more readily pointed out to the student, while he still has the copy to put in his book.

Although satisfactory results may be obtained by the use of process plates, or even of any slow plate in the making of the negatives required, still where many plates are to be made at the same time, the quality of the results and the speed of manipulation place the wet-plate in a class by itself. Not only are the resulting prints more contrasty, and thus more like the black and white originals, but the negatives will print in a fraction of the time otherwise required, and far less care is needed to get a good print. In reproducing a line drawing, an over-exposure of 100 per cent. does not materially injure the print from a wet-plate negative. With rapid paper, printing takes about a minute, and three or four frames will keep a man busy.

By using blue prints it is easy to keep up with the times and add new things as they appear, without much labor or delay, and this method would seem to have advantages over all others for teaching the construction and operation of industrial machinery.

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THE ACQUIREMENT OF PROFICIENCY IN QUALITATIVE ANALYSIS.

A DIGEST OF PRESENT AMERICAN IDEAS.

BY HERMON C. COOPER.

The scope of a thorough course in qualitative analysis seems to be such an unsettled matter that I have sought to ascertain by correspondence the current American opinions regarding it. The majority of those asked have replied, and all the replies (twenty in number) have shown great interest but no unanimity of opinion.

Notwithstanding that a large amount of thought has been given to the analytical methods cf qualitative analysis rather little attention seems to have been paid to the scope and ultimate value of the course. The problem of a thorough course is one of pedagogical concern rather to universities that develop professional chemists than to the independent colleges and other schools that afford liberal education. Moreover it is a different problem in America from what it is in Germany, where qualitative analysis is the main feature of the introductory practicum.

A thorough course will be generally regarded as including practice in the reaction tests and systematic methods of separation of about twenty-five metals, the same for at least thirty acids, a brief study of selected preliminary dry tests and a presentation of a systematic procedure of "dissolving," *i. e.*, preparing materials for analysis in the wet way. The instructor easily follows the beaten path through the complete analysis of simple salt mixtures and his class is consequently introduced to the practice of qualitative analysis in a thorough and satisfactory manner.

Such an introduction, however, is not generally considered sufficient for the prospective chemist and practice is given with various materials occurring in nature and the arts. It is obvious, I think, that, the forepart of the course being well taught,[1] the thoroughness of the course depends on the extent and character of this final practice with miscellaneous examples. Shall this final practice be extensive, including (say a dozen) truly miscellaneous natural and commercial materials, some hard to decompose and containing traces; the student's report to be essentially correct and to include all ingredients whose presence can be detected by the methods pursued; *or*, shall it be brief, confined to three or four typical minerals and commercial products, with a necessary allowance made for the inexperience of the student when the report (75 per cent. correct, for instance) is accepted. In following the second alternative the instructor may point out that experience will show that certain types of substances (*e. g.*, native silicates) rarely contain certain ingredients, wherefore the intelligent analyst will often employ a selected, limited procedure, and, further, that the subsequent quantitative procedure of analysis will shed much light on the qualitative composition.

The replies from some professors are colored by local conditions. Thus a limited allowance of time dictates the answer in a few cases. This is a serious and effective, but scarcely fundamental, argument. Most chemistry curricula are in such an evolutionary state that an early opportunity for readjustment of hours can be depended on.

The expense of supplying the necessary platinum crucibles is an argument for brief practice from the teacher in a large state university. This will be encouraging to the smaller and the richer institutions.

In general the replies favor the extended training by more than two to one. However, the difficulty of reducing the question to simple terms makes it hard for any one to give a categorical reply, and it should also be pointed out that many of those experienced in industrial analysis hold the minority view.

Professor TALBOT[2] favors a course designed to give an intelligent knowledge of the usual systematic procedure with a limited amount of practice with the more complex and less soluble materials. "It is obvious," he says, "that qualitative analysis is a portion of our science in which a man may profit by long and varied experience, and I think that every student should have had some experience in the analysis of a complex

[1] Implying careful attention to the laws, properties and reactions involved, to the solubility differences as the basis of separation and to manipulation, as well as to logical reasoning.

