its subordination to more favored branches, it is quite impossible to understand. The Conference of Ten recommended "That physics be pursued the last year of the high school course." That recommendation meets the enthusiastic approval of every physics teacher whose experience is worth considering. The exigencies of the school programme sometimes require that physics be crowded down into the third year, but the instructor in this subject should never cease to protest against any further lowering of the standard by its relegation to the second year. When only a single year is sought for a subject of such transcendent importance, the studies that are crowded to the front for from three to six years should be compelled, in all fairness and reason, to give way, if necessary, at the point where the physics properly belongs. The pupil will then be provided with the requisite knowledge of geometry so essential to the intelligent study of physics, and may be presumed to have that maturity of mind which will enable him to profit by the study.

The limits of this paper do not permit me to enlarge on the method to be pursued in teaching physics. It must suffice to say that the student in the elements needs a text-book of principles for the purpose of securing accuracy and to enable him to dwell long enough on any portion to comprehend it. To the didactic work of the class room should be added the method of the laboratory. Practical work acts like a mordant to fix the color which may otherwise be evanescent. It is the testing machine to determine the strength and toughness of intellectual fibre. It furnishes a scale by which to evaluate acquisitions. It is the method of original investigation applied to the student; he will not discover any new laws of nature, but he will discover his own ignorance and limitations.

HENRY S. CARHART.

*THE TEACHING OF BEGINNING CHEMISTRY.**

THE momentous changes which have been brought about in chemical science within the past two decades are too often lost sight of in teaching the elements of the subject. It is easier to go in the old way, the habit of descriptive chemistry, founded primarily on the atomic hypothesis, is too well established to be suddenly uprooted, and, as a consequence, in America we can see but little progress toward a more rational and scientific means of beginning the study. The reason for this unsatisfactory condition is most probably to be found in the history of the development of science during the present century. Gay-Lussac, Dalton, Berzelius, Davy, Faraday, and the other lesser lights who appeared upon the chemical firmament between the years of 1800 and 1826, were completely engrossed with the discovery of new elements, the determination of chemical equivalents and the relationships between these latter quantities and the atomic weights. It was then that our system of chemical notation originated, and for this, even if his name were not inseparably connected with other lines of advance, we owe a lasting debt of gratitude to Berzelius. Naturally at this time, methods of analysis in inorganic chemistry, both qualitative and quantitative, assumed the greatest importance, for where the composition of so many new minerals remained to be ascertained, and when in each a possible new element might be discovered, such work must necessarily claim the attention of the foremost investigators. Scarcely an appeal was made to turn the science into broader channels, the material side was uppermost, the statics of chemistry was being investigated, and there was no time to think of the nature of chemical changes from any standpoint other than that of the transposition of matter. The

* Delivered before the Dept. Nat. Sci. Instruction, N. E. A., Buffalo, July 10, 1896.

voice of the great Berthollet was, it is true, raised in a demand for the study of the physical aspect of chemical change, while Avogadro explained the meaning of Gay-Lussac's and Dalton's discoveries of the simple relationships between combining gas volumes, but both were unheeded, for the chemical field was not ripe for such development. During the latter part of the life of Berzelius we find such investigators as Wöhler, Liebig and Dumas busily engaged in building a new edifice of structural organic chemistry, and at the same time the tendency showed itself to unduly emphasize the importance of chemical symbols, for the theory of compound radicles with its numerous variations, held most men in its grasp. Chemical bodies were classified according to arbitrarily constructed formulæ, regardless oftentimes of obvious family relationships; theory began to outrank exact observation; and, even with so careful an experimenter as Berzelius, chemical formulation began to distort and replace ascertained facts. This chaos, produced by the clashing of minds, all equally qualified to dictate in the chemical field, was further heightened by the lack of any reliable scientific basis for the determination of atomic weights; there were almost as many systems as there were chemists. It was only after 1850, when Cannizzaro successfully revised Avogadro's hypothesis, when the laws of thermodynamics were established and when the impulse toward a logical system of atomic weights was given, that some advance toward order was made. From this time on, owing to the labors of Kolbe, Williamson, Strecker, Gerhardt, Laurent and finally Kekule, our present views of valence and structural chemistry began to take the place of former confusion. With the advent of the definite theory of quadrivalence of carbon, at first advanced by Kekule simply as a means of classification, a basis for united action was given which was eagerly seized on by all of the workers in the chemical field. Never before had so simple a theory been adopted, and never before had one appeared which so heartily met with the approval of most men. So easily comprehended, indeed, were these views that, as a logical consequence, chemists were carried too far in their enthusiasm; if the tetravalence of carbon was established, why was not a constant valence true of all other elements? Acting on the impulse, the classification into monads, diads and triads, etc., was made, often in utter disregard of easily observed facts. Theories were once more confused with the facts from which they were deduced, and an arbitrary method of chemical teaching, far removed from the basis on which physics rested, was inaugurated. The chemical symbol and chemical equation were given a rank and place far above their merits; and, as a consequence, the scientific axiom that all theoretical deductions must be founded upon carefully observed facts was too frequently lost sight of. Even Mendelejeff and Lothar Meyer, in their Development of Newland's Periodic System, were often tempted to force dogmatic classification upon the chemical world. This tendency in chemical teaching has continued to the present day, and along with it we still have the undue emphasis laid upon analytical chemistry, a remnant of Berzelius's time, although the chemical field has been so widened that many other branches of the science have far outgrown the latter in relative importance.

