a cavernous condition of the Trenton in Ohio, then Dr. Orton's terrace structure of the top of the Trenton becomes of value as indicating slopes in the general plane of the cavernous part of the formation. By this I mean to indicate the probability that the whole formation is not cavernous to an equal extent throughout (from top to bottom), but that certain members of the mass are more soluble than the rest. In Pennsylvania the Trenton itself is not cavernous on a grand scale: our sinking springs are along the outcrop of the passage-beds at the bottom of the Trenton and Bird's-eye and top of the calciferous. The whole formation in front of the Alleghany Mountains is between six and seven thousand feet thick. The uppermost thousand feet is very compact and non-mangesian; the underlying mass is composed of alternate layers of limestone and dolomite, with some low-lying calcareous sandstone groups. Dr. Orton reports the formation in Ohio 'magnesian, of a fair character throughout most of its extent,' but 'somewhat siliceous in some of the drillings.' It will be an important item of investigation, how far the cavernous horizon in Ohio corresponds to that in Pennsylvania, where the formation is ten times as thick as in Ohio. Dr. Orton inadvertently remarks (p. 18) that 'there is no warrant for assuming its universality as a limestone' under the country between middle Ohio and middle Pennsylvania. But I am sure that he will revise the remark when he reflects that a formation which is 'universally limestone' from Tennessee to the Manitoulin Islands in a north and south direction, and is universally limestone along the whole Appalachian belt from Alabama to New York, cannot possibly be any thing else than limestone under the intermediate region of the bituminous coal-measures. If there is any reasoning from the exposed to the concealed in geology, all geologists must feel sure — quite sure — that the lower Silurian formation No. II. must underlie Wheeling and Pittsburgh as a limestone formation, non-magnesian at top, magnesian at middle and bottom, at least two thousand if not three thousand feet thick, and at a depth of, say, ten thousand feet beneath the present surface.

But I have been led on to a much greater length than I expected, by the importance of the subject, to the new gas and oil industry of Ohio. I cannot trespass longer on your space with the obvious applications of what I have adduced above to the vexed questions of local capriciousness, etc., in the new oil and gas field.

J. P. LESLEY.

Philadelphia, Sept. 1.

## The law of volumes in chemistry.

The questions regarding the so-called molecular weights and volumes of liquids and solids, which are now attracting the attention of chemists, can, I think, be better understood if we keep in mind the principles enunciated by the writer in 1853, that "the doctrine of chemical equivalents is that of the equivalency of volumes," and that "the simple relations of volumes which Gay-Lussac pointed out in the chemical changes of gases apply to all liquid and solid species;" so that "the application of the atomic hypothesis to explain the law of definite proportions becomes wholly unnecessary." In further illustration of this view, it was said in 1867 that "the gas or vapor of a volatile body constitutes a species distinct from the same body in a liquid or solid state; and the liquid and solid species themselves often [probably always] constitute two distinct species of different equivalent weights." From this it follows that freezing, melting, and vaporization are chemical changes. The union of many volumes of a vapor or gas in a single volume of a liquid or a solid is a process of chemical combination, while vaporization is chemical decomposition. Such decomposition is either with or without specific difference, and examples of these two modes are seen respectively in heterogeneous dissociation and in integral volatilization, which latter is the breaking-up or dissociation of a polymeric species into simpler forms having the same centesimal composition. Both of these processes are subordinated to the same laws of pressure and temperature, and involve similar thermic changes in the relations of the bodies concerned. In this enlarged conception of the chemical process we find a solution of the problems above named, and an explanation of the distinction which has been made between 'the chemical molecule' and 'the molecule of the physicist.' That the latter has a much less simple constitution than the former, as calculated from the results of chemical analysis and from vapor-density, has been long maintained alike on dynamical and chemical grounds. It is discussed by the writer in 1853 in the essay already quoted, entitled 'The theory of chemical changes and equivalent volumes,'[1] and again in the late paper of Spencer Pickering in the *Chemical news* for November, 1885.

If, then, as maintained by the writer, the law of volumes is universal, and if the production of liquids and solids by the condensation of vapors is a process of chemical union giving rise to polymerids, the equivalent weights of which are as much more elevated as their densities are greater than those of the vapors which combine to form them, the hypothesis of atoms and molecules, as applied to explain the law of definite proportions and the chemical process, is not only unnecessary, but misleading. According to this hypothesis, which supposes molecules to be built up of atoms, and masses of molecules, the different ratios in unlike species between the combining weight of the chemical unit or molecule (as deduced from analysis and from vapor-density; $H = 1.0$) and the specific gravity of the mass are supposed to represent the relative dimensions of the molecule. Hence the values got by dividing these combining weights by the specific gravity have been called 'molecular volumes.' The number of such molecules required to build up a physical molecule of constant volume would, according to this hypothesis, be inversely as their size. If, however, as all the phenomena of chemistry show, the formation of higher and more complex species is by condensation, or, in other words, by identification of volume, and not by juxtaposition, it follows that the so-called molecular volumes are really the numbers representing the relative amount of contraction of the respective substances in passing from the gaseous to the liquid or solid state, and are the reciprocals of the coefficient of condensation of the assumed chemical units. If steam at 100° C. and 760 millimetres pressure, with a formula as deduced from its density of $H_2O$, and a combining weight of 18, is converted into water at the same temperature, 1,628 volumes of it are condensed into a single volume, having a specific gravity of 0.9588, which at 4° C. becomes 1.0000. Water is

