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FOR THE ARMED FORCES

GENERAL CHEMISTRY

PART II

EXPERIMENTS

BY

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PREFACE

THE experiments in this book are designed primarily to accompany the author's General Chemistry — Principles and Applications. They are cited throughout that book and are referred to by number as being in Part II. The selection, arrangement, and subdivisions of the experiments are such, however, that teachers will find this book itself serviceable under various conditions.

Teachers should notice several things about the experiments in this book. First, as a whole they are divided into two kinds — regular and supplementary. Second, the regular experiments include not only those acknowledged as of fundamental value in a general course, but also practical and novel experiments which emphasize the relation of chemistry to everyday experiences of students. Third, the supplementary set includes experiments suited for beginners, but varying widely in length, difficulty, and utility. These experiments are just what their name implies — supplementary. They will serve numerous uses: *e.g.* to lay special emphasis on certain principles and applications, to provide additional opportunity to acquire skill in manipulation, to supplement information gained by the regular experiments, to provide illustrative demonstrations for the classroom, to furnish material for individuals who prefer or need special experiments or who are compelled to meet specific requirements, to present attractive laboratory work to students who cannot (or will not) pursue chemistry scientifically, and to stimulate those who are interested in the practical applications of chemistry. Fourth, this

liberal provision for laboratory work not only permits the selection of a sufficient number of experiments adapted to a wide range of equipment, but also enables teachers to accomplish one or more aims, *e.g.* giving general mental training, inculcating the scientific point of view, meeting college preparatory requirements, teaching the fundamental principles of chemistry, emphasizing relations of chemistry to household arts and to industries, and utilizing chemistry as a factor in vocational education. These aims, varied as they seem, can be accomplished by judicious utilization of text and experiment, not only because adequate material is available but also because the text-book and laboratory manual have been made flexible in content and arrangement. On page xiii there are suggestions which will assist teachers in selecting experiments suitable for different kinds of courses.

The directions for performing the early experiments are rather full. Experience has convinced the author that beginners need adequate directions at the outset. The directions for performing the semi-quantitative experiments are also full, for time and annoyance are saved by avoiding repetitions necessitated by inadequate directions.

The Introduction contains directions for preparing, constructing, and arranging apparatus and for performing many general laboratory operations. Students should be required to familiarize themselves with this part of the book and to use it as occasion demands. In the Introduction there will also be found information about the procedure in case of accidents and some suggestions about laboratory note books. Annotated lists of the supplies needed for the experiments will be found at the end of the book.

L. C. N.

Boston, Mass.,
May, 1914.

CONTENTS

(Supplementary Experiments are marked S.)

SUGGESTIONS FOR TEACHERS

The author does not intend that all the experiments in this book shall be performed by a class in the time usually devoted to a first course in chemistry. In selecting experiments well adapted to equipment and best suited to needs, teachers will find the subjoined lists serviceable. The numbers in parentheses refer to optional experiments.

LIST I — **General Course.** This group contains experiments calling for a well equipped laboratory and a liberal amount of time, and as far as possible the course should include these experiments. Numbers **1, 2,** (4s), (5s), **6, 7,** (8s), (9s), **10, 11,** (12s), (14), (15), **16, 17, 18, 19, 20, 21, 23, 24,** 26s, (28s), (29), **33 or 41s, 34, 35 or 42s, 36, 37, 38, 39, 40,** (43s), (44s), **45 or 52s, 46 or 53s,** (47), (48), **49, 50,** (54s), (56s), **58, 59, 66 or 67, 70 or 71, 79s, 80, 81, 82, 83, 84, 85,** (88s), (89s), (91s), (94), (95), (96), **97,** (104), (106), (109), (111), (115), (116), **131, 132,** (133), **134,** (135), **136,** (138s), **139s,** (140s), **144, 153, 156,** (157), (158), (159), **170,** (171), **174,** (176s), **177s, 179s, 181, 182, 184, 185,** (187), (191s), (193s), **196,** (197), (198), **199,** (200), (201), **203s,** (204s), (206), (207), **209,** (212s), **217, 218, 219,** (225), (229s), (230s), (235s), **238s.**

LIST II — **Shorter Course.** The experiments in this group constitute a consecutive course and are suitable wherever equipment is moderate and time limited. Numbers **1, 2, 6, 10, 14, 17, 18, 19,** (20), **23, 24, 34, 35 or 42s, 36, 37, 38, 39, 40,** (41s), **46 or 53s, 49, 50, 79s, 80, 83 or 89s, 94, 95,** (96), (97), **104, 106, 108,** (111), (112), (115), (116), (123s), **131, 132, 135, 136,** (144), (153), (156), (157), (158), **170, 174, 179s, 182, 184, 196, 199, 203s,** (204s), **207, 209, 217, 218, 219,** (220).

