axis, decreases from the centre of the field both in the direction of increasing and decreasing pressures. The tenour of these results is an additional indication of the recurrence of a lower critical temperature at which cycles must necessarily vanish. The decrease of the breadth of the cycles in the direction of decreasing pressures suggests the possible occurrence of a point in the region of negative external pressure, so circumstanced that beyond it the substance would solidify at a lower pressure than that at which it fuses. This may be interpreted as follows: the normal type of fusion changes continuously into the ice-type of fusion through a transitional type characterised by the absence of volume lag.

An independent discussion, more searching in character, has quite recently been given by Tammann. Tammann points out that for the normal case of fusion and for increasing pressure, the two determinative factors of the Clapeyron equation—the volumes and latent heat of fusion—will not in general simultaneously become and remain zero. He argues that the volume constant will at the outset decrease with pressure passing through zero to negative values. Hence the curve representing the relation of melting-point to pressure must initially rise to a maximum when the melting-point pressure ratio is zero, and then decrease. Contemporaneously the latent heat of fusion, decreasing continually with pressure, eventually also reaches zero, but at a much later stage than the volume constant. At this stage, therefore, since melting-point and the volume constant now have definite values (the latter negative), the melting-point and pressure ratio is negatively infinite. Hence the curve expressing the relation of melting-point to pressure decreases with increasing pressure from the maximum specified as far as the pressure at which latent heat is zero, and there drops vertically downwards. Thus Tammann's melting-point pressure curve, with its initial and final ordinate in the direction of temperature, maps out a field of pressure and temperature, within which the body is solid. Outside of this region the body is liquid, and cannot by pressure alone be conceivably converted into the solid state. Any thermodynamic change involving a march through the boundary of this region is accompanied by the discontinuity of fusion, of viscosity, &c. A march through the final ordinate (for which latent heat is zero) is probably not accompanied by such discontinuity. For a given temperature there may be two fusion pressures. At a temperature sufficiently below the melting-point, the continued increase of pressure should therefore move the normally fusing body from the solid into the liquid state continuously. This is a somewhat anomalous result of close reasoning; but it must not be forgotten that in the depth of our ignorance of the actual occurrences above several thousand atmospheres, the term anomaly is a misnomer. Indeed, if we regard the melting-pressure curve beyond the stated maximum as characterising the ice-type of fusion (which Tammann does not do), our difficulties would in a measure be reconciled.

Tammann finally points out that the term lower critical temperature is not justified by the character of the phenomenon. Data for melting-point and pressure, due to Damien, seem directly to corroborate the occurrence of zero values in the ratio of melting-point and pressure increments, but Damien's tests are restricted to a pressure interval much too small to be trustworthy. Of the two bodies which have been tested throughout long-pressure intervals, naphthalene shows a linear melting-point and pressure ratio for 2000 atmospheres, while the carbon tetrachloride of Amagat, though initially concave upwards, soon also becomes linear. Clarence King has therefore, in geological considerations, so represented it. To conform with Tammann's inferences the interior of the earth would have to be a fluid.

One point of issue, however, in these cases is clear: at Andrews' critical temperature both the difference of specific volumes and the latent heat of fusion vanish simultaneously wherever observed. Under corresponding conditions of change from liquid to solid, the internal pressures are of tremendously greater value for both states, and the passage of the solid into the liquid molecule may involve an immense transfer of energy without any corresponding change of volume: for the density of the molecule itself eludes observation. The manner of this isothermal change from one state to the next is in all cases along the characteristic doubly inflected contour first pointed out by Thomson for vapours, and since elaborated by Van der Waals, Clausius and others. We may for brevity call this a *volume lag*, and measure it in terms of the pressure or the volume interval subtended. The liquid can exist even above the critical temperature, which would mean that even here pressuremust be reduced below the critical pressure in order to rupture the liquid molecule.

