hébert. The oil obtained from these seeds appears to consist wholly of triolein.—New facts relating to the mechanism of hyperglycæmia and hypoglycæmia; influence of the nervous system on glucose formation and histolysis, by M. M. Kaufmann. The conclusions are drawn that: (1) in hyperglycæmia, and hence in diabetes, glucose formation and histolytic resorption are active; (2) in hypoglycæmia, glucose formation and histolysis are diminished; (3) section of the medulla near the brachial enlargement modifies the action of the liver; this organ then supplies the blood with less sugar and more glycogen; nutrition is also generally modified, the storage power of the tissues is augmented and their histolytic resorption diminished.—On some points in connection with spermatogenesis in the *Sélaciens*, by M. Armand Sabatier.—On the fixation of *Acéphales* by the byssus, by M. Louis Boutan.—On the attachment of Amœbæ to solid bodies, by M. Félix Le Dantec.—Histological observations on the functional adaptations of the epidermic cell in insects, by M. Joannes Chatin.—On a new practical process for the estimation of calcium carbonate in arable soils, by M. Antoine de Saporta. The estimation is based on the alteration in density of a moderately dilute solution of hydrochloric acid when chlorides are formed from soil constituents and dissolved.—On some Micrococci from the *Stéphanien*, upper coal-measures, by M. B. Renault.—On mildew: its treatment by a new process, "lysolage," by M. Louis Sipière.—The mulberry disease, by M. A. Prunet. The disease described appears to be due to a fungus allied to *Cladochytrium viticolum*. This fungus is named by the author *Cladochytrium Mori*.—Researches on the conditions which have determined the principal characters of the lunar surface, by M. Stanislas Meunier.—On the rôle of our sensations in the perception of mechanical phenomena, by M. P. Clémentitch de Engelmeyer.

DIARY OF SOCIETIES.

LONDON.

THURSDAY, FEBRUARY 7.

ROYAL SOCIETY, at 4.30.—On the Application of the Kinetic Theory to Dense Gases: S. H. Burbury, F.R.S.—On the Abelian System of Differential Equations, and their Rational and Integral Algebraic Integrals, with a Discussion of the Periodicity of Abelian Functions: Rev. W. R. Westropp-Roberts.—The Oscillations of a Rotating Ellipsoidal Shell containing Fluid: S. S. Hough.
LINNEAN SOCIETY, at 8.—The Comparative Morphology of the Galeodidæ: H. M. Bernard.—New Marine Algae from Japan: E. M. Holmes.
SOCIETY OF ANTIQUARIES, at 8.30.
CHEMICAL SOCIETY, at 8.—The Electromotive Force of an Iodine Cell: A. P. Laurie.—The Action of Heat on Ethylic β -amidocrotonate: Dr. Collie.—The Acidimetry of Hydrofluoric Acid: Prof. Haga.
LONDON INSTITUTION, at 6.—The Germination of Barley: A. Gordon Salamon.

FRIDAY, FEBRUARY 8.

ROYAL INSTITUTION, at 9.—The Anti-toxic Serum Treatment of Diphtheria: Dr. G. Sims Woodhead.
PHYSICAL SOCIETY, at 5.—Annual General Meeting.—An Exhibition of Simple Apparatus: W. B. Croft.—On the Tin Chromic Chloride Cell: S. Skinner.
ROYAL ASTRONOMICAL SOCIETY, at 3.—Anniversary Meeting.
INSTITUTION OF CIVIL ENGINEERS, at 8.—The Construction and Maintenance of Roads: Chas. H. Godfrey.
MALACOLOGICAL SOCIETY, at 8.
CLINICAL SOCIETY, at 8.

SATURDAY, FEBRUARY 9.

ROYAL BOTANIC SOCIETY, at 3.45.
SUNDAY, FEBRUARY 10.
SUNDAY LECTURE SOCIETY, at 4.—Deep Sea Explorations in their Geological Bearings: Dr. R. D. Roberts.

MONDAY, FEBRUARY 11.