LIST III — **College Preparatory Course.** This group covers the usual entrance requirement for college. Teachers are urged to substitute short experiments from the supplementary set wherever the principle is identical. Numbers (1), (2 or 4s or 5s), **6, 7, 8s, 9s, 10, 11, 12s, 13s,** (14 or 25s), (15), **16,** (17), (18), (19), (20), **21, 22,** (23), (24), **26s, 29,** (32s), **33, 35, 36, 40,** (41s), (42s), **46, 47, 48, 49,**

50, (52s), (53s), (54s), 56, 57, 61 or 64s, 62 or 65s, (63s), (66), (67 or 73s), (68), (70 or 71), 78s, 79s, 80, 81, 82, 83, 84, 85, 88s, (89s), 90s, 91s, (94s), (95s), (96s), (97s), 99s, (104), (105), (106), (108), (109), 111, (112), 115, 116, (117), (118), 119, 120, 127s, 131, 132, 134, (135), 136, 138s, 139s, (144), (152), 153, (155), 156, (157), (158), (159), (160), (170), (171), 172, 176s, 177s, (178s), 179s, (181), 182, 184, (185), (186), (191s), (193s), 196, (197), (198), 199, 200, 201, 203s, (206), (207), 209, (212s), 217, 218, 219, 220s, (223s), (225), (229s), (230s), (235s), 238s.

LIST IV — **Practical Course.** This group includes experiments which emphasize the applications of chemistry. The fundamental experiments in List II may be substituted for certain ones in this list; omissions may also be made as time and equipment determine. Numbers **14, 15, 17, 18, 19, (25s), 26s, 31s, 34, 36, 37, 38, 39, 44s, 49, 52s, 53s, 58, 59, 60s, 69, 70, 79s, 80, 81, 82, 83, 86, 87, 88s, (89s), 92s, 93s, 94, 98s, 99s, 100s, 101s, 102s, 106, 107, 111, 112, 113, 115, 116, 118, 119, 120, 122s, 123s, 124s, 126s, 128s, 136, 137, 140s, 150s, 151s, 159, 169s, 171, 172, 175, 177s, 178s, 179s, 180s, 188s, 190s, 192s, 194s, 197, 198, 199, 203s, 204s, 207, 208, 210s, 216, 220s, 221s, 225, 232, 233, 236s, 237s, 238s.**

LIST V — **Food Experiments.** The fundamental experiments on the chemistry of food are collected in this group. Numbers **14, 25s, 26s, 84, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121s, 122s, 123s, 124s, 125s, 127s.**

LIST VI — **Quantitative Experiments.** This group includes the experiments that involve accurate weighing and measuring. Numbers **13s, 22, 27s, 32s, 57, 61, 62, 63s, 64s, 65s, 78s, 88s(*b*), 130(*b*), 135(*a*), 146(*b*), 151s(*d*), 165s(*b*), 181(*c*), 186(*c*), 213s, 216(*c*), 228s, 229(*c*).**

LIST VII — **Demonstration Experiments.** In this group are placed experiments which may be performed by he teacher before the class. Many of these experiments may be used to supplement the individual work suggested in List II or as substitutes for certain experiments in List I. Numbers **4s, 5s, 14, 26s, 28s, 29, 30, 34, 43s, 44s, 47, 48, 50, 66, 67, 68, 70, 71, 72s, 73s, 74s, 76s, 77s, 85, 90s, 92s, 95, 98s, 102s, 127s, 132, 133, 140s, 142, 145s, 148s, 154, 177s, 190s, 192s, 198, 202s, 204s, 207, 208, 210s, 239, 240, 241, 244s.**

EXPERIMENTS

GENERAL CHEMISTRY

EXPERIMENTS

INTRODUCTION

GENERAL DIRECTIONS — ACCIDENTS — NOTE-BOOKS

1. The Bunsen burner is used as the source of heat in most chemical laboratories. It is attached to the gas cock by a piece of rubber tubing. It is lighted by turning on the gas full and then holding a lighted match in the gas a short distance above the top of the burner. If the flame is yellow, turn the ring at the bottom of the burner until the flame is a faint blue. The colorless or bluish flame should be used in all experiments unless the directions state otherwise. The hottest part of the flame is near the top.