Taking heed of the errors of the past, it is time to bring the teaching of chemistry to a purely scientific basis of experimental observation, to omit theoretical deductions, especially the atomic theory, until such a time as the pupil has at his disposal sufficient material to give it a definite basis to rest upon.

There are two laws which are fundamental throughout chemistry, the law of definite and the law of multiple proportions. No matter whether or not we hold to the atomic theory, these would remain unalterable and by their existence would inevitably force the science to be a quantitative one. By leaving this basis, or ignoring it, while still keeping the atomic hypothesis in sight, even great chemists have been led to adopt the most impossible theories and to distort the most carefully established facts, as the history of Prout's hypothesis abundantly demonstrates. But, if the foundations of chemistry are quantitative, why not begin the study of it in such a way that this aspect is thoroughly and permanently brought out to the attention of the student? The difficulties in the way are not great; the necessary equipment for the work does not add a large outlay to those expenditures which all properly provided laboratories already have to meet, and in the majority of cases experiments for beginners can be altered from the qualitative to the quantitative ones by the simple graduation of a glass tube. The quantitative neutralization of acids by bases and *vice versa*, easily carried out with accurate results, is especially useful, combining, as it does, both the laws of definite and multiple proportions and the most striking chemical characteristics of two important classes of compounds.

The study of the combining volumes of gases is also simple and necessary as leading up to subsequent important theoretical considerations; only by following a course of accurate work can a proper basis be secured for future generalizations.

The atomic theory has no place in the beginning of the study of chemistry. The reactions which students encounter during the first period are as easily understood without it as with it. Its early use is confusing and pernicious, giving, as it does, a visionary and immaterial basis for the science, which is too apt to cling to the pupil throughout his subsequent course. Our belief in this theory has been brought about by the convergence of a number of lines of investigation which have made use of facts discovered both in physics and in chemistry, and it should be dealt with in this way. If we use it in any other we are bringing ourselves back to the scientific standpoint of Aristotle, whose deductions were subjective and not objective.

Chemical formulæ are, of course, in their present meaning, founded on the atomic theory, and therefore are to be excluded until after the proper work has brought about their logical development. It is not, however, inexpedient to introduce a few symbols which represent not atoms, but equivalent weights which are so related as to be referred to one gram of hydrogen as a unit, for by this means an advantageous conciseness of expression can be obtained. So, to use a concrete example, it can readily be demonstrated that, by the action of certain metals on acids, a definite quantity of hydrogen is substituted by a given weight of each metal, and, if in such an experiment we select the unit weight of hydrogen as a basis of calculation, we have a means at hand of ascertaining the reacting quantities of the substances in question. These relationships are further exemplified by the experiments on neutralization, so that, finally, a few of the simple reactions can be expressed by a system of notation which is founded only on observed facts. In this way a basis is obtained for further enlargement and explanation when the time comes to introduce theoretical deductions, and thus the pupil can be brought to understand the scientific means by which our present system has been brought about. It is too often the case that students who have even had a somewhat extended chemical instruction are only able to present their knowledge in a language of symbols, of the fundamental meaning of which they have no conception. They are chemically helpless if they cannot have pencil and paper and are not allowed to express themselves in the form of chemical equations. It must be confessed that the teachers are more responsible for this state of affairs than the pupils, because in many text-books and laboratory manuals we find, possibly for the sake of a mistaken idea of saving printer's ink and paper, directions, paragraph and chapter headings given in the shape of chemical formulæ to a beginner in the science. The current language was constructed for chemists as well as for other mortals, and I see no reason why we should not express ourselves in its terms. The pupil should be able to tell us what he knows, and he should not be wedded to his writing materials.