[2] All opinions quoted are regarded as personal, not institutional and not necessarily representing the present teaching practice in the institution to which the person belongs.

and, perhaps, refractory mineral and be held for a considerable degree of accuracy; but, if he has been trained to work intelligently and neatly, it seems to me probable that he will adapt himself quickly to any one particular line of material with which he later comes in contact as a part of routine work." The varied nature of qualitative problems makes it seem to him more a question of chemical intelligence and ingenuity than of reproducing the experiences of the instructional laboratory even in the case of the practicing analyst. He would "rather require a real familiarity with the chemistry of the analytical scheme, such as would make the analyst watchful and critical, than to increase the number of unknowns to the extent suggested."

A manufacturing chemist of extensive analytical experience (Mr. J. T. BAKER) considers fewer miscellaneous exercises preferable because we then "give the practicant a general idea of qualitative analysis while at the same time enabling him to cover more ground and thereby broaden his mind instead of wasting much useful time in his effort to work out vexing and unnecessary problems * * * quite different from those he will encounter in practical work outside." "The object sought by the practicant is not a mechanical training but an education," one that will make him "familiar with various lines of scientific work and necessarily so, for the problems that confront the chemist are not wholly chemical, but are physical, mechanical, electrical and even temperamental."

Dr. L. C. JONES writes in a similar strain, considering the essential things to be "familiarity with chemical methods, habit of accuracy and absolute confidence in results obtained." He thinks that the essential facts might be taught by typical salt solutions, and work upon commercial materials possibly delayed until the student reaches quantitative analysis.

Professor DENNIS also favors fewer miscellaneous exercises. Dr. J. E. TEEPLE thinks that practice in the analysis of mineral or commercial products should be a mere incident as compared with a fundamental knowledge of the reactions.

It appears to be the idea of these men that experience with concrete unknowns is decidedly secondary to a study of the chemistry and application of the systematic scheme. Indeed qualitative analysis seems to be regarded by some as an essential part of the laboratory course in general chemistry. The writer (COOPER) thinks that American opinion is trending in the opposit direction.

Turning next to the contrary opinions: A teacher in a large university says we should aim to equip the student to perform an exhaustive qualitative analysis; "otherwise how can the course be called 'thorough' " and he quotes Prof. A. A. NOYES[1] to the effect that inability to make a

[1] Noyes and Bray, THIS JOURNAL, 29, 141 (1907).

good qualitative analysis is a common source of error in quantitative results. To accomplish this the said teacher advises giving the student a number of minerals, commercial products, etc., involving some rather small percentages.

In a similar strain Prof. W. T. HALL adds: "The final verification in the quantitative analysis by its summation to 100 is unsatisfactory. Often a substance like tin-stone is called 'silica,' etc. . . I agree with Professor HILLEBRAND[1] that 'frequently the analysis is entrusted to a student without other experience than that gained by the analysis of two or three artificial salts and as many comparatively simple natural minerals and with a laboratory instructor as adviser, whose experience in rock analysis may be little superior to his own. In other words: one of the most difficult tasks in practical analysis is expected to be solved by a tyro.'" Professor HALL points out also that "a great deal of chemical inspiration can be imparted to a student and training for scientific investigation given by a thorough course in qualitative analysis where the work is made as varied as possible."

The replies of Profs. A. H. GILL, G. B. FRANKFORTER and L. W. ANDREWS are similar to this. Some technical chemists also support this view. Mr. W. D. RICHARDSON reminds us that "a student learns his general chemistry only after he has studied qualitative and quantitative analysis and thus the longer and harder course would have an indirect bearing of the greatest importance. Dr. Teeple, however, discredits the latter clause.