2. Heating. — The following directions should be observed in heating with the Bunsen burner: —

(1) The burner should always be lighted before any piece of apparatus is held over it, or before it is placed beneath a wire gauze which supports a dish or flask.

(2) Glass and porcelain apparatus should not be heated when empty nor over a bare or free flame even if they contain something — unless directions so state. Vessels requiring a support should be placed on a wire gauze which stands on the ring of an iron stand, and heated gradually from beneath (Fig. 110). Vessels should be heated and cooled gradually; if removed from the gauze while hot, they should be placed on a block of wood or piece of asbestos — never on a cold surface.

(3) Many experiments require the heating of test tubes. These tubes should be dry on the outside. The temperature

of a test tube containing a solid should be raised gradually by moving it in and out of the flame, or by holding it in the flame and rolling it slightly between the thumb and forefinger. Special care must be taken to distribute the heat evenly. If the test tube contains a liquid, as is usually the case, only that part containing the liquid should be heated; the test tube should also be inclined so that the greatest heat is not applied to the thin bottom. When the liquid begins to boil, the test tube should be removed from the flame for an instant or held over it. In some experiments test tubes can be held between the thumb and forefinger without discomfort. As a rule a test tube holder should be used (Fig. 100).

3. Cutting, Bending, and Drawing Glass Tubing. — (*a*) *Cutting.* Determine the length needed, lay the tube on the desk, and with forward strokes of a triangular file make a short but deep scratch where the tube is to be cut. Grasp the tube in both hands, and hold the thumbs together behind the scratch; now push gently with the thumbs, pull at the same time with the hands, and the tube will break at the desired point. The sharp ends should be smoothed by rubbing them with emery paper or by rotating them slowly in the Bunsen flame until a yellow color is distinctly seen or until the end becomes red-hot.

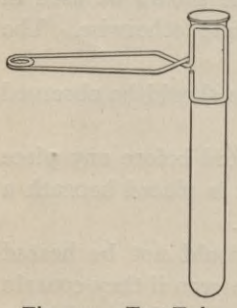

Fig. 100.—Test Tube and Holder.

(*b*) *Bending.* Glass tubes are bent in a flat flame. An ordinary illuminating gas flame may be used, but the Bunsen flame can be flattened by a wing-top attachment, which slips over the top of the burner tube. The flattened Bunsen flame should be slightly yellow and about 7 centimeters (2.5 inches) wide for ordinary bends. A **right-angle bend** is made as follows: Determine the point at which the tube is to be bent. Grasp the tube in both hands, and hold it so that the part to

be bent is directly over the flame. Slowly rotate it between the thumbs and forefingers, and gradually lower it into the flame. Continue to rotate it until the glass feels soft and ready to yield. Then remove it from the flame, and slowly bend it into a right angle. It is convenient to have at hand a block of wood or some other right-angled object to assist the eye in completing the bend into an exact right angle. It is desirable though not always necessary to anneal the bent part of the tube. This is done by holding it in a yellow flame until it becomes coated with soot; it should then be placed on a block of wood, and when cold wiped clean. Tubes can be bent into an **oblique angle** by heating them through about twice the space required for a right angle; a very slight bend, however, is often made by holding the tube across the flame and heating a short space.

(*c*) *Drawing.* Glass tubes can be drawn to a finer bore or into two pointed tubes as follows: Heat the tube as in (*b*) through about 2.5 centimeters (1 inch) of its length, remove from the flame and slowly pull it apart a short distance; let it cool for a few seconds, and then pull it quickly to the desired length. Stirring rods can be made from glass rod in the same way.

