

the useful arts, and which brings about a better knowledge and appreciation of the life and growth of that planet which we inhabit for a while, and wish to hand on to our descendants as little impaired in vitality and energy as is consistent with the economic use of our own life-interest in it.

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*THE TEACHING OF CHEMISTRY IN GRADED
AND SECONDARY SCHOOLS.**

TEACHERS of science are familiar with the noticeable difference in the attitude of a student when beginning the study of chemistry and when beginning the study of the other sciences. In almost every science but chemistry the student has previously had some familiarity, at least with the material things with which the subject has to deal, while in chemistry the phenomena are all of a decidedly new order. It is hard for a student to become interested in an odorless, tasteless, invisible aggregation of molecules called a 'gas,' while he is immediately interested in the leaf of the botanist, the structure of the frog of the biologist, the mechanical models of the physicist and, indeed, the figures of the geometrician are not without interest when compared with the obscurity of chemical theory.

As a result the teacher of the science other than chemistry has a certain foundation to begin building on. It would, indeed, be an unobserving child who had never perceived leaves, insects and the common mechanical appliances of daily life and consequently had not at least a superficial knowledge of these common objects with which the science deals.

It is undeniably true that the fundamental principles of chemistry are of so

complex a nature as to require a more mature mind for their comprehension, but can not the child be made familiar with some of the simpler chemical actions even without understanding why the exact order of phenomena appears? By so doing the mind would be prepared to consider at a later period of development the more important principles without having to delay till the simpler phenomena became familiar.

It here becomes an important question as to how early in a child's life this training should begin. It has, indeed, been jocularly said that a certain professor of organic chemistry in one of our large colleges provided his babies with a set of blocks after the nature of the Kekulé models of the carbon atom.

When we consider the thousand and one things crowded into the life of the child of to-day one hesitates considerably before suggesting another. There has been, however, of recent years, a strong undercurrent of opinion in favor of nature study. The teacher in the kindergarten and the primary and grammar school, by developing the powers of observation and drawing attention to the workings of the laws of nature, is rendering incalculable assistance in teaching the sciences. Unfortunately, chemistry profits the least by this preliminary training.

It was formerly recognized that the beautiful phenomena attending many chemical actions were unusually attractive to children and, indeed, to adults. This was attested by the popularity of the chemical lecture in lyceums, lecture courses, churches, etc.

If I may be pardoned in introducing a bit of personal experience, my interest in the subject was first awakened by a popular lecture on 'A Basket of Charcoal.' I had never seen chemical phenomena before. It was a complete revelation. Obviously

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at the age of twelve I could not understand the reason for any of the wonderful things shown that night, but in attempting to repeat some of the simpler experiments the question naturally arose, as it will to a majority of boys, *why* did this happen? I have been a good deal surprised, in talking with a large number of chemists, to find their first interest in the subject due in many instances to the quickening influences of an experimental lecture. The atomic theory and the theory of valence are not attractive things to the beginner, certainly not to the beginner who is not familiar with some of the facts leading to the adoption of these theories, but the beautiful phenomena of the experimental lecture naturally arouse an interest in chemistry as the beautiful flower awakens an interest in botany.

Some have contended that an interest thus awakened is liable to be of too evanescent a nature; it is wrongly founded; chemistry is like a toy or glittering spectacle soon to be forgotten. I doubt this and firmly believe that in some way or other the child should have the opportunity of seeing these phenomena, if only as a source of pleasure. No harm can be done, the idea suggested by the word chemistry can not be lowered, all the phenomena are of an elevating nature and, granted that only entertainment is obtained, it is a wholesome source of amusement.

If we take this ground, obviously the age at which the phenomena of chemistry can profitably be presented to the child is determined only by his degree of intelligence and ability to perceive. The child a few months old may not appreciate or even observe a brilliantly lighted Christmas tree, while a few months later it might be a source of great delight to him. The pupils in a kindergarten would certainly appreciate a few simple chemical experi-

ments. The grammar school lower grades would of course more fully develop the idea that it was something more than fireworks, while in the higher grades the subject might properly be introduced under the name of chemistry and the pupils themselves could be intrusted with the performance of a few simple experiments. The difficulty of showing chemical experiments is more fancied than real, for with the simplest apparatus, such as glass tumblers, many of the striking color changes may be shown, while the chemicals necessary may be selected so as to be readily obtainable; vinegar, chalk, marble, soda, the common acids, coloring matter of red cabbage, etc., are all such materials. Some dealers put up little packages containing chemicals and apparatus for performing simple experiments at a very small cost. These sets are advertised in the cheap papers throughout the country.