One phase of chemical investigation has made such enormous strides of late years that it can no longer be ignored even by beginners in the science. I refer to so-called physical chemistry. From the start the teacher and pupil must recognize that there are two enduring things in the universe—matter and energy—and that but half of the tale has been told, when in studying a chemical change, only the former has been considered. Of course, it is not possible in all cases to consider the latter; none of us are as yet able to do that, no matter how great our experience or how much we have worked in this line; but in the simple reactions which are encountered at the beginning of the course the question of energy changes can be dwelt upon as clearly as the others. Such a line of work requires a certain knowledge of physics, and "as chemistry is a branch of the study of the relations of matter and energy it should be preceded by the more general aspect of this subject which is undertaken by physics. Obviously, owing to the close connection between chemistry and physics it will frequently be required to more clearly outline physical topics in chemical work, and to enable the teacher to make such outlines, a preliminary general knowledge of physics is necessary."* Another topic in physics which must necessarily be introduced before the atomic hypothesis is taken up, is the kinetic gas theory, for a comprehension of which some knowledge of elementary energetics is necessary. It is very easy to make the pupil learn the dogmatic statement that 'in equal volumes of gases, under like conditions of temperature and pressure, there are equal numbers of molecules,' but to make him understand why this fundamental theory is accepted by the scientific world, and what is its bearing on our present system of atomic weights, requires careful reasoning and conscientious teaching, without which the dogma becomes as useless as any other empirical utterance. In short, I would have the pupil's preliminary work, both physical and chemical, so centered around observed facts that he will approach his theoretical conclusions with a mind free from bias, and so logically trained in the successive steps that he may enter upon his more difficult task in a condition to comprehend its full meaning and significance. It is desirable that he should feel the need of some such theory as the atomic theory, before the teacher shows him the way for its development.

Double decomposition and phenomena attendant upon it have lately come to be among the most important topics in physical chemistry. This subject must be introduced in an elementary course, but the present state of the science forbids that it shall be treated from an empirical standpoint in which the most important fact is the obtaining of a precipitate which can be made to serve the purpose of identifying

*Extract from a report made by a committee consisting of Messrs. Noyes, A. Smith and Freer at the conference of chemists of the Northwest at Chicago, January 2, 1896.

some chemical individual. These chemical separations are simply particular cases incidental to certain conditions obtainable in a series of general phenomena, and as such they should be treated. An elementary knowledge of chemical equilibrium, of dissociation in solution, of the separation of ions by the electric current and of the modern views of neutralization, is now as essential to the beginning of chemistry as any of the descriptive portions. Armed with such a knowledge, the pupil can approach many subsequent facts, which were formerly simply memorized, from a reasoning standpoint.

To render such a course of study as I have outlined successful, it is necessary only to take up but a few of the more common elements and compounds, doing the work thoroughly and conscientiously. Important chemical deductions are as well illustrated by a few widely distributed and simple substances, as by many. The time for the study of all of the elements and of their relations in the periodic system is not in the beginning. Such work can only be undertaken in a systematic spirit when the pupil has been taught to reason in the terms of the science. A mass of descriptive detail, no matter how well it is memorized, is not chemical science; the time is passed for that; we are not longer in the age of Berzelius. For the same reason I would leave the subject of valence for a later period. The reasons for its acceptance are many and complicated; they are the result of painstaking work, of much bitter strife and heartburnings, and are too intricate for the beginner. I have much more faith in the pupil who has been trained to accurate observation, who can logically connect what he has seen and who can tell what he knows, than in the one who, by a system of arbitrary instruction, can write down any number of chemical formulæ and equations, founded on a dogmatic and too early discussion of the theories of valence. Are not even the most brilliant investigators in the science in doubt as to its present position and as to its future development?