4. Filtering. — A solid may be separated from a liquid by filtering. A circular piece of porous paper is folded to fit a glass funnel, and when the mixture is poured upon this paper the solid — the residue or precipitate — is retained, while the liquid — the filtrate — passes through and may be caught in a test tube or any other vessel. The filter paper is prepared for the funnel by folding it successively into the shapes shown in Fig. 101— I, II, and then opening the folded paper so that three thicknesses are on one side and one on the other as in III. The cone-shaped paper is next placed in the funnel and moistened with water, so

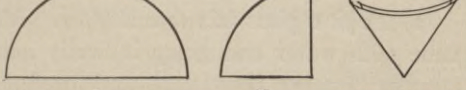

Fig. 101. — Folded Filter Paper.

that it will stick to the sides of the funnel. The liquid to be filtered may be poured directly upon the paper or down a glass rod which touches the edge of the test tube; the lower end of the rod should nearly touch the paper inside the funnel, so the liquid will run down the side and thereby avoid bursting the apex of the filter paper. The funnel can be supported as shown in Fig. 102.

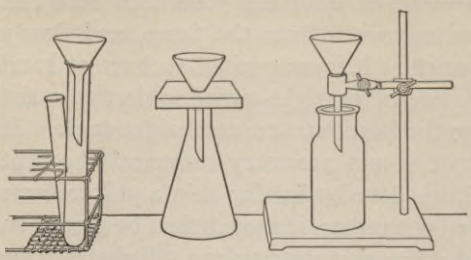

Fig. 102. — Funnel Supported for Filtering.

5. Constructing and Arranging Apparatus. — The various parts of an apparatus should be collected, prepared, and put together before starting the experiment in which the apparatus as a whole is used. The parts that are to fit each other should be selected and arranged so that all joints are gas-tight, and as a final precaution, especially in long experiments or those involving weighing, the apparatus should be approved by the Teacher. The following suggestions will be helpful: —

(1) *To insert a glass tube into rubber tubing.* Cut one end of the rubber tubing at an angle, moisten the smoothed end of the glass tube with water, place the end of the glass tube in the angular-shaped cavity so that both tubes are at about a right angle, grasp the rubber tube firmly and slip it slowly up and over the end of the glass tube.

(2) *To fit a glass tube to a stopper.* Moisten one end of the tube with water and grasp it firmly near this end; hold the stopper between the thumb and forefinger of the other hand, and work the tube into the hole by a gradual rotary motion. Proceed in the same manner, if the tube is to be pushed through the stopper. *Never* point the tube toward the palm of the hand that holds the stopper. *Never* grasp a bent tube

at the bend when inserting it into a stopper — it may break and cut the hand severely.

(3) *To bore a hole in a cork.* Rubber stoppers are preferable, but if corks are used, they can be bored as follows: Select a cork free from cracks or channels and use a borer which is one size smaller than the desired hole. Hold the cork between the thumb and forefinger, press the larger end against a firm but soft board, and slowly push the borer (previously moistened with water or soap solution) by a rotary movement through the cork, taking care to bore perpendicularly to the cork. If the hole is too small, enlarge it with a round file.

(4) *To make a test wire.* (*a*) *Platinum.* Rotate one end of a piece of glass rod, about 10 centimeters (4 inches) long, in the flame until it softens. At the same time grasp a piece of platinum wire about 7 centimeters (3 inches) long firmly in the forceps about 1 centimeter (.5 inch) from the end, and hold it in the flame. When the rod is soft enough, gently push the hot wire into the rod. If a glass tube is used, it should be drawn out to a very small diameter (see **3** (*c*)) before inserting the platinum wire, but in other respects the two operations are practically identical. (*b*) *Nichrome.* An efficient test wire for many experiments can be made by winding a piece of nichrome wire around a match stick. The completed wires are shown in Fig. 103.

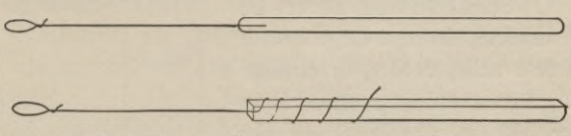

Fig. 103. — Test Wires — Platinum (Upper), Nichrome (Lower).

