LABORATORY EXERCISES TO ACCOMPANY FIRST PRINCIPLES OF CHEMISTRY

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TO ACCOMPANY

FIRST PRINCIPLES OF CHEMISTRY

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PREFACE.

THIS Laboratory Manual is designed to accompany the authors' "First Principles of Chemistry." It is, in some measure, founded on Handbook 21 of the State Department of Education of New York, which was prepared by the authors in the spring of 1905, and which met with such success as to lead to the writing of the "First Principles of Chemistry."

Such of the experiments from the Handbook as appear in the present Manual have been carefully revised and improved where experience has shown this to be desirable. A number of other experiments have been added in order to give greater freedom of selection, and to provide fully for such schools as are favored with ample time for laboratory work. The authors believe that these exercises will be found to furnish a typical range of experiments suitable for an elementary course. Though practical and industrial applications receive considerable attention, yet a sound knowledge of the fundamental facts and principles of the science is considered of most importance to the beginner, since it is only through painstaking labor along theoretical lines that the achievements of industrial chemistry have been obtained.

It is hoped that the Manual will prove an attractive introduction to the experimental determination of chemical facts, and will lead the pupil to an interest in chemical theory for its own real and permanent value.

The authors gratefully acknowledge indebtedness to that large body of chemistry teachers whose kind reception of the "First Principles of Chemistry" has encouraged them to publish the present laboratory course.

NEW YORK, September, 1908.

GENERAL SUGGESTIONS TO TEACHERS.

Selection of Experiments. — The time usually allotted to laboratory work in a first course in Chemistry is not sufficient for performing all the experiments given in this manual. As an aid in the selection of a well-balanced course, the experiments are divided into the following groups:

GROUP A. Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 14 A or 14 B, 15, 16, 17, 19, 21, 25, 26, 27, 28, 29, 31, 32, 33, 34, 35, 38, 39, 40, 43, 44, 47, 48, 49, 50, 51, 52, 54, 58, 59, 60, 66, 67, 68.

GROUP B. Nos. 11, 12, 13, 18, 20, 24, 41, 42, 53, 57, 64.

GROUP C. Nos. 22, 23, 30, 36, 37, 45, 46, 55, 56, 61, 62, 63, 65, 69, 70, 71.

It is recommended that all students be required to perform the experiments of Group A. These experiments are fundamental in nature, and very valuable as a means of laboratory instruction. This list, together with a certain number of experiments from Group B, will satisfy the usual college entrance requirement in Chemistry.

Most instructors will doubtless assign to their classes a good portion of the exercises in Group B. The several quantitative experiments in this subdivision are valuable for their training in manipulation, for the theory they illustrate, and for the interest they arouse.

It is hoped that every laboratory section will find time for some of the experiments in Group C, particularly those dealing with the practical applications of Chemistry.

The Directions for the Experiments. — At first the directions for the laboratory operations are somewhat detailed, that the

beginner may have the help needed to perform the experiment readily and intelligently. As the student gains in experience and self-reliance, the directions become less full.

The *questions in ordinary type* generally call for statements of fact. The answers to them should be woven into the written description of the laboratory operations and their results.

The *questions in italic* require reasoning from the observed experimental data. It is often advisable for the student to postpone the *recording* of answers to these italicized questions until the operations of the experiment have been completed. Many instructors prefer to have the answers to such questions form a separate part of the note-book record under some such heading as *Discussion*. The authors have taken great care to avoid questions which the student cannot fairly or legitimately answer from the experimental data. In some cases *Class Discussion* appears in parentheses after certain questions. This means that the student requires further information in order to give a complete answer. Such information is often best furnished in a class discussion.

The *tabular forms for numerical data* should be written in the laboratory note-book at the beginning of the experiment, so that the measurements may be recorded as soon as they are made.

Apparatus and Material. — It has been the aim of the authors to use such simple forms of apparatus as are commonly found in the ordinary laboratory equipment. For their general availability, attention is called to the agate pans and the Syracuse form of watch glasses. This watch glass is superior to glass plates for covering and handling bottles of gas. Although the brass capsule, ramrod, and holder used in Experiments 8 and 14 B can be purchased, many instructors will prefer to have them made in the laboratory shop. Accordingly, directions for making them are inserted here.

The sodium capsule is made either (*a*) by cutting $\frac{1}{4}''$ brass tubing ($\frac{1}{32}''$ wall) into pieces about an inch long, and soldering a brass disk $\frac{1}{8}''$ thick into one end; or (*b*) by drilling $\frac{5}{16}''$ brass

rod with a $\frac{1}{8}''$ or $\frac{5}{16}''$ drill. The latter can be readily done by mounting the rod in a draw-in chuck in a lathe, first drilling and then cutting off.

The handle consists of a piece of No. 14 copper or brass wire. A few turns are wrapped tightly around the capsule, and about 8″ of the wire project at right angles to the capsule. The outer end of the wire should either be bent into a flat loop or be forced into a short piece of dowel rod.

A ramrod of iron or brass, about 5″ long, sliding easily in the capsule, should be provided.

In the lists of material, *concentrated acid* means acids of the indicated specific gravity: hydrochloric acid, 1.19, sulphuric acid, 1.84, and nitric acid, 1.42. The concentrated ammonia water should have a specific gravity of 0.90.

For *dilute acids* and ammonium hydroxide the authors commonly employ the following concentrations: —

Ammonium hydroxide (1 : 4), that is, one part by volume of concentrated ammonia water to four volumes of water.
Hydrochloric acid (1 : 4)
Nitric acid (1 : 4)
Sulphuric acid (1 : 6)

All students should be given, early in their course, definite directions for the safe mixing of concentrated sulphuric acid with water. The required amount of water should be measured out. Then small portions of the concentrated acid should be poured slowly into the water, and the mixture should be agitated after each addition.

In many cases special concentrations for acids and other solutions are given at the head of the experiment. When no concentration is expressed, one to ten is understood, that is, one part by weight of the chemical to ten parts by weight of water. (A cubic centimeter of water at ordinary temperature is considered to weigh one gram.) In the majority of cases, however, one to twenty solutions will be found to work quite as well as the one to ten, with a consequent saving of reagents.