One of our best known consulting and analytical chemists Dr. S. P. SADTLER, writes: "If it is the design to equip the young men to make successful applications for the wider range of positions that offer in the manufacturing and commercial world, they should have an opportunity to see and exercise their power upon a moderate list of technical products. These need not be very complex mixtures, but they ought to be such substances as he would have put into his hands for analysis when he takes the position of chemist for a manufacturer or dealer in materials that have to be tested." This position seems to occupy middle ground in the discussion. Incidentally Dr. SADTLER strongly urges instruction in what is called a proximate analysis, as distinguished from an ultimate one, and the inclusion of organic analysis, saying that the student should learn "the selective action of solvents and how to apply class reactions as means of identification of the constituents of a mixture."

Prof. J. H. WALTON, JR., in charge of qualitative analysis at the University of Wisconsin, points out the desirability of requiring detection of small quantities from a standpoint of manipulation. "Moreover," he writes, " so much of practical qualitative analysis deals with the detec-

[1] U. S. Geol. Survey, *Bull.* 422, 16 and foll.

tion of mere traces of impurities." It seems to him that "after the student has had a certain amount of his qualitative work, he should be able to eliminate certain constituents for himself. For example, if given a silicate, he ought to see that such a thing as potassium iodide would not be present."

Prof. L. W. ANDREWS observes *apropos* "that the student will be sufficiently prone to omit everything that can be omitted, without receiving special stimulation in that direction."

Nevertheless, there is considerable practical value in being able "to eliminate certain constituents." One of our best analysts among manufacturing chemists (Mr. G. P. ADAMSON)—apparently favoring fewer miscellaneous analyses—thinks that the student should be taught to analyze the given materials "in accordance with the composition of the ores or rocks as found in nature, testing only for the ordinary constituents, *e. g.*, in copper ore, testing for copper, silica, iron, arsenic, silver and gold. The finer points in the analysis and rarer elements will be determined afterward when a quantitative analysis is made." He would not necessarily use the summation to 100 as a test. Indeed he would probably agree with Dr. TEEPLE that "a complete quantitative analysis is the exception rather than the rule."

We do well, therefore, to stop at this point to consider what is meant by these modified analyses, or *intelligent analyses*, as we may call them. Dr. F. W. CLARKE deals with the problem vigorously in his introduction to "Analyses of Rocks and Minerals."[1] He deplores the old form of "complete analysis" which used to be practiced in the Geological Survey laboratory and is still followed by many. In such an analysis the constituents of direct petrographic significance were determined. The minor ingredients were incorporated with the principal ones and a summation to 100 per cent. was obtainable. Such work, according to CLARKE, is often grossly misleading and is inadequate to modern requirements, only the most refined methods of work and statement being admissible. A typical result of the more careful analyses is the discovery that barium and strontium are found to be almost universally diffused in igneous rocks.

However, it is evidently not the practice of the Survey to demand[1] that an amount of time "altogether disproportionate to the immediate objects to be sought" should be expended on every analysis. The general rule of the Survey is "that the constituents which are likely to be present in sufficient amount to admit of determination in the weight of a sample usually taken for analysis * * * should be sought for, qualitatively, at least, in the ordinary course of quantitative work and their presence or absence noted among the results. A special note should be made of neglect to look for substances which it is known are

[1] U. S. Geol. Survey, *Bull.* 419, 3.

likely to be present." A thorough microscopic examination of the rock in thin section is often of greatest aid to the analyst. Professor HILLEBRAND writes anent this discussion, that he would not leave the student wholly in the dark with his miscellaneous unknown and so "let him waste much time in a vain search for what is not likely to be there."

It appears that it has required very extensive experience to determin what elements should be tested for in an intelligent rock analysis and one is impressed with the fact that the accuracy of all such "intelligent" analyses from a qualitative standpoint is merely a matter of probability and that we need to study the precision of our analyses qualitatively as well as quantitatively.