6. Manipulation. — Ability to use apparatus rapidly, accurately, and neatly is acquired only by experience. The following suggestions will facilitate the acquisition of this needful skill: —

(1) *Pouring liquids and transferring solids.* (*a*) Liquids can be poured from a vessel without spilling, by moistening

a glass rod with the liquid and then pouring it down the rod. The angle at which the rod is held varies with circumstances. This is a convenient way to pour a liquid from a vessel containing a solid without disturbing the solid. (*b*) Liquids should be poured from a bottle by holding the bottle as shown in Fig. 104. Notice that the stopper and bottle are held in the same hand. The stopper is removed by holding palm of the hand upward and grasping the stopper between the the fingers before the bottle is lifted (Fig. 105). All stoppers should be removed this way when possible, and not laid down, because the impurities adhering to the stopper may run down into the bottle and contaminate the solution. The drop on the lip of the bottle should be touched with the stopper before the latter is put into the bottle; this simple operation prevents the drop from running down the outside of the bottle upon the label or upon the shelf. (*c*) Solids should never be poured directly from a large bottle into a test tube, retort, or similar vessel. A convenient method is as follows: Rotate the bottle slowly so that the solid will roll out in small quantities; catch the solid on a narrow strip of paper creased lengthwise, and slide the solid from the paper into the desired vessel.

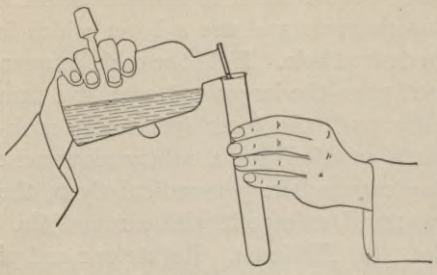

Fig. 104. — Pouring a Liquid from a Bottle.

Fig. 105. — Removing the Stopper from a Bottle.

(2) *Collecting gases.* Gases are usually collected over water by means of a pneumatic trough, a common form of

which is shown in Fig. 108. The vessel to be filled with gas is first filled with water, covered with a piece of filter paper, inverted, and placed mouth downward on the support of the trough, which is previously filled with water just above the support. The paper is then removed, and the vessel slipped over the hole in the support. Glass plates instead of filter paper may be used to cover the bottle. The gas which is evolved in the generator passes through the delivery tube, and bubbles up through the water into the vessel, forcing the water out of the vessel as it rises. All gases insoluble in water may be thus collected. Some heavy gases, such as hydrochloric acid, chlorine, and sulphur dioxide, are collected by allowing the gas to flow downward into an empty bottle, and displace the air in the bottle, i.e. by downward displacement (Fig. 122). Ammonia and other light gases are usually collected by allowing the gas to flow upward into a bottle, i.e. by upward displacement (Fig. 125).

7. Weighing. — Most experiments in this book involve only approximate weights of substances; a few require accurate weights. Approximate weighings are made on the scales and accurate weighings on the balance.

The following rules should be observed in all weighings: —

(*a*) Before weighing, see that the scales and balance are clean and properly adjusted. If out of order, do not attempt the adjustment yourself, but report the case to the Teacher.

(*b*) Substances are put on the left side and weights on the right. Heavy objects and weights should be put in the center of the pan.

(*c*) Substances should not be placed directly on the platform or pan, except pieces of metal or glass objects. In weighing on the scales, put pieces of paper of about the same size in each platform; the left one should be creased. Take the substance from the bottle with a clean spoon or spatula, or pour it out by rotating the bottle as described in **6** (*c*); if you weigh out too much, do not put it back into the bottle, but throw it into the waste jar or a special bottle. In using

the balance, if the substance should not be placed on the pan, weigh a small watch crystal or crucible and then weigh the substance in this vessel. Sometimes a piece of apparatus is not put on the pan but hung from the balance hook.

The process of weighing is as follows: —

A. Scales. Put the object or the paper and substance on the left side; on the right side put the exact weight if it is known or the approximate weight if the exact weight is not known. Now add or remove substance or weights until the pointer swings the same number of spaces each side of the middle division. Weighings of single grams and fractions are usually made by sliding a rider along a graduated beam on the front of the scales.

B. Balance. Put the substance or object on the left pan and the weight judged to be equal on the right pan. Release the beam carefully by turning the screw or lever, and note the movement of the pointer. If the added weight is incorrect, arrest the beam and change the weights, taking care to add or remove the weights systematically. Then release the beam again and observe as before; if the pointer does not swing the same number of spaces each side of the central line, arrest the beam and change the weights accordingly. Continue until the correct weight is obtained. As soon as the substance or object is weighed, note the weights on the pan and record at once, then compare the weights with those missing from the box; if correct, so indicate in the notebook, and finally check the weight by noting the weights as they are returned to the box. The following should be rigidly observed: —

(*a*) Always arrest the beam before changing the weights or the load (i.e. the object or substance).