While thus we see that the actual experiment is within the reach of all, there is a very good book written in the conversational style which furnishes to many young people fascinating reading. I refer to the book written by Mrs. Lucy Rider Meyer entitled 'Fairy Land of Chemistry.' No one who picks up this entertaining little book can fail to be impressed with the ingenuity of the writer as well as with the scientific accuracy of the material. In this selection, a fair sample of the general style of the book, two children are in their uncle's laboratory and are looking at a jar of chlorine.

"Where did you get it, Uncle?" asked she.

"Out of salt," replied the Professor.

"Why, Uncle! do you really mean that that green smoke came out of salt—the salt that we eat?"

Professor James looked at his niece with a queer little twinkle in his eyes.

"What do you think about fairies?" asked he.

"Oh! fairies are splendid," answered Jessie, wondering what fairies had to do with salt.

"But they are not real folks, you know. I wish they were."

"Well," said her uncle, "that gas is nothing more nor less than a collection of real fairies with green dresses on."

Jessie opened her eyes very wide toward the green jar. * * *

"Do they have real legs and arms?" asked she, looking curiously at the green gas.

"They certainly have arms—or rather an arm, for this kind has only one. And I suppose they have legs, for they run around briskly enough sometimes."

"What are their names?" asked Jessie.

"There are so many of them, and they are so small and so much alike, that no mortal has ever been able to get acquainted with them separately. But the wise men who first found out about them, named the whole tribe Chlorine, from the color of the dresses which they wear. Chlorine is taken from a Greek word which means green. But this is only one tribe. There are sixty or seventy others—all different, and all having different names."

"Do they all dress alike?" asked Jessie.

"Each tribe has its own uniform, which is usually the same, but you can find almost every color among different tribes. One tribe—a first cousin to Chlorine—always wears a dark red dress, and there are several that have a wonderful magic cloak that makes them quite invisible."

While this may not be the deepest kind of scientific literature, we must allow that if our children are to listen to fairy stories these are good ones.

It is interesting to note at this point that the conversational style adopted in this book was used very satisfactorily one hundred years ago for books written for children of larger growth. In 1806 Jane Marcet published a book entitled 'Conversations on Chemistry.' A note beneath the catalogue title of this book in H. Carrington Bolton's 'Bibliography of Chemistry' reads: 'This work passed through more than twenty editions, having a success now difficult to comprehend.' The writer, the preface tells us, is an admirer of Sir Humphry Davy, and has attended his lectures at the Royal Institution. The

conversation is supposed to take place between a Mrs. B., who is a teacher, and two young ladies. The following selection is characteristic.

Emily. "And how do you obtain the oxy-muriatic acid?"

Mrs. B. "In various ways; but it may be most conveniently obtained by distilling liquid muriatic acid over oxyd of manganese, which supplies the acid with the additional oxygen. One part of the acid being put into a retort, with two parts of the oxyd of manganese, and the heat of a lamp applied, the gas is soon disengaged, and may be received over water, as it is but sparingly absorbed by it. I have collected some in this jar."

Caroline. "It is not invisible like the generality of gases; for it is of a yellowish color."

Mrs. B. "The muriatic acid extinguishes flame, whilst, on the contrary, the oxy-muriatic makes the flame larger, and gives it a dark red color. Can you account for this difference in the two acids?"

Emily. "Yes, I think so; the muriatic acid will not supply the flame with the oxygen necessary for its support; but when this acid is further oxygenated, it will part with its additional quantity of oxygen and in this way support combustion."

Mrs. B. "This is exactly the case; indeed the oxygen added to the muriatic acid adheres so slightly to it that it is separated by mere exposure to the sun's rays. This acid is decomposed also by combustible bodies many of which it burns, and actually inflames, without any previous increase of temperature."

Caroline. "That is extraordinary indeed. I hope you mean to indulge us with some of these experiments?"

Mrs. B. "I have prepared several glass jars of oxy-muriatic acid gas for that purpose. In the first we shall introduce some Dutch gold leaf.—Do you observe that it takes fire?"