In the fields of the various commercial products it may be that some analysts have acquired a corresponding rich experience so that an intelligent analysis is satisfactory, but laboratory teachers are scarce who know the results of such experience in the various fields. Apparently here is an opening for a new manual as a guide to intelligent, or classified, practical analysis. Without a guide the practice work of the student would require a wholly impracticable amount of time.

The *general verdict* of this symposium is difficult to ascertain because of the modifications and digressions introduced by participants, but the writer believes that the majority of teachers and experienced analysts will join in advising (1) a systematic qualitative procedure of known sensitiveness for the common metals and acids; (2) the carrying out of this procedure in all cases, unless a limited analysis is specified; (3) tests for rarer constituents (arbitrarily selected for the present; perhaps we may some day have a rapid systematic procedure for all the metals and even acids); (4) a tabulation of results that will indicate exactly what has been tested for. It may not be amiss to add that the composition of all practice unknowns must be known to the teacher and further that there ought to be a good market for such standardized qualitative unknowns of a concrete character.

However much the majority of us may desire to give a generous assortment of unknowns toward the end of the course it is very doubtful if the freshman or sophomore will profit proportionally by it. He needs mental growth more than comprehensive analytical practice. According to Professor H. L. WELLS, of Yale University, "it is hardly possible to equip the student for exhaustive qualitative analysis in his first course in the subject. He needs experience in quantitative analysis." Professor Wells would accordingly "devote much attention in this first course to formal rather than to practical, qualitative analysis;" he would, however, include some minerals, etc., as practical examples.

Later in the curriculum, perhaps in connection with his advanced

[1] Hillebrand, U. S. Geol. Survey, *Bull.* 422, 21.

quantitative analysis, the student can be greatly enriched by a course giving the practice prescribed by the majority of our contributors, in the full and reliable qualitative analysis of varied materials. This sort of plan is followed at the University of Chicago. Two quarters are given in elementary qualitative analysis, including an exhaustive analysis of ordinary salt mixtures and twenty or more simple unknowns. "After these two quarters," writes Professor STIEGLITZ, "students are admitted to quantitative analysis and, if they intend to go into technical positions, they take later a third quarter in qualitative analysis, in which they get commercial products, ores, minerals, pigments, some rare element work, cyanides, etc." In the introductory course "special stress is laid also on instruction from the general chemistry point of view." A similar plan is probably in force elsewhere.

Those teachers who wish may also point out in the later course how the nature of the material excludes certain constituents. All should make clear the light that is afforded by the solubility observations. Furthermore, some additional theoretical applications can be elucidated and, in general, an eminently satisfactory and profitable treatment of qualitative analysis concluded. This subsequent finishing-course seems to offer a solution of the main problem of our discussion.

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SUGGESTIONS AS TO CERTAIN DESIRABLE CHANGES IN CHEMICAL NOMENCLATURE.

BY EDWARD BOOTH.

The nomenclature of chemistry is better and in every way more serviceable than that of any of the other sciences, but it is still far from perfect. It has not yet reached the point at which betterment is impossible. This paper is a plea for further improvement. In 1787, a century and a quarter ago, Lavoisier, presenting a paper to the French Academy said: "It is time to free chemistry from obstacles of all kinds which retard its progress, to introduce into it a true spirit of analysis: and it is by the perfecting of the language that this reform is to be effected." And he then proceeded in the same paper to suggest a nomenclature which was promptly adopted by the Academy, which with the few changes and additions required by the growth of the science is still in universal use and which has completely fulfilled the expectations of the great man who devised it.

It is unnecessary to enter into historical details, yet a brief résumé may not be inappropriate. Up to the time of Lavoisier's paper chemical nomenclature was in a chaotic condition very much as are those of some of the other sciences at the present time. Names had been given in most arbitrary and unreasonable ways: sometimes suggested by a physical property, or a fancied resemblance to some material in common use;