(*b*) If on releasing, the beam does not swing, arrest and release again, or fan one pan very gently.

(*c*) Record the result of all weighings in the proper place in a notebook, — never on a scrap of paper.

(*d*) Handle all weights with special forceps, unless otherwise directed.

8. Measuring. — Liquids are measured in graduated cylinders and burettes (Figs. 134, 132). The lowest point of the curved surface of the liquid, called the meniscus, is its correct height (Fig. 106). The average ordinary test tube ($6 \times \frac{3}{4}$ inch) holds about 30 cubic centimeters, while the large test tube (8×1 inch) holds about 75 cubic centimeters. Time can be saved by remembering these volumes.

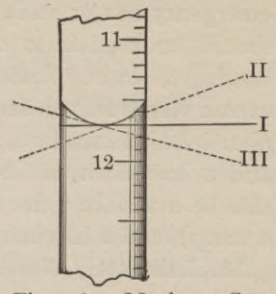

Fig. 106. — Meniscus. Correct Reading is along Line I.

9. Smelling and Tasting. — Unfamiliar substances should never be tasted or smelled except according to directions, and even then with the utmost caution. Never inhale a gas vigorously, but waft it gently with the hand toward the nose. Taste acids, etc., by touching a minute portion of the dilute solution to the tip of the tongue, and as soon as the sensation is detected, reject the solution at once — never swallow it.

10. Accidents. — (1) **Cuts** should be washed in clean cold water and then covered with collodion or court plaster if slight, or bandaged firmly if severe. (2) **Burns** caused by hot objects should be covered with a paste made by mixing sodium bicarbonate (baking soda) and carron oil (an emulsion of lime water and oil) and then bandaged. (3) **Acids and alkalies** if spilled on the hands or spattered on the face should be washed off with water; if a burn is produced, this may be treated as described above. (4) If a **poison** is swallowed, a physician should be called at once; meanwhile an emetic consisting of warm water and mustard should be administered, and subsequently the proper antidote, if known, should be given. (5) If **irritating gases** are inhaled, breathe plenty of fresh air; if the gases get into the eyes, wash the eyes freely with water and then drop in weak boric acid or borax solution with a medicine dropper. (6) **Faintness** may be overcome by holding a handkerchief moistened with ammonia or cam-

phor near the nose. (7) **Fires** may be extinguished by sand or by carbon tetrachloride. If the clothing catches fire, a damp towel or asbestos blanket should be used. (8) An **emergency box** or cabinet provided with the following articles should be kept in a convenient place: Absorbent cotton, bandages, court plaster, pins, thread, scissors, collodion, carron oil, sodium bicarbonate, vaseline, smelling salts, camphor solution, mustard, boric acid solution, medicine dropper, and a handbook of first aid to the injured. There should also be available a fire extinguisher, a box of sand (including a scoop), and a blanket.

11. Laboratory Notebooks. — A neat and accurate record of all experiments performed by the pupil should be made in a notebook provided for this purpose. This record and the form in which it may be kept will vary with conditions. It should contain at least the following: — (1) The number and title of each experiment and the date of performing. (2) A *brief* account of each experiment in such a form that the experiment can be repeated without error or the essential parts subsequently used. (3) Answers to all questions — not merely yes or no, but answers in which the question itself is involved. (4) A simple sketch of the apparatus. (5) All numerical data involved in weighings and calculations. (6) An index.

EXPERIMENTS

PROPERTIES — CHANGES

Experiment 1 — Properties of Copper Sulphate

MATERIALS. — Copper sulphate, test tubes and rack, Bunsen burner, test tube holder, iron nail, ammonium hydroxide, barium chloride solution.