LONDON INSTITUTION, at 5.—Truth and Falsehood as to Electric Currents in the Body: Prof. Victor Horsley, F.R.S.
ROYAL GEOGRAPHICAL SOCIETY, at 8.30.—North-West British Guiana: G. G. Dixon.—A Journey in German New Guinea: Captain Cayley Webster.
SOCIETY OF ARTS, at 4.—Means for Verifying Ancient Embroideries and Laces: Alan S. Cole.
CAMERA CLUB, at 8.15.—A Simplified and Improved Form of Photographic Lens: H. Dennis Taylor.
ROYAL INSTITUTE OF BRITISH ARCHITECTS, at 8.
MEDICAL SOCIETY, at 8.30.

TUESDAY, FEBRUARY 12.

ROYAL INSTITUTION, at 3.—The Internal Framework of Plants and Animals: Prof. C. Stewart.
INSTITUTION OF CIVIL ENGINEERS, at 8.—Paper to be further discussed: The Mechanical and Electrical Regulation of Steam-Engines: John Richardson.

ANTHROPOLOGICAL INSTITUTE, at 8.30.—The Ethnographic Survey of the United Kingdom: E. W. Brabrook. Prehistoric Remains in Cornwall. Part I.: A. L. Lewis.—On the Northern Settlements of the West Saxons: Dr. John Beddoe, F.R.S.

ROYAL PHOTOGRAPHIC SOCIETY, at 8.—Annual General Meeting.
ROYAL VICTORIA HALL, at 8.—A Visit to Russia: Smith Woodward.
ROYAL HORTICULTURAL SOCIETY, at 3.—Annual General Meeting.
FEDERATED INSTITUTION OF MINING ENGINEERS.—Meeting at Birmingham.

ROYAL ASIATIC SOCIETY, at 3.
ROYAL MEDICAL AND CHIRURGICAL SOCIETY, at 8.30.
ROYAL COLONIAL INSTITUTE, at 8.

WEDNESDAY, FEBRUARY 13.

SOCIETY OF ARTS, at 8.—Light Railways: W. M. Acworth.
SANITARY INSTITUTE, at 8.—Dry Methods of Sanitation: Dr. George Vivian Poore.
PHARMACEUTICAL SOCIETY, at 8.30.

THURSDAY, FEBRUARY 14.

ROYAL SOCIETY, at 4.30.
ROYAL INSTITUTION, at 3.—Meteorites: L. Fletcher, F.R.S.
INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—On Reversible Regenerative Armatures, and Short Air Space Dynamos: W. B. Sayers.
SOCIETY OF ANTIQUARIES, at 8.30.
MATHEMATICAL SOCIETY, at 8.—Notes on the Theory of Groups of Finite Order, III, and IV.: Prof. W. Burnside, F.R.S.

FRIDAY, FEBRUARY 15.

ROYAL INSTITUTION, at 9.—Mountaineering: Clinton T. Dent.
GEOLOGICAL SOCIETY, at 3.—Annual General Meeting.
QUEKETT MICROSCOPICAL CLUB, at 8.—Annual General Meeting.
EPIDEMIOLOGICAL SOCIETY, at 8.—Dr. Atkinson, of Hong Kong.

BOOKS, PAMPHLET, and SERIALS RECEIVED.

BOOKS.—Good Reading about many Books (Unwin).—La Pratique du Teinturier: J. Garçon, tome 1 and 2 (Paris, Gauthier-Villars).—Mussel Culture and the Bath Supply: W. L. Calderwood (Macmillan).—Lehrbuch der Algebra: Prof. H. Weber, Erster Band (Brannschweig, Viewig).—Sea and Land: Prof. N. S. Shaler (Smith, Elder).—Steam and the Marine Steam Engine: J. Yeo (Macmillan).—N. S. W. Report of the Minister of Public Instruction for the Year 1892 (Sydney).—Proceedings of the International Conference on Aerial Navigation held in Chicago, August 1 to 4, 1893 (New York, American Engineer, &c.).—Progress of Science: J. T. Marmery (Chapman and Hall).

PAMPHLET.—Etudes Climatologiques: A. Lancaster (Bruxelles).
SERIALS.—Century Magazine, February (Unwin).—Contemporary Review, February (1-bister).—Asclepiad, No. 42, Vol. xi. (Longmans).—Bulletin de l'Académie Royale des Sciences de Belgique, No. 12, tome 28 (Bruxelles).—Reliquary, &c., January (Bemrose).—National Review, February (Arnold).—Zeitschrift für Physikalische Chemie, xvi, Band, 1 Hef (Leipzig, Engelmann).—Geographical Journal, February (Stanford).

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