Pronounced as these phenomena are for the change from gas to liquid, they become much more remarkable, indeed often formidable, for the change from liquid to solid. In this case a volume lag subtending more than 100 atmospheres is the rule; in other words, it takes a much greater pressure to solidify a liquid at a given temperature than to liquefy the solid. Among all these cases there is a group of well-known bodies in which, while the solidification pressure is of marked intensity, the isothermal pressure of spontaneous fusion may even be below zero, or be in the region of negative pressure. Take the single example of thymol, among many: this body between zero Centigrade and its melting point at 53°, can be kept in either the solid or the liquid state at pleasure. Given at about 50° in the liquid state it would require more than 2000 atmospheres to solidify it. If solid, it must obviously remain so even if pressure be wholly removed. But thymol may be similarly treated, beginning with the under-cooled liquid state at 28°, *i.e.* 25° below its melting point. Even here at least one thousand atmospheres are needed to condense it (400 have been tried quite ineffectually). Once solid, it would require about 1000 atmospheres of *negative* external pressure again to melt it. In other words, it could not be melted again on the same isothermal.

If we but knew more about the physical constants involved in these transformations, we could predict the results along the lines of J. W. Gibbs's splendid theory of the equilibrium of heterogeneous mixtures; but with the dearth of our concrete knowledge of long range physical phenomena relating to liquids and solids, we must be content with humbler methods.

I have always regarded the significant behaviour, instanced for the case of thymol, as capable of a broad interpretation. Profs. J. J. Thomson and Fitzgerald in the British Isles, and Elihu Thomson in America, have recently sought for atomic dissociation in the electrolysed vacuum of a Crookes' tube. Speaking to the same point, I would venture to assert that we may reasonably look to the volume lag for a rational account of the genesis of atoms. We have already met with two orders of volume lag: the first at the mergence of gas into liquid being usually a few atmospheres in isothermal value; the second at the mergence of liquids into solid, a hundred or even one thousand times as large in isothermal value, and characterised by the fact that, whereas freezing pressures may be enormous, the corresponding isothermal melting pressure may even be markedly negative.

If then we further inquire as to what will happen if we indefinitely compress the solid along a suitable isothermal, I think it is logically presumable that, with the succeeding and profoundly accentuated volume lag, we shall reach the next atom in a scale of increasing atomic weights.

However enormous the condensation pressure for this purpose may be, it is supposable, in the light of the examples already given that, along an accessible isothermal, the disintegrating external pressure of the new atom may be permanently negative. Hence the new atom will persist within the pressure and temperature range available in the laboratory.

But the last stage is virtually identical with the first, or the inherent nature of these changes is periodic. The inference is therefore that, under suitable thermal conditions and continually increasing pressure, the evolution of atoms, of molecules, of changes of physical state, again of atoms and so on indefinitely, are successive stages of periodically recurring volume lag.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

THE Rev. A. M. Fairbairn, Principal of Mansfield College, Oxford, will distribute the prizes to the successful students of St. Thomas's Hospital on Saturday, October 2, at 3 p.m., in the Governors' Hall.

PROF. ROBERT G. AITKEN and Mr. W. H. Wright have been appointed assistant astronomers at the Lick Observatory.

A NEW centre of the London County Council Technical Education Classes will be opened next Monday evening, October 4, at the Charterhouse and Rogers' Memorial Institute, Goswell Road, E.C. The committee of the school announce that workmen's classes in workshop arithmetic, workshop chemistry and physics, workshop drawing and mechanics will be conducted.

THE revised regulations relating to the subjects of examination for degrees in science at the University of London were published a few days ago. The regulations come into force at the beginning of 1899. The subjects for matriculation are Latin, English, mathematics, general elementary science (a new subject), and any one of the following languages or sciences:—Greek; French; German; Sanskrit; Arabic; Elementary Mechanics; Elementary Chemistry; Elementary Sound, Heat, and Light; Elementary Magnetism and Electricity; Elementary Botany. The general elementary science refers to the physical and chemical properties of matter, and the subject will be treated, wherever possible, from an experimental point of view, numerical examples or problems being restricted to very simple calculations. In the intermediate examination in science, candidates will only be required to take up three of the following subjects, viz.: (1) Pure and mixed mathematics; (2) experimental physics; (3) inorganic chemistry; and (4) botany and zoology. It will thus be possible for students of physical science to obtain a pass or take honours without studying the biological subjects; and, on the other hand, biological students will not need to take up mathematics. For the final B.Sc examination, eight subjects are given, and candidates will be examined in any three of them. The subjects are:—Pure mathematics, mixed mathematics, experimental physics, chemistry, botany, zoology, animal physiology, geology, and physical geography. All the syllabuses have been revised, and their general tendency is towards a fuller practical knowledge of the subjects than has hitherto been expected from candidates.