(*a*) Examine some copper sulphate and observe its properties. What is its physical state, i.e. is it a solid, a liquid, or a gas? What is its color? Drop a small piece into a test tube half full of water; is it heavier or lighter than water? Is it soluble in water? Conclusive evidence regarding its solubility may be obtained by heating the test tube. If you are unfamiliar with the method of heating usually employed in a chemical laboratory, proceed as follows: Connect the Bunsen burner with one end of the rubber tube and slip the other end tightly over the gas outlet, turn on the gas and light it; rotate the ring at the base of the burner until the flame is colorless or faint blue, and finally adjust the gas pressure until the flame is about 10 centimeters, or four inches, high. Attach the test tube holder to the test tube just below the lip (Fig. 107), put the lower part of the test tube in the flame and move the test tube slowly up and down, taking care to incline it slightly and to heat only the part that contains the liquid; if the liquid boils too vigorously, the test tube should be removed from the flame or held above it. Continue to heat gently until there is conclusive evidence of the solubility of the copper sulphate. Does copper sulphate dissolve readily in water? Stand the test

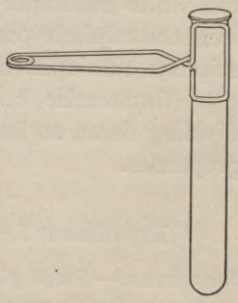

Fig. 107. — Test Tube and Holder.

tube in the test tube rack to let the liquid cool, or cool it by holding the test tube in a stream of water.

(*b*) Determine the properties of copper sulphate exhibited when different substances act upon it. If the liquid formed by heating copper sulphate and water is not uniformly colored, pour it into another test tube and then back again into the original test tube. When the liquid is thoroughly mixed, divide it into three equal parts, using test tubes as containers. Incline one test tube, carefully slip a clean iron nail into it, and let the test tube stand in the rack several minutes. Meanwhile add ammonium hydroxide solution to the second part until the test tube is about half full, and mix the liquids by shaking or by stirring with a glass rod. Add a little barium chloride solution to the third part, shake well, and let this test tube also stand undisturbed in the rack. Examine the three test tubes in succession. Pour the liquid out of the first test tube, remove and examine the nail. What does the deposit resemble? What is the deposit? If you are in doubt, compare the deposit with a piece of copper. The deep blue liquid in the second test tube contains a dissolved substance which is formed when copper sulphate and ammonium hydroxide act upon each other. Likewise in the third test tube, the white substance which settles to the bottom is formed from the sulphate portion of the copper sulphate when copper sulphate acts upon barium chloride.

(*c*) Summarize briefly the properties of copper sulphate, dividing them, as far as possible, into physical and chemical properties.

Experiment 2 — Physical and Chemical Changes

MATERIALS. — Small piece of wood, test tubes and holder, burner, fusible metal, glass rod, sulphur, block of wood.

A. *Wood.* Slip a small piece of dry wood into a test tube, attach the holder, and heat cautiously; hold the test tube so that the open end is slightly the lower, and move the test

tube slowly back and forth in the flame. Heat until there is definite evidence of a change in the wood, and then remove the test tube from the flame. Slip out the solid, and when cool examine it. Has the essential change in the wood been physical or chemical?

B. *Fusible Metal.* Examine a small, thin piece of fusible metal and note its characteristic properties. Fill the test tube half full of water, attach the holder, and heat the water to boiling, taking care not to heat the test tube above the surface of the water. When the water is boiling, remove the test tube from the flame, slip the metal into the test tube, and observe the change in the metal, if any. Cool the water by holding the lower part of the test tube in a stream of water. When the test tube is cool enough to handle without discomfort, pour off the water, and slip out the solid. Examine the metal carefully and compare its properties with those originally observed. What kind of a change did the metal undergo?

C. *Glass or Rubber.* Rub a glass rod or a fountain pen briskly on a piece of cloth, and hold it near very small bits of dry paper. Describe the result. After a moment try again. What kind of a change did the glass or the rubber (of the pen holder) undergo?

D. *Sulphur.* Examine a piece of sulphur and note its properties, e.g. color, brittleness, solid condition. Put a small piece on a block of wood and light the sulphur by directing the flame upon it. Observe the color and size of the flame of the burning sulphur. Observe also (very cautiously) the odor of the gaseous product by wafting a little gently toward the nose. Compare the properties of this gaseous substance with those of the sulphur. Has the essential change in the sulphur been physical or chemical? Why?

NOTE. — As soon as the properties of the burning sulphur have been observed, extinguish it with a little sand or by pressing it with a piece of stiff paper.

