THE TEACHING OF QUALITATIVE ANALYSIS IN COLLEGES OF PHARMACY.*

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There seem to be two quite different methods followed in teaching qualitative analysis and a brief discussion of these methods may be of value at the beginning of this paper.

First.—**The method followed in universities and colleges that require a year of college mathematics as a prerequisite and give a year's work in qualitative analysis.** In this method, the mathematical side of the subject is emphasized and a great deal of time is given to the theoretical discussion of chemistry. In fact, more attention is given to the theoretical phase of the subject than to the actual separation and identification of chemical compounds. I believe that this method is a little extreme even with the time devoted to mathematics as a prerequisite. It must be said, however, that the student is sure to get a better grasp of the fundamentals, and if fundamentals are mastered, it is to be assumed that they can be applied by a student of ordinary intelligence; therefore, a long drill in separation and identification of compounds is not necessary. Obviously this method cannot be used in a *two*-year course in pharmacy.

Second.—**The method in which little or no attention is paid to the theoretical phase of the subject, but much time is spent in learning, by rule of thumb, a scheme of separation and identification and much practice is given in applying this scheme.** The aim of this method seems to be "How many compounds can you analyze?" and not, "How well do you understand the fundamentals of the subject?" This is the old method that was followed before much work was done on the theoretical study of chemistry. Judging from the textbooks used, this method is still followed in many colleges of pharmacy. This is unfortunate because the student is not made aware of the recent advances in chemistry and is, therefore, handicapped in his work when he gets out of college. I believe that there is a middle ground between these two extremes and one that can be followed in any college of pharmacy. A discussion of this middle course may be of some value and this is my sole excuse for preparing this paper.

A person may learn to operate an automobile without knowing anything about the mechanical parts of the same. Such an operator may be successful as long as there is nothing to interfere with the perfect execution of the machine, but as soon as any interfering difficulties present themselves he is helpless. The same is true of the student who has learned qualitative analysis without understanding the basic principles of the subject. Everything goes well until some interfering substance appears and then he is at sea. In other words, a person may follow directions blindly, be it those for the operation of an automobile or those for the separation and identification of chemical compounds, and be fairly successful if no interfering difficulties are presented, but when difficulties do appear he cannot overcome them. We should not be content to present the subject of chemistry in this way.

The question naturally arises "How much time can we give to the teaching of the whys and wherefores of the subject?" I maintain that any course in qualitative analysis that requires less than 36 hours of lectures and 100 hours of labo-

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ratory practice is of little value to the student. In fact, it would be much better if this number of laboratory and lecture hours were doubled, but I have given this as a minimum for the presentation of the bare fundamentals. I have selected this time as a minimum because I believe that in any *two*-year course in pharmacy this number of hours can be given to the teaching of qualitative analysis.

Granted that this number of hours can be given to the subject, how much theoretical chemistry can be presented? I will attempt to outline the subjects that can be covered in addition to the study of the metals and the scheme of separation and identification.

First.—Two or three lectures on the subject of colloid chemistry and its application, presenting only the bare fundamentals and in a way that they can be grasped by the ordinary student. There are many applications of colloid chemistry in qualitative analysis, but I will mention only a few of them. In the precipitation of the second group, the student is instructed to control the acid content and to have the solution hot when H_2S is added. The student should understand that this is to prevent arsenic from precipitating in the colloidal form and he should understand why this prevents it from doing so. Again in the third group he is likely to have difficulty in filtering aluminum and chromium and he should understand the tendency of these hydroxides to precipitate in the colloidal form and thus clog the pores of the filter. They are likely to adsorb some of the elements, causing failure to detect them and, therefore, this precipitate should be well washed. He should also know that organic matter should be destroyed at first, because it is often colloidal and may adsorb some elements. Many other applications of colloid chemistry will be met with, but sufficient has been given to illustrate the points raised.

Second.—Three or four lectures should be given to the subject of ionization constant and solubility—product constant. (It is assumed that the subject of ionization has been treated in general chemistry.) It is impossible to explain why copper is precipitated in the second group and zinc is not precipitated unless we understand the action of HCl in this precipitation. The student will learn that ZnS is insoluble in a neutral solution and soluble in an acid solution, and he should have an explanation of the action of the hydrogen-ion concentration on the ionization of H_2S. This cannot be given him without an understanding of the ionization constant and the effect of a common ion (hydrogen). The solubility product constants of PbS and ZnS also play an important part in this separation and this must be explained to him.

Again in the fourth group (Ba, Sr and Ca) he learns that Sr may be precipitated by a saturated solution of $CaSO_4$ and that, if a readily soluble sulphate such as $(NH_4)_2SO_4$ be added to a mixture of Sr and Ca and the precipitate filtered off, practically all of the Sr is removed and that enough Ca remains to give a precipitate with an oxalate. He should understand why this is true. Of course he may be told all of these things and be made to understand that he must follow directions given in the textbook, but such teaching is poor teaching and no active instructor will be content with it. Ionization and solubility-product constants play a very important rôle throughout the separation and identification of compounds and no student can fully understand these reactions unless he has a good grasp of the principles underlying these two factors.

Third.—Two lectures should be given on the subject of hydrolysis and the students should be given experiments to illustrate the principles involved. No other reaction causes the pharmacist as much trouble in prescription compounding and a thorough grasp of it is necessary. It is not sufficient that he learn verbatim that potassium acetate is alkaline in reaction and alum is acid in reaction. He should know why this is true so that he can understand similar difficulties. It is not sufficient to tell him that Al and Cr are precipitated as hydroxides, and all of the rest of the group as sulphides. He should understand hydrolysis so well that he can readily grasp the reason for this difference in the salts of the third group.

Fourth.—One or two lectures should be given on the subject of mass action and its application. A student who has not had this subject presented to him cannot understand the precipitation of BiOCl and its subsequent solution by means of increased hydrogen-ion concentration and its reprecipitation when the solution is added to a large volume of water. Neither can he understand the solubility of $Al(OH)_3$ in NaOH but not in NH_4OH. Many other applications of this principle are involved in qualitative analysis, but sufficient have been given for illustrative purpose.

Fifth.—Three or four lectures should be given to the subject of oxidation and reduction and its application. Here we should also discuss the electron theory if it has not already been discussed in general chemistry. For years we have balanced oxidation and reduction equations by rule of thumb. By means of the electron theory we can readily explain this method of balancing equations. In fact, all oxidation and reduction reactions can be more easily understood by means of this theory. Our method of separating Cl, Br and I depends upon their oxidation potentials or, as we say to-day, upon the difference in the ease with which these substances lose a negative electron. Thus you see the electron theory when used to explain oxidation and reduction clears up a difficulty that has been a stumbling block to students of chemistry for years. In a similar way this theory explains valence much better than any other theory.

In conclusion I wish to say, first, that it is possible to give a fairly good course in qualitative analysis to students who have not had college algebra and trigonometry; second, that the old method of teaching qualitative analysis by rule of thumb is entirely inadequate for present-day conditions and that any pharmacy college which continues to use it will find that it is to the detriment of the college and to the students thereof; third, that at least 36 lecture hours and 100 laboratory hours should be given to this subject; fourth, that with this amount of time and with the discussion of theoretical chemistry and its application to qualitative analysis a fairly good course can be given.

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