

Academic Training in Analytical Chemistry

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The extreme complexity of modern chemistry forces every chemist to become to some degree a narrow specialist, yet the dangers of over-specialization must be acknowledged by all. The academic training of every chemist should provide a firm basis of a thorough familiarity with all of the major divisions of chemistry, and to a lesser degree of related sciences, as a foundation for subsequent specialization. The need for a broad working familiarity with all phases of chemistry is particularly acute for the analytical chemist. Modern industry is demanding more analyses, it is demanding analyses more rapidly and often more precisely, and it is frequently demanding that the analytical results be adapted to automatic process control. To be able to respond to these demands, the analytical chemist should ideally be an expert in the diverse fields of organic chemistry and electronics, of inorganic chemistry and biochemistry, of instrumentation and others.

College and university offerings in analytical chemistry have been the subject of frequent critical reexamination within the past few years. Many possible changes have been suggested, some very sweeping and others minor, some of a long range nature and others of immediate possibility. The purpose of the present report is to record some viewpoints which have been expressed in extensive discussions at Indiana University between Professor L. L. Merritt and the present author.

The following features should be included, along with others, in a complete academic program for the professional analytical chemist:

1. a thorough grounding in the "classical" principles of analytical chemistry;
2. a comprehensive familiarity with chemical methods of analysis of important natural and manufactured materials;
3. a thorough survey of all of the major divisions of chemistry, including advanced course work in each;
4. a working familiarity with the type methods of instrumental analysis;
5. some class work and laboratory work in applied electronics;
6. some class work and laboratory work in the principles and methods of instrumentation, including automatic control devices;
7. specialization within some phase of analytical chemistry.

These seven considerations are commented upon in the following paragraphs, in which the numbers refer to the above listing.

1. It is felt that the first course in quantitative analysis should continue to emphasize the "classical" principles of the subject. The

basic principles of stoichiometric relationships, formation of precipitates and chemical equilibria are still the foundation stones of quantitative analysis. Any minor changes which can be made to make the subject more alive and more exciting to the student, however, are always of possible value. Many teachers now include some colorimetry in the first course. The use of a direct reading pH meter to obtain titration curve data is experimentally simple yet of value in making the theory of titrations seem more real. The author has found that the use of electron micrographs to illustrate precipitation phenomena adds much to student interest. Laboratory demonstration periods may be utilized from time to time to introduce, and even to exhibit in operation, some of the instruments and other modern developments within analytical chemistry. Students in the author's beginning quantitative analysis course have each semester exhibited keen interest in regularly scheduled guided tours through the laboratories which are used for advanced courses and for research in analytical chemistry. This latter is possible only in a school possessing a well-equipped graduate division, although modern instruments can be "shown" to any class by means of pictures in the wealth of literature made available by the manufacturers.

2. An advanced course in analytical chemistry, not including instrumental methods, is necessary to fulfill this requirement. Such a course is required of all graduate students at Indiana University. The analytical chemistry of each element is considered in turn. In addition this course provides opportunity for presentation of special topics, such as micro-analytical methods, statistics in analytical chemistry, atomic weight determinations, new analytical reagents, and others.

3. There is much difference of opinion as to what portion of the graduate training of a chemist should be devoted to formal course work. Nevertheless, there can be little doubt that the analytical chemist in particular can benefit from extensive course work in all of the major branches of chemistry. All doctorate candidates at Indiana University are required to take at least two courses in each of four divisions.

4. This requirement can be met efficiently after the student has had at least some course work in the major fields of chemistry including physical chemistry. Both class work and laboratory work should be included. Although a senior level course in a large school can be satisfactory to fulfill this requirement, it generally necessitates a course for which graduate credit can be awarded. Emphasis should be placed upon the instruments available commercially, as well as upon the general applicability of each type method, the usual range of precision and accuracy, and other salient features.

5 and 6. It is felt that in many instances the electronics requirement can be met most efficiently by a course in electronics for chemists within the chemistry department. Such a course is currently available for graduate credit at Indiana University. This course at present includes brief introductions to instrumentation and to control devices. It is planned that this phase of the curriculum be expanded.

7. Specialization may be aided by special topics courses on an advanced level, by seminars and by research work.

In summary, some of the significant requirements which must be fulfilled by an adequate academic training for professional analytical chemistry have been enumerated, and comments have been made upon each with particular reference to the way in which these requirements are being fulfilled at Indiana University.