The interest aroused in the subject by this little book can be explained, it seems to me, by the nature of the description. There is a vividness to it that a bald statement of fact lacks. The personal element is strong and the minds of at least three persons all considering the same question are reflected in the pages of the book.

It is true, however, that the descriptions are in general much more philosophical and mature than those in a book suitable for children could be, and yet is there not a noteworthy suggestion in the remarkable success of this book? If the conversational style appeals to elders, all the more would it be sure to appeal to the child.

It would seem as if a book might be written adopting this style and treating the subject in a manner suitable for children of the grammar school grade. Bearing in mind that the object of grammar school chemistry is only to familiarize the pupil with chemical phenomena and not to attempt to explain and thus confuse the mind with chemical theories, there seems to be no reason why an interest in things chemical can not legitimately be developed.

In the high school the treatment chemistry should receive is naturally somewhat different. The nature of the phenomena, including perhaps some simple quantitative relations, may properly be studied, the main objects to be gained being: first, increased powers of observation and, second, an accumulation of chemical facts regarding the more common elements and their compounds and a few fundamental laws, especially those of quantity.

To bring the science into closer touch with common life Lassar-Cohn's admirable book, 'Chemistry in Daily Life,' may profitably be read and studied. This plan eliminates practically all chemical theory from a high school course.

It will doubtless be considered heresy to dignify instruction of this nature by the name of chemistry. Should it be said that a student has studied *chemistry* without having had some drill in chemical theory?

It is true that the algebraic expression of a chemical action in the form of an equation may perhaps be used and the idea of symbols elaborated somewhat. Is it best

to go much farther? How many pupils in our secondary schools have any conception of chemical theory six months after they have been through the usual course in chemistry? It is the common experience of examiners of candidates for admission to college that the three months intervening between the termination of a high school course and the fall examinations in chemistry for admission to college seem almost entirely to obliterate the slight knowledge of chemical theory possessed by the pupil. Of all chemical knowledge theory goes out of the mind first, chemical facts next and descriptions of apparatus last. It has frequently been my experience that if, for example, a candidate for admission to college is asked how he made oxygen, he invariably starts with the test-tube, cork, delivery-tube, glass bottle and pan of water. Generally at this stage there is a long pause with the chances greatly against his remembering what material was used, and it is seldom that any intelligent grasp of the fundamental principles involved in the chemical action is exhibited.

It seems to me that this condition needs remedial action. The pernicious custom of using stereotyped schemes for records in note books is, I think, one great cause for this unsatisfactory state of affairs. Mechanically entering records under operation, observation and conclusion headings invariably results in an elaborate and needlessly painstaking description of the generally simple apparatus; a less thorough, if anything, too elaborate description of the changes in physical appearance of the materials used and a meager, oftentimes wholly inaccurate, deduction. The result is that what is seen by the eyes and described in detail, *i. e.*, the apparatus and physical characteristics of the material, is longest retained in the memory.

It is in just this point that laboratory in-

struction fails. Students never grasp the idea that the apparatus and the manipulation are simply a means to the end. On the other hand, the skillful lecturer can perform the same experiment, direct the attention to the important phenomena, reiterate the principles involved and leave an impression much less confused and more evenly balanced between the three parts, operation, observation and conclusion.

For grammar school pupils only such record of work as will instil habits of care and accuracy need be demanded. A sketch (no matter how rough) will tell more than pages of description. A word or two may be added to the sketch by way of rendering obscure parts clear, but no further description of apparatus should be encouraged. What is seen may properly be told in a simple, natural way with no attempt on the teacher's part to guide the line of thought. After the book is examined the teacher may then properly designate the non-essentials and emphasize the characteristic changes of substance in the action under consideration. To distinguish between essential and non-essential phenomena is one of the greatest difficulties experienced by the beginner. Conclusions must of necessity be of the most obvious kind with such elementary pupils and no theory should be called for.

In high schools, the pupils being of more mature mind, the record of work should be more carefully supervised. The sketch should still be insisted upon and the actual written description cut down to a minimum. The observations should be given in a natural way with continual caution against undue attention to insignificant details. The phenomena illustrated by experiments performed at this stage of the pupil's chemical education are in general very simple and do not require the eyes of a trained observer. It may be objected

that since one feature of chemical training is to train the powers of observation, nothing should be done to designate as insignificant or unimportant any observations properly made. This too is a question that has not been settled satisfactorily to all, but when a student persists in burdening the mind with a lot of unimportant observations at the expense of the fundamental principles, the desirability of eliminating the non-essential is apparent.