PERHAPS the most critical period in the career of a man of science is when he has completed his college course but has not established himself sufficiently to obtain a post of any value. For the benefit of promising students thus situated, the municipality of Lyons has, it is stated, decided to make some provision. According to the announcement, the municipality proposes to lend to young men on leaving the University the funds necessary "for their first needs," on their simple word of honour to repay the sum advanced as soon as their pecuniary position allows them to do so. The *British Medical Journal*, in referring to this action, says:—A similar humane principle has, indeed long been acted upon by the Union des Anciens Étudiants de l'Université Libre of Brussels, which not only provides bursaries for deserving poor students, but in case of need procures employment for them after graduation, and in some cases a loan to start them in a profession. But this is the work of a private body, and the help that can be given is on a much smaller scale than the Lyons municipality proposes to give. The German Government, in certain cases, allows students to go through the University curriculum without payment of fees on their undertaking to discharge the liability when they are able to do so, and the old University of Paris was sometimes equally accommodating. It is often, however, even more difficult to find a market for academic and professional knowledge than to acquire that knowledge, and it is to such cases that the Lyons municipality proposes to lend the needed helping hand. The Fellowships of the older universities of this country have a distinct use for the same purpose, but they are for the few, and not always for those who most need them, nor perhaps for those who would make the best use of them. The Companies of the City of London seem not infrequently to find it difficult to dispose of their unearned increment in a really useful way. We venture to commend to them the example of the City of Lyons. We also congratulate the University of Lyons on its connection with a Corporation so enlightened and so anxious to further its interests.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, September 20.—M. A. Chatin in the chair.—On the hypocycloid with three inflections, by M. Paul Serret.—On oxycellulose, by M. Léo Vignon. This substance is prepared from cellulose by the action of hydrochloric acid and potassium chlorate, and its composition is expressed by the formula $C_{24}H_{38}.O_{21}$. Its absorptive power for dyes is greater than that of cellulose. Oxycellulose behaves as an aldehyde towards Schiff's reagent.—On retamine, by MM. J. Battandier and Th. Malosse. The combination of this base with hydrobromic, sulphuric, and hydriodic acids have been prepared, the last-named being obtained in fine crystals, $C_{15}H_{26}N_2O.2HI$.—The influence of colouring matters upon the fermentation of highly coloured red wines, by MM. P. Carles and G. Nivière. The incomplete transformation of sugar into alcohol in highly coloured wines is not due to the acidity, but to the antiseptic action of the colouring matter itself.—On the function of *Pseudocommis vitis* (Debray) in two diseases of the vine, by M. E. Roze.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—Quantitative Chemical Analysis: Profs. Clowes and Coleman, 4th edition (Churchill).—City and Guilds of London Institute, Programme of Technological Examinations, Session 1897–98 (Whittaker).—Traité Élémentaire de Mécanique Chimique fondée sur la Thermodynamique: Prof. P. Duhem, Tome 2 (Paris, Hermann).—Glimpses into Plant Life: Mrs. Brightwen (Unwin).—Organic Chemistry for the Laboratory: Prof. W. A. Noyes (Easton, Pa., Chemical Publishing Company).—University College, Bristol, Calendar for the Session 1897–98 (Bristol, Arrowsmith).—Thermo-Geographical Studies: C. L. Madsen (Williams and Norgate).—International Congress on Technical Education. Report of the Proceedings of the Fourteenth Meeting, held in London June 1897 (Trounce).—An Introduction to Geology: Prof. W. B. Scott (Macmillan).—In Northern Spain: Dr. H. Gadow (Black).—Epping Forest: E. N. Buxton, 4th edition (Stanford).—Vorles-ungen über Bakterien: Dr. A. Fischer (Jena, Fischer).—Among British Birds: O. A. J. Lee, Part 6 (Edinburgh, Douglas).—Diagrams illustrating Principles of Mining: F. T. Howard and F. W. Small (Chapman).—Elementary Practical Physiography (Section 1): J. Thornton (Longmans).—First Principles of Electricity and Magnetism: C. H. W. Biggs (Biggs).—University Geological Survey of Kansas, Vol. 2 (Topeka).—British Central Africa: Sir H. H. Johnston (Methuen).—Elementary Geometrical Statics: W. J. Dobbs (Macmillan).—The Story of Germ Life: H. W. Conn (Newnes).—The Mathematical Psychology of Gratry and Boole: M. E. Boole (Sonnenschein).—Deductive Physics: F. J. Rogers (Ithaca, N.Y., Andrus).—Wild Neighbours: Outdoor Studies in the United States: E. Ingersoll (Macmillan).—Lectures on Physiology. 1st Series. On Animal Electricity: Dr. D. J. Waller (Longmans).—Les Choses Naturelles dans Homère: Dr. A. Kums (Anvers, Buschmann).—University College of North Wales, Calendar, 1897–98 (Manchester. J. E. Cornish).

