A LABORATORY OUTLINE OF GENERAL CHEMISTRY

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Fourth Edition.

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PREFACE TO THE THIRD EDITION

The extensive use of the previous editions seems to have shown the acceptability of the general plan of the book. This conclusion has been confirmed by the fact that the second edition has been translated into German, and that a translation of the present one into Russian is being prepared. In the present, therefore, the fundamental features of the previous edition have been preserved. In brief, the aim has been to furnish the basis for a systematic, coherent, and instructive study of the elements of chemistry from the modern standpoint.

In the effort to make misapprehensions and mistakes as nearly impossible as may be, the directions have been entirely rewritten, and in many cases have been amplified, and a number of the experiments have been modified. An entirely new set of figures has also been drawn. To render the exercises more instructive, and still further to discourage mechanical work, a larger number of questions has been inserted. With the same end in view, data in regard to solubility have been introduced (Appendix) as a new feature, and their use in explaining chemical phenomena has been illustrated in many experiments. The rationalizing value of using the conceptions of chemical dynamics, the electromotive series, and the degrees of ionization has been emphasized by more frequent references.

Some of the formal quantitative experiments have been modified, and the directions have been made clearer. The value of these experiments has been found to lie chiefly in the basis they give for clear understanding of the difficult subject of combining, atomic, and molecular weights.

When quantitative experiments were first used in elementary chemistry it was hoped that they would also assist in developing an abiding realization of the quantitativeness of all chemical phenomena and, as a consequence, make all the thought and work of the student more rigorous. In the experience of the authors, however, quantitative experiments of the usual kind fail to accomplish this important result. Students who have performed such experiments still add a test-tube full of sulphuric acid to a liquid known to contain only a trace of a compound of lead, and still think less than a dozen bubbles of hydrogen sulphide sufficient to precipitate the lead from

10 cc. of approximately normal lead nitrate solution (see **74** *g* and note 36, p. 67). They attempt to make potassium chlorate without considering that a few bubbles of chlorine (perhaps liberally mixed with air) will not saturate three grams of potassium hydroxide (see **57** *a*), or they take too much water and then, not having considered the solubilities and, therefore, not knowing what is wrong, throw away the product and lose valuable time by starting entirely *ab initio*. The failures which result from this lack of a sense of quantity are innumerable, and the discouragement often a serious hindrance to ultimate success. The fault, of course, is in the instruction, and the remedy lies in exercises and questions devised to cultivate this missing sense. It is to meet this situation that the tables of solubilities have been introduced and have been referred to frequently (see, *e.g.*, **54**, **55**, **126** *a*, **127**, **137** *c-f*, **139** *d*). With the same object, the tables of degrees of ionization have been utilized (see *e.g.*, **64**, **66**), and the varying degrees of activity of acids have been observed (*e.g.*, **154**) and measured (**120**). Still further to cultivate rational experimentation, the solutions on the side-shelf should be approximately normal (or in simple multiples or submultiples of this concentration), and the student may then be led to note the concentrations and, in many experiments, to take suitable quantities accordingly. The importance of the point of view indicated in the foregoing can hardly be overestimated. Genuine success in business or in the professions, and often even the mere making of a livelihood, depend so largely on ability to reason quantitatively that practice in this kind of reasoning is of inestimable value in education. If, on the contrary, the work in chemistry is purely haphazard in this respect, the study of the science may easily be a positive detriment rather than a benefit, and that whether the student ultimately makes direct use of his knowledge of the science or not.

If it appears that these changes have made the work more difficult, it must be remembered that valuable knowledge can be obtained only by effort, and that the value of the knowledge is in proportion to the effort, provided the latter is directed rationally along instructive lines. Easy chemistry must be superficial and empirical, in proportion to its simplicity. It is easy to perform experiments mechanically; it is necessarily more difficult to interpret the results and extract all that they can teach.

The book is intended for beginners in colleges, universities, and professional schools. It must be understood, however, that no one class is expected to perform all the experiments.

Only from one-half to three-quarters of the whole material can be covered in thirty-three weeks, by a student working four to six hours a week. The authors have found no difficulty in arranging a course only twelve weeks long, and utilizing considerably less than half the contents. The outline is subdivided into numerous small paragraphs, so that each instructor may be able to make such a selection as will suit the work he desires to give. It is hoped that the whole body of material is sufficiently great to permit the arrangement of a course of almost any character. Thus, many or few quantitative experiments may be given, and many or few theoretical matters illustrated. Emphasis may be laid on work leading to analysis, or some of that work may be sacrificed in order to include a larger number of preparations. The student may even be directed in certain paragraphs to ignore the questions. Finally, the order of the experiments may be altered without serious disturbance.

The recent great improvement in the work in chemistry in secondary schools makes it desirable to recognize and encourage this work by outlining a different selection of experiments for those who have studied the science before, and, if possible, to give such students separate class-room instruction.

Sample selections of experiments for beginners and for more advanced students have been given in a separate pamphlet, which will be sent to instructors, upon request, by publishers. This pamphlet includes also lists of apparatus and chemicals and other data helpful in the organization of the laboratory instruction.

In the preparation of this edition the authors have received helpful suggestions from Prof. S. Lawrence Bigelow of the University of Michigan, from Prof. Ralph H. McKee of Lake Forest University, and from Prof. H. N. McCoy, Dr. C. M. Carson, and Mr. T. B. Freas of the University of Chicago, as well as from many others. We wish here gratefully to acknowledge the improvements which the *Outline* owes to these suggestions.

THE AUTHORS.

CHICAGO AND ANN ARBOR,
May, 1907

PREFACE TO THE FOURTH EDITION

THE third revised edition having been exhausted within a few months of its publication, the opportunity is taken to introduce some needed alterations. Aside from a few corrections, only one considerable change is made. This consists in the transfer of Chapter V of the last edition bodily so that it follows Chapter VII of the same edition. This places the quantitative experiments on equivalent weights after the work on water, chlorine and hydrogen chloride instead of before it. In the "Introduction to General Inorganic Chemistry," to which the Outline is a companion volume, the discussions of molecular and atomic weights and of the atomic hypothesis occur at this point and are therefore now contemporaneous with the quantitative experiments dealing in part with the same subjects. Thus there have been adjusted the two difficulties in making a convenient scheme of work, which were formerly occasioned by the lack of laboratory work to accompany the molecular and atomic hypotheses and their applications, and, at a different stage, the great excess of laboratory work over class-room work at the time when the main set of quantitative experiments was being performed. Many instructors will feel that, apart from this mere matter of pedagogical convenience, the postponement of the quantitative work is in itself advantageous, because, after more laboratory experience, greater ease of performance and greater accuracy in results may now reasonably be expected.

This opportunity may be taken to call attention to the change in the nomenclature of ionic substances (p. 55) in Chapter X *et seq.* This considerable departure from the system used in the text-book was made only after careful consideration. The nomenclature now employed in the outline, although it has been developed chiefly since the text-book was written, has already come into fairly consistent use in American chemical literature. In Great Britain no one system has established itself. In Germany a plan similar to that here adopted has been used by Ostwald and others for several years.

THE AUTHORS.

November, 1907.