Training in the description of an experiment by first stating the principle involved is to my mind the only proper course. When once this is firmly established in the mind and the object of the experiment is clear, the mere recording of manipulation becomes a matter of secondary consideration. Mechanical methods of recording surely are to be avoided.

If, however, this schematic method is retained in the study of qualitative analysis, the reason for its elimination in elementary work may to some seem obscure. The warmest advocates of this system of notation in qualitative analysis must recognize the marked difference in the two cases when it is pointed out that in the elementary laboratory the operations are of widely dissimilar nature and would demand greater breadth of description, while in qualitative analysis the operations are essentially alike.

It can be seen at once that a course in chemistry such as is here proposed would not be in accord with the methods of several hundred text-books written for academies and high schools. The incompatibility would be most noticeable with those consisting in whole or in part of qualitative analysis. Fortunately there are but few treating wholly of qualitative analysis. Of the other class there is unfortunately a yearly increasing number. However, the introduction of qualitative analysis into

secondary schools has but few ardent supporters.

In teaching chemistry in graded and secondary schools would it not be more profitable to spend the time in the laboratory on pure descriptive chemistry, and could not the time spent on abstract chemical theory more profitably be spent emphasizing the relations expressed in the phrase 'The Chemistry of Daily Life'?

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SCIENTIFIC BOOKS.

Chemical Analyses of Igneous Rocks Published from 1884 to 1900, with a critical discussion of the character and use of analyses. By HENRY STEPHENS WASHINGTON. United States Geological Survey, Professional Paper No. 14. Washington, Government Printing Office. 1903. Pp. 495.

In the first two or three decades of the last century, rocks, in contradistinction to the individually well-defined minerals, were regarded merely as aggregates of minerals in presumably fortuitous combinations and lacking in that definiteness or constancy of composition which would justify their study as a whole. As time went on, however, the chemical aspect of petrography gradually attracted more attention, its great importance being first clearly recognized by Abrieh, who in 1841 pointed out the necessity for a knowledge of the chemical composition of rocks in dealing with the problems of their origin and mutual relations as well as for their satisfactory classification and proper nomenclature.

Bunsen's well-known hypothesis that all igneous rocks might be considered as mixtures in various proportions of two supposed original or normal magmas—the trachytic and the pyroxenic—gave a marked stimulus to the study of their chemical composition. But with the abandonment of this view, which broke down under the weight of the evidence accumulated to test it and with the introduction of the microscope as a means of petrographical study in the early seventies, anal-

yses lost much of their interest, being, as Dr. Washington observes, 'inserted perfunctorily in petrographical writings, in obedience to custom, as ornamental embellishments, while the chief efforts of the petrographer were devoted to the elucidation of the purely mineralogical and textural characters of the rocks described.'

During the past ten years, however, the chemical composition of rocks has again attracted much attention—more especially on account of its important bearing on the theoretical side of petrography—the crystallographic and optical properties of the constituent minerals and the details of structure no longer being the only subjects of investigation. The chemical composition of an igneous rock is now recognized as distinctly the most important fact which can be learned concerning it, and the one which is of the greatest value in dealing with the great questions of origin and genetic relations, as well as affording the most reliable basis for classification.

For the study of the chemical composition of rocks, the tables of analyses collected by Roth and which were issued at intervals from 1861 to 1884, have up to the present been the great storehouse of information. They present in tabular form and with certain critical notes practically all the rock analyses which had been published up to the year 1884. Since this latter year, however, a great number of analyses have appeared, in widely scattered journals, proceedings and reports, showing a marked improvement in quality as compared with the old analyses.

In the present volume Dr. Washington has collected all the analyses which have been published during the seventeen years from 1883 to 1900, and has presented them excellently arranged according to the quantitative system of classification recently proposed by him in conjunction with Iddings, Pirsson and Cross, together with full references and with critical notes when required, the whole being introduced by an admirable series of chapters dealing with the character of rock analyses and their bearing on rock classification. The vol-