

ing them of mental self-reliance and the power to weigh evidence and think clearly.

Unless a change be made, chemistry will surely earn a place among that group of pedagogic processes which Huxley strove so hard to have displaced, and which he characterized as the direct and preventible cause of most of the world's stupidity.

W. LASH MILLER

THE GENERAL ESSENTIALS IN TEACHING QUALITATIVE ANALYSIS

THE growing tendency to give more heed to the methods of teaching the natural sciences in the colleges has called forth the following generalizations regarding the second course in chemistry. The pedagogical aspects of the first course have been ably discussed by many teachers. The abundance of text-books on the second course, qualitative analysis, seems to indicate that every teacher follows his own notions and that no book is very generally satisfactory, all of which is unfortunate and perhaps unnecessary. There are, however, certain principles that seem to be regarded as essential by the majority of thoughtful teachers and an effort to present these principles appears to be worth while.

The main essential in conducting this course is to *teach qualitative analysis*. It is valuable and interesting on the side to learn many reactions, but only those reactions which are concerned in separations and identifications can be considered essential to the object in view. The study of other reactions is a study of general chemistry.

Opinions differ as to what introductory tests should be made by the beginner, but the above principle is successfully carried out when each individual substance (ion) is first subjected alone to the same reactions which it will undergo when present in a miscellaneous mixture under analysis. Such a parallel study of the members of a group will reveal to the intelligent student the possibilities of separation.

Secondly, *the procedure must be definite and explicitly stated*. Recent experimental

studies in testing qualitative methods, particularly those of A. A. Noyes and assistants, have shown that the conditions of successful work must be carefully studied out for each step. Separations are very largely based on solubility differences, which is a quantitative matter; the directions must be devised with this in view and must be full enough to leave no room for doubt in the average mind.

Accordingly, it is essential, in the third place, that *the printed procedure be conscientiously followed in detail*. If varying conditions make it necessary to add more or less of a reagent in certain cases, the procedure should give information; but when a procedure has been worked out on the basis of elaborate qualitative and quantitative tests, as have some of our modern procedures, a pupil can not expect to get reliable results, if he follows his own untutored discretion. Analyzing from a memorized procedure is indeed likely to be a dangerous undertaking, since the memories of most young chemists will be liable to lead them astray as to the proper proportions or even the proper reagents. It is not to be understood that the procedure should be blindly followed, *e. g.*, with a false conscientiousness that would lead the worker to filter a solution when no precipitate was formed, but that those operations which are done should be conducted as directed.

In order that the pupil may be able to reproduce the proper experimental conditions for the tests, the pupil must be so carefully trained in the art and language of manipulation that he will have no difficulty in conducting the operations as the author intended.

A fourth essential is to *teach the bases of separation*. This is one of the most important and difficult tasks of the teacher, for much of the logic of the course is herein involved. By bases of separation are meant the differences in the physical and chemical behavior of substances which are utilized for the purpose of separation. These are the real "foundations of analytical chemistry." They should be clearly presented in the lec-

tures and must be elucidated and vigorously emphasized by the laboratory teacher.

It is in this connection that Dr. Benner's recent suggestion¹ is particularly valuable, viz., that the pupil should keep his test-tubes with their tests until the instructor can inspect them. If parallel tests are applied to the individual members of a group (which will be the case, if the preliminary drill consists as stated by the present writer in the third paragraph), the bases of separation can be pointed out on the test-tube rack. If the results of the tests are not preserved, the quizzing instructor must make use of the notes on these experiments or the pupil's memory of the results.

Many teachers think highly of the inductive method as a means of imparting an understanding of the bases of separation. The most consistent and extensive use of this method known to the writer was made in the University of Nebraska by Professor John White.² After the pupil has made a parallel study of the members of a group as to their behavior toward a series of reagents he is required to devise the procedure for himself. The principal merit of the plan is that it makes mechanical work impossible and teaches clearly the bases of separation. It needs to be closely supervised and the average instructor would regard it as too slow; moreover, the procedure devised by the best pupils must be discarded for the more perfectly developed procedure of the high-class modern manuals. The writer uses this inductive plan only in connection with the first group studied (silver group).

Fifthly, we must *teach the chemistry* (and some physics) *of the tests*. A recent canvass³ has shown that many consider qualitative analysis invaluable as an agency for developing the pupil's knowledge of chemistry. Whether or not we wish to utilize qualitative analysis for this purpose, the knowledge of the chemical and some other phenomena involved in the tests is essential to an under-

standing of qualitative analysis. The pupil himself recognizes this as an attribute of a good course and he fully appreciates it when he finds himself learning his chemistry from experimental observation instead of from the book, much more truly than in general inorganic chemistry. The chemistry of the tests deservedly engages much of the teacher's attention during the major part of the course.