In conclusion I would like to answer the argument that I know will be brought against me. It will be said that while the outlined course is well adapted for those who wish to make a life study of chemistry, it can scarcely be applied to pupils who will never take any more chemical work than that given in an elementary course. It is absurd to suppose that an elementary course is intended to produce a chemist. The most that can be done is to give the beginner some knowledge of the fundamental principles of the science. Such being the case, how can we best give the pupil the mental discipline incidental to the scientific habit of thought, and at the same time put him in a position to go on with his work in chemistry, should he so elect? Surely not by taking incidental facts from the entire field, by introducing him to theories which he can not comprehend, and by burdening his memory with a mass of material which disgusts him with the science and leaves him helpless for future advancement. We must always take pains, in teaching beginners, to pick out that which is absolutely essential to their comprehension of the science as such, and even if we use only such materials we shall find that the allotted time is more than filled. We must not depart from our ideal of scientific truth to meet a demand which we recognize as not in the interests of the science. By failing to teach the pupil the true elements of chemistry, and by attempting to make the course, as it is termed, 'practical,' we are in reality doing the most impractical thing imaginable, not at all teaching the real science of chemistry, besides stunting the pupil's future scientific growth.

Above all, we should compel our students to observe accurately and never to put their conclusions in their note books, until they can base such conclusions on what they have seen. I have known of teachers who require their students to balance large numbers of equations, outside of the laboratory and according to set rules, and thus entirely subvert the purpose of chemical notation, which is, at its best, but a short means of expressing observed chemical facts, and as such should only be used in the laboratory as a means of describing what the student has actually seen. The former course leads the beginner to the conclusion that chemical reactions must actually take place exactly as the equation demands; the latter teaches him to observe accurately and to express his observations in the terms of the science. Finally, I regard such work as this fitted only for advanced students; the chemical equation has but a small place in the beginning study of chemistry.

PAUL C. FREER.

CURRENT NOTES ON ANTHROPOLOGY.

MYTHS OF THE NORTHWEST COAST.

FOR some years Dr. Franz Boas has been collecting and publishing the myths and stories of the tribes of the northwest coast. In the last number of the *Zeitschrift für Ethnologie* for 1895 he sums up his theories of their development and extension. His conclusions are that the tribes there located not only borrowed from all parts of America, but drew largely for their material from the Old World also.

This conclusion from such an eminent authority will give considerable satisfaction to those who are on the hunt for traces of Asiatic culture in America. Dr. Boas reaches it by counting the number of 'elements' or incidents in a story, and then ascertaining how many of them reappear in a similar story told at a more or less distant point. If the coincidences are many, he considers it proof of borrowing.

There are various objections to this rough and ready method, notably one, to wit: that all 'elements' are not equally valuable for comparison, to which obvious fact he does not appear to attach much weight.

It is curious to note in the same number of the *Zeitschrift* that Frobenius, in discussing the prevalence of vase worship, quite positively condemns the hypothesis which is at the base of Dr. Boas' arguments. Evidently the subject is still an open question.

THE STORY OF 'NUMBER NIP.'

THE story of 'Number Nip,' the tricky wood and mountain sprite, is not unknown to English folklore, but is not prominent in it, and was introduced at a rather recent date from Germany. There, under the name Rübezahl, he figures, especially in the Riesengebirge, as a prominent personage in the tales and superstitions of the population. He has been made the subject of a singularly learned monograph lately by Dr. A. Lincke, of Dresden, who, in an octavo of fifty pages, brings together pretty much everything, at least references to it, that has been written about him.

The general conclusion appears to be that Rübezahl is no more at home in the Giant Mountains than he is in England; that perhaps he is of Slavonic origin, and that his name is a Slavonic word rendered into a German equivalent by that process of popular language which some linguists call 'otosis;' and that in this change of place and name, like many a human analogue, he left his good character behind him. Originally he was probably a divinity of the fields and crops, or vegetation and growth. Or he is a rain and thunder god of the old Germans, to which Dr. Lincke inclines; in either case, once a highly respectable god, and no mere Kobold. The title of Dr. Lincke's paper is 'Die Neuesten Rübezahlforschungen. Ein Blick in die