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[1] See the author's 'Chemical and geological essays,' pp. 426–437, and, further, *ibid.*, pp. 453–458.

thus 1,628 ($H_2O$); and the weight of its volume at the temperature of formation, as compared with an equal volume of hydrogen gas or of steam, in other words, its equivalent weight, is $1,628 \times 18 = 30,304$, which thus corresponds to a specific gravity of 1.0000; ice, at its temperature of formation, with a specific gravity of 0.9167, being 1,487 ($H_2O$) with an equivalent weight of 26,766. The hydrocarbon, $C_4H_{10} = 58$, condenses to a liquid having, according to Pelouze and Cahours, a specific gravity of 0.600, which corresponds to an equivalent weight; as compared with that of water, of 17,582, or approximately 303 ($C_4H_{10}$), with a calculated specific gravity of 0.5997. The reciprocal of the coefficient of condensation (or so-called molecular volume) of steam is 18, while that of the gaseous hydrocarbon is $600 : 1000 :: 58 : x = 96.66$.

The chemical unit for bodies, which, like these, volatilize integrally, is fixed by the density of their vapors; while for fixed species, like anhydrous oxides and silicates, or for those which by heat undergo heterogeneous dissociation, as for example calcite and hydrous silicates, the unit may be the simplest formula deduced from analysis, or, for greater convenience in calculation in the case of oxides and silicates, may have a value corresponding to $H = 1$, or $O = 8$. The unit for silica thus becomes $SiO_2 \div 4 = 15$; that for alumina, $Al_2O_3 \div 6 = 17$; and that for the magnesian silicate, $SiMg_2O_4 \div 8 = 17.5$. Such unit-weights as these have been employed by the writer in his late essay on 'A natural system in mineralogy,' in the tables of which they are represented by P; while the values got by dividing these numbers by the specific gravity of the species have been designated unit-volumes, and represented by V. The writer of that essay, in deference to the general usage of chemists, therein adopted the received terminology of 'molecular weights' and 'molecular volumes,' and, failing at the time to grasp the full significance of his own earlier teachings as to the universality of the law of volumes, spoke of the so-called molecular weight as an unknown quantity, although in accordance with that principle this molecular weight, or, properly speaking, this equivalent weight, is simply deduced for any body the specific gravity of which is known.

T. STERRY HUNT.

Centre Harbor, N.H., Sept 3.

## The old gorge at Niagara.

The existence of a drift filled channel running from the west side of the whirlpool on the Niagara River, to the wide, open valley of St. David's on the north face of the Silurian escarpment, has been known to geologists ever since the publication of Sir C. Lyell's 'Principles of geology.' It was considered by him as an ancient channel of the river, and it has been so regarded by many geologists ever since. Arguments numerous and of no slight weight can be quoted in favor of this opinion. But of late years it has been somewhat modified, and a disposition has been manifested to regard this drift-filled valley of St. David's as consisting of two smaller valleys, one of which was excavated by a stream flowing into the place of the present whirlpool, and the other into the valley of St. David's. On the latter theory there may be a solid barrier of rock not far underground between the two valleys. In the latter no such bar can exist.

Into the discussion of this subject I will not now enter. It would require more time and space than can be afforded. I desire merely to mention a single fact. In the course of the arguments on this point it has been apparently taken for granted, if not asserted, that no rock can be seen in place along this gorge, but that it is filled deeply with drift almost from end to end. During the recent meeting of the American association I took an opportunity of going up the valley from the whirlpool, and was much surprised to find a ledge of limestone exposed at its bottom about a hundred feet above the river. On both sides it disappeared beneath the talus, but probability indicates its continuance from side to side, especially as a considerable surface is exposed. This point can only be decided by quarrying.

The importance of a bed of limestone so situated, on the discussion of this question, is obvious. It does not seriously affect the latter of the two hypotheses mentioned above, which is, however, beset by other grave difficulties. But in regard to the former it proves, that, if the Niagara River ever passed that way, its bed was far above the present level. No concealed side-channel can be admitted in this case. The space is too small. A line of drill-holes carried along the course of the valley can alone supply the evidence needed for a decision between the two rival theories.

It is scarcely necessary to point out the bearing of this fact on those calculations of the age of the great gorge which assumes that any part of it above the lower rapids was merely cleaned out and not excavated from solid rock since the end of the ice age.

E. W. CLAYPOLE.

## Science for a livelihood.

Some time ago I read in your journal a stirring editorial, calling for young men to devote their energies and life to the cause of science, and deploring the lack of persons who were willing to encounter hard work and poor pay because of love for investigation and study.

Early this summer, after graduating from a first-class scientific school, I made application to four agricultural stations in this and other states for some position, pay no consideration whatever. Having been brought up on a farm, and having a first-rate scientific education, a love of the natural sciences (in which I have done a little practical work), and an excellent physique, I thought myself fitted for investigation in scientific fields, particularly as I love it above all else.

In every case I received answer, 'Places all full.' I have begun to doubt if investigators and workers are needed in the natural or experimental sciences, and think that a poor young man who cannot afford to give money to the work has no call in this field. Am I right? C. B.

Brooklyn, N.Y., Sept. 4.

## Revivification.

In answer to your Paris correspondent, I would say that quite recently, a native of India, after his conversion to Christianity, gave an exhibition and full explanation of the trance, as I am informed by a missionary just returned from that country. Full particulars can be obtained by addressing Rev. S. Knowles, Gonda, Province of Oude, India.

E. T. NELSON.

Ohio Wesleyan university, Sept. 6.