PAMPHLETS.—Glacial Observations in the Umanak District, Greenland: Prof. G. H. Barton (Boston).—Theory of the Motion of the Moon: Dr. E. W. Brown (Royal Astronomical Society).—A Descriptive Catalogue of Useful Fibre Plants of the World: C. R. Dodge (Washington).—South American Trade of Baltimore: Dr. F. R. Rutter (Baltimore).—Some New Orchids from Sikkim: G. King and R. Pantling, Pp. 1 and 2 (Calcutta).—Materials for a Flora of the Malayan Peninsula: Dr. G. King, Nos. 8 and 9 (Calcutta).—Flax-growing: Major Fraser (Cable Company).—Les Forces de la Nature, &c.: T. L. Bienkowski (Léopol).—Kritik der Exakten Forschung, F. Ego (Leiden, Brill).—Reisen in den Mollukken, &c.: Prof. R. Martin, 1ste Liefg. (Leiden, Brill).—Mineral Statistics of the United Kingdom for the Year 1896 (Eyre and Spottiswoode).

SERIALS.—Psychological Review, September (Macmillan).—Journal of the Franklin Institute, September (Philadelphia).—Archives of the Roentgen Ray, July (Rebman).—American Journal of Science, September (New Haven).—Botanische Jahrbucher, Vierundzwanzigster Band, 2 Heft (Leipzig).—Physical Review, May–July (Macmillan).—Himmel und Erde, September (Berlin).—An Account of the Crustacea of Norway: G. O. Sars, Vol. 2, Parts 7 and 8 (Bergen).—L'Anthropologie, July and August (Paris).—Botanische Jahrbücher, Dreiundzwanzigster Band, v. Heft (Leipzig).—Proceedings of the Physical Society of London, September (Taylor).—Economic Journal, September (Macmillan).—Timehri, June (Stanford).—Zoologist, September (West).—Beiträge zur Psychologie und Philosophie, i. Band, 2 Heft (Leipzig).—Annalen der K.K. Universitäts-Sternwarte in Wien, x., xi. and xii. Band (Wien).—American Naturalist, September (Philadelphia).—Longman's Magazine, October (Longmans).—Sunday Magazine, October (Isbister).—Good Words, October (Isbister).—Annales de l'Observatoire Magnétique et Météorologique de l'Université Impériale à Odessa, 1896 (Odessa).—Memoirs and Proceedings of the Manchester Literary and Philosophical Society, Vol. 41, Part 4 (Manchester).—East Asia, No. 2 (Longton, Hughes).

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