A sixth essential is to *cultivate self-reliance* from the start. The teacher and the procedure are not mated if the pupil is allowed to think that the procedure has many loopholes or pitfalls whereby the learner may be deceived. If the general procedure is really weak at any point, a supplemental note should appear in the procedure, dealing with the possible difficulties. Furthermore, the pupil must be encouraged to rely on careful work and to defend it against the teacher's suspicions. It may even be justifiable to approve a presumably incorrect report on a minor constituent rather than let a conscientious student have his faith in his work undermined, but the need of taking this measure should seldom arise. Recording the report of an unknown in ink in the note-book is a splendid means of developing reliable work. The pupil will seek to clear up all doubts before he commits himself to an unerasable report.

Self-reliant work by the pupil is quickly discouraged by any knowledge or suspicion that the instructor is guessing at the composition of an unknown. He must know exactly what the pupil ought to find, which means that the instructor's, or standardizing, analysis should be made by the same procedure as the pupil follows, since more delicate tests would sometimes give a positive result not yielded by another test. Any one who is familiar with qualitative laboratories must realize that in precision of instruction they average far behind the mathematics class-rooms or physical laboratories.

In the seventh place, *the pupil must be trained in the proper handling of a miscellaneous concrete substance* involving difficulties of dissolving and of detecting major and minor constituents. This is dealt with in the

¹ SCIENCE, N. S., XXXIII., 778.

² Compare White's "Exercises in Qualitative Analysis," Holt & Co., New York.

³ J. Am. Chem. Soc., XXXIII., 630.

writer's paper on "The Acquirement of Proficiency in Qualitative Analysis,"⁴ which is based on letters from many teachers of qualitative analysis and leads to the conclusion that the intelligent handling of a miscellaneous qualitative analysis can best be taught in a subsequent course accompanying or following the course in advanced quantitative analysis.

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SURVEYS IN ALASKA

FOURTEEN parties of the Geological Survey, including about 50 men, are at work surveying and studying the mineral resources of Alaska. These parties are widely scattered over the territory and are doing work of many different classes.

One party is engaged in exploring Noatak River, in northwestern Alaska, north of the Arctic circle. This party, which is under the leadership of Geologist P. S. Smith, with C. E. Griffin as topographer, will make its way up Alanta River with canoes and hopes to find near the head of the river a pass across to the head of the Noatak and to descend that river to the Arctic Ocean at Kotzebue Sound. The region which will be traversed is unsurveyed and much of it is almost unknown.

A. G. Maddren is studying the geology and mineral resources of the extreme northeastern part of Alaska, north of Porcupine River. He is working in conjunction with a survey party of the International Boundary Commission.

Investigations of the water available for placer mining in the several camps of the Yukon-Tanana region, begun four years ago, are being continued this year. C. E. Ellsworth is engaged in this work in the Fairbanks and Birch Creek districts and E. A. Porter in the Fortymile district. These engineers made their way inland in the early part of April and began work as soon as the ice broke in the streams.

Two parties are continuing the reconnaissance mapping and study of the mineral re-

sources of the Yukon-Tanana mining districts. One of them, which is under the charge of L. M. Prindle, assisted by J. B. Mertie, Jr., is working in the area known as the Circle quadrangle, which lies between parallels 64 and 66 and meridians 142 and 146. The other party, led by H. M. Eakin is in the Rampart quadrangle, an area covering about a degree of latitude between meridians 150 and 154. The preliminary mapping of these quadrangles, which include some placer districts, should be completed this year.

The region tributary to the Pacific seaboard of Alaska is the one which is now attracting most attention, because its mineral resources are being made available by railways. For this reason the surveys and investigations of this part of the territory are being energetically pushed by the Geological Survey. The province includes fields of high-grade coal and also copper and gold deposits, besides considerable arable land.

Two parties are at work extending the surveys in the southern part of the Copper River region, including the Hanagita Valley and the Bremner River basin. One of them, under D. C. Witherspoon, is making topographic surveys; the other, under F. H. Moffit, assisted by Theodore Chapin, is making geologic surveys and studying mineral resources.

A topographic base map of the Valdez Inlet mining district has been completed by J. W. Bagley. Mr. Bagley began work in April and continued until the middle of July, when he transferred his party to Kenai Peninsula and began a survey of the Moose Pass mining district. After completing this work he will begin the mapping of the Sunrise placer district.

R. H. Sargent, with a party of five men, landed at Kachemak Bay about June 1 and began mapping the western part of Kenai Peninsula.

G. C. Martin is engaged in studying the coal resources of the same region. Later in the season Mr. Martin will visit the Katalla oil field.

Kenai Peninsula has recently become the scene of some important developments in

⁴*J. Am. Chem. Soc.*, XXXIII., 630, April, 1911.