LECTURE NOTES ON QUALITATIVE ANALYSIS

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QUALITATIVE ANALYSIS.

BY

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PREFACE.

ALTHOUGH the advantages to be gained by teaching qualitative analysis by lecture are sufficiently obvious, it is a serious disadvantage to the student that the necessity of taking proper notes often prevents him from seeing what takes place upon the lecture table. This little book was intended to give concisely the most important facts essential to intelligent work in the laboratory, and thus give the student more leisure for observation in the lecture room.

A comparative description of those compounds of bases and acids which are commonly found or used in analysis is first given, and afterwards a method of separation which experience has proved to be sufficiently simple and accurate, is briefly explained. This method of procedure from the properties of compounds to the methods of separation will also serve to show the way in which the more difficult problems of analysis must be solved.

No tables for analysis have been given, since their use is of questionable advisability, and, if used, are much better drawn up by the student himself.

Symbols have been used throughout for reagents for the sake of brevity, those used in solution being distinguished by the addition of "Aq."

For the sake of simplicity, water has often been omitted from the formulæ of compounds, inasmuch as the number of molecules of water

is largely dependent upon circumstances, and its presence is of minor importance.

Of a compilation of this sort, it is hardly necessary to add that its facts are taken mainly from the text-books of Fresenius and Rose, and the Dictionary of Solubilities of Storer.

CAMBRIDGE, Sept. 1, 1874.

INTRODUCTION.

QUALITATIVE ANALYSIS is that branch of chemistry which treats of the recognition of elements or their compounds. It demands a thorough study and comparison of the several elements and their compounds, of the phenomena exhibited by them under various conditions, and the determination of the particular conditions essential to the manifestation of each. It is advisable, at first, to take into consideration only the more common compounds, and to leave for subsequent study all rare elements and all but a few of the compounds of carbon (organic substances).

The phenomena exhibited by a substance under various conditions are termed its *reactions*. The conditions under which reactions are studied may be divided into two classes: those dependent upon solution, and those independent of it; the two modes of examination are known as the wet and the dry way. In either case any known substance which is used in effecting a reaction is called a *reagent*.

Reactions in the dry way are dependent upon volatilization, or chemical change effected by heat. The nature of these changes will be sufficiently clear after a study of the reactions described in the preliminary examination.

In the wet way a reagent is used to effect solution or to determine a metathesis. Experience has shown that when the solutions of two substances are mixed, and a compound insoluble under the existing conditions can be formed by metathesis, that this insoluble compound is formed; or when a substance volatile under the existing conditions can be formed, that it is formed and escapes. An insoluble substance

separating from solution is called a *precipitate*. If the precipitate settles readily, the liquid may be decanted, or, in any case, it may be separated by filtration, when the liquid is called the *filtrate*. Inasmuch as the completeness of the separation of those substances which are precipitated by a reagent from those which are left in solution depends upon the insolubility of the precipitate, all the conditions which may affect its solubility must be known and considered.

A *general reagent* is used to precipitate a number of substances, a *special reagent* as a test for a single substance. Some special reagents give no precipitate, but cause a change of color. The precipitate thrown down by a general reagent always requires further examination, and it is better to submit to a confirmatory test the precipitate caused by a special reagent. A precipitate or reaction is said to be characteristic when no further test is needed.

There are two things essential to success in qualitative analysis, the accurate observation of phenomena and a correct interpretation of their significance, neither of which can be attained without conscientious work in the laboratory. By studying the reactions of known substances, taking care to observe everything which takes place, however small it may seem, the power of observation will be educated, and it will soon be possible to determine what is accidental and what essential, and experience will show what is the meaning of each reaction observed.

In this book it is supposed that the student already has a good knowledge of general chemistry. Such knowledge is essential, and may be gained by the aid of any good text-book on chemistry. Experience in laboratory work and manipulation, though not absolutely necessary, is on all accounts desirable.*

It is best to begin with the study of the bases, and, taking each group by itself, to compare the properties of the different members. The description of the properties of bases is intended as a guide

* The student may be referred to the following text-books:—

PRINCIPLES OF CHEMICAL PHILOSOPHY. By Josiah P. Cooke, Jr. Boston, 1874.

A MANUAL OF INORGANIC CHEMISTRY: Arranged to facilitate the Experimental Demonstration of the Facts and Principles of the Science. By C. W. Eliot and F. H. Storer. New York, 1868.

INORGANIC CHEMISTRY. By T. E. Thorpe. New York, 1874.

in this work. The truth of each important fact given there should be experimentally proved, and reactions seen in the lecture-room should be repeated, if possible.

After a thorough study of the properties of a group of bases, a method of separation should be devised and compared with that given in course of analysis. The members of the group must then be separated from each other, taking care that the facts upon which the method of separation is based are well understood, and the sources of error distinctly recognized. The separation of the group as a whole from the other groups must then be considered, and the conditions necessary for complete separation clearly made out. After the basic groups have been studied in order, and each of the bases can be detected with certainty, a similar method should be followed with acids, taking as a guide the description of the properties of acids, and the methods given for their detection.

The student will then be prepared to make complete analyses. He should begin with simple salts, and proceed gradually to complex mixtures and insoluble substances, in every case proving the presence or absence of each base and acid which he has studied. In the analysis of such compounds the reactions in the dry way should first be observed. Here the significance of each reaction may be learned, as before, by practice upon known substances, or the reactions of a substance may be carefully observed, and its composition afterward determined by analysis in the wet way. The correct interpretation of reactions in the preliminary examination requires long practice. Great care must be taken to distinguish between those reactions which are so decisive that they may be taken as tests for the presence or absence of certain substances, and those which are proofs or indications of presence, if observed, but from whose non-appearance no negative conclusions can be drawn.

As far as practical work is concerned, it will be necessary to give here only a few general directions, and point out a few common errors. Neatness and cleanliness are absolutely necessary. The reagents must be carefully preserved from contamination. The stoppers of the bottles must not be misplaced, nor laid down while the reagent is used. The reagent bottles should