

**A COURSE OF INSTRUCTION
AND SYSTEM PROCEDURE
IN THE QUALITATIV
CHEMICAL ANALYSIS**

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A Course of Instruction and System Procedure in the Qualitativ Chemical Analysis by Arthur A. Noyes

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ARTHUR A. NOYES

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BY

ARTHUR A. NOYES

PROFESSOR OF THEORETICAL CHEMISTRY IN THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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PREFACE.

This text-book is an attempt, on the experimental side, to train the student of qualitative analysis in careful manipulation and exact methods of procedure, such as are commonly employed in quantitative analysis. It is an attempt, on the theoretical side, to make clear to the student the reason for each operation and result, and to accustom him to apply to them the laws of chemical equilibrium and the principles relating to the ionization and complex formation of substances in solution. It is believed that in both these ways the educational value of the subject is greatly increased.

The book is divided into two main Parts, entitled *The Course of Instruction* and *The System of Analysis*. In presenting the system of analysis the plan adopted in the earlier editions of this book has been followed, namely, that of separating sharply the description of the operations from the discussion and explanation of them. The operations are described with as great definiteness as possible in short paragraphs entitled "Procedures"; and each of these is followed by "Notes" in which are given the reasons for the operations, the precautions necessary and difficulties encountered in special cases, the chemical behavior of the different elements, the indications afforded of their presence, and the application of the theoretical principles to the reactions involved. The system of procedure has been thoroly revised as a result of the extended investigations made in the laboratory of this Institute during the past six years and described in volumes 29, 30, 31, and 34 of the *Journal of the American Chemical Society*. As a result of these investigations, in which the author has had the able cooperation of Professor W. C. Bray and Professor E. B. Spear, the process of analysis has been made much more reliable, so that now it is possible with careful manipulation to detect one milligram of any constituent in the presence of 500 milligrams of any other (except in a few combinations where the limit of detectability is two milligrams). At the same time the process has on the whole been considerably simplified. The larger size of the present edition is due, not to greater complexity of the process, but to the inclusion in the Procedures of the more explicit directions necessary to secure accuracy in the separations and reactions, to the insertion of confirmatory tests for most of the elements, to the development of a more systematic process for the detection of the acidic constituents, and to the elaboration of the notes and especially the inclusion in them of the theoretical explanations made possible by the recent development of our knowledge of solutions.

The Part entitled *The Course of Instruction* includes the directions for the laboratory work and a series of questions to be answered in connection with the laboratory exercises. The laboratory work from beginning to end is closely correlated with the systematic scheme of analysis. For experience has convinced the author that the plan followed in many text-books of requiring the student to study the separate reactions characteristic of the various elements before undertaking their systematic separation is highly unsatisfactory. However valuable the knowledge of the additional reactions may be, it is found in practice that the performance of such a large number of independent, disconnected experiments makes little impression on the student's mind and fails to awaken his interest in the subject. Qualitative analysis affords an effective means of teaching a part of inorganic chemistry chiefly because it unites into a connected whole a great variety of isolated facts, and because the student sees a practical use of the information presented to him; but these advantages evidently do not apply to facts not directly related to the process of analysis.

The Questions on the Experiments are intended to aid in making sure that the student understands the work that he is doing in the laboratory and that he derives from the subject the mental training which it ought to afford. The questions are for the most part of such a character that, in order to answer them properly, the student not only must study the Notes on the Procedures, but must also give to the questions some independent thought; the questions being in general of the nature of simple problems.

The best plan of conducting the course, when circumstances permit, is in the author's opinion as follows. The class, if large, is divided into sections of from 15 to 25 students. At the beginning of each laboratory exercise, which should be at least three hours long, or at the beginning of every second laboratory exercise, the instructor holds an informal conference with each section, at which the experiments to be next made are discussed in outline, and those made at the previous exercises are reviewed in detail. The conferences are carried on mainly by questioning the individual students and by encouraging them to ask questions as to matters which they do not understand. As preparation for each conference the student is expected to study the general plan of the analytical separations to be taken up as presented in the Tables preceding the description of the analysis of each group, and also to study the Notes on the Procedures which he has previously worked through and to answer the printed questions upon those Procedures. The best plan, when the laboratory time permits, is to require the student to read the notes at the time an experiment is being performed, and to write out in the laboratory the answers to the questions on that experiment before beginning the next one. The class is kept nearly together in the laboratory work by giving to the faster working students additional unknown solutions on each group, and by allowing those who are falling behind to omit some of the less important procedures.

Even when the time available for the subject of qualitative analysis does not permit of so complete a course as that here presented, the student gets, in the

PREFACE.

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author's opinion, a better training by working through selected parts of an exact scheme of analysis carefully and thoroly than he does by covering the whole of an elementary scheme superficially. Portions of the system of analysis that may be well omitted in briefer courses are Procedures 63, 65, and 67-70, relating to the removal of phosphate and the separate detection of cobalt and nickel, and Procedures 4-8 and 119 relating to the treatment of substances insoluble in acids. In addition, the work on the acidic constituents may be limited to that referred to in the first two paragraphs of Procedure 100.

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