Supplementary Experiments

Not all the Supplementary Experiments need be done. Those should be selected that are needed to emphasize certain applications or principles. These Experiments may also be assigned to pupils who work quickly or who need special preparation for examinations.

Experiment 3 — Properties of Iodine

Materials. — Iodine, alcohol, carbon disulphide.

(*a*) Examine a piece of iodine and observe its physical state, luster, color, and odor. Touch it with the finger and observe the effect upon the skin. Drop a piece into a test tube half full of water. Is it heavier or lighter than water? Stand the test tube in the rack and let it remain undisturbed until needed for (*c*).

(*b*) Drop a piece of iodine into a dry test tube, grasp the test tube near the top with the test tube holder, and gently heat the bottom of the test tube in the upper part of the flame until a definite change occurs in the iodine. What is the effect of heat upon iodine?

(*c*) The solubility of iodine may now be determined. Shake the test tube containing the water and iodine, let any undissolved iodine settle and then pour the liquid into another test tube. Examine this liquid. Is there evidence of dissolved iodine? If the evidence is inconclusive, add a few drops of carbon disulphide and shake well. Carbon disulphide is much heavier than water and sinks to the bottom; at the same time it absorbs any dissolved iodine and becomes violet in color. What final conclusion can be drawn regarding the solubility of iodine in water? Measure 15 cubic centimeters of alcohol in the graduated cylinder, and pour it into the other test tube that contains the piece of undissolved iodine. Shake well, and warm slightly by holding the test tube above a low flame for a minute or two; *take care not to set the alcohol on fire.* Shake well. What is the evidence of the solubility of iodine? Confirm the conclusion by pouring a little of this liquid into a test tube half full of water, adding a few drops of carbon disulphide, and shaking well. What final conclusion can now be drawn regarding the solubility of iodine in alcohol?

(*d*) Summarize briefly the properties of iodine.

Experiment 4 — Physical and Chemical Changes

MATERIALS. — Copper wire, electric bell apparatus.

(*a*) Examine a piece of clean copper wire and notice especially its color and flexibility. Grasp one end of the wire with the forceps, and hold the other end in the hottest part of the flame until the copper melts and undergoes a definite change. Then remove it from the flame and examine the black product. Compare its properties with those of copper. Is it apparently a different substance from the copper? Why? What kind of a change did the melted copper undergo?

(*b*) Introduce a piece of copper wire into the circuit of an electric bell apparatus. Does copper conduct electricity? Remove the wire and examine it. What kind of a change did it undergo?

(*c*) Roll a piece of copper wire into a ball, drop it into a test tube half full of dilute nitric acid, and warm gently. What is the evidence that the copper is undergoing a change? Verify the observation by utilizing a preceding experiment. What kind of a change did the copper undergo when treated with nitric acid?

Experiment 5 — Physical and Chemical Changes

MATERIALS. — Magnesium, forceps.

Examine a piece of magnesium and note its properties, especially the luster, color, and flexibility. Grasp one end firmly with the forceps and hold the other end in the flame for an instant and then remove it. Observe the result. Examine the whitish substance that is formed and compare its properties with those of magnesium. Has the essential change in the magnesium been physical or chemical? Why?

OXYGEN

Experiment 6 — Preparation and Properties of Oxygen

MATERIALS. — 15 grams of potassium chlorate, 15 grams of manganese dioxide, 5 bottles (about 250 cubic centimeters each), filter paper, joss stick or splint of wood, sulphur, deflagrating spoon, piece of charcoal fastened to one end of a copper wire (30 centimeters long) and a wad of iron thread (often called "steel wool") to the other end. The apparatus is shown in Fig. 108. *A* is a large test tube provided with a one-hole rubber stopper, to which is fitted a short glass tube *B;* the delivery tube *D* is attached to the short glass tube by the rubber tube *C*.

I. *Preparation.* Weigh the potassium chlorate on a piece of paper creased lengthwise, and slip it into the test tube; do the same with the manganese dioxide. Shake the test tube until the chemicals are thoroughly mixed; then hold the test tube in a horizontal position and roll or shake it until the mixture is spread along about one half of the tube. Insert the stopper with its tubes, and clamp the test tube to the iron stand, as shown in Fig. 108, taking care not to crush the tube.

Fill the pneumatic trough with water, until the support is just covered. Fill the bottles *full* of water, cover each with a piece of filter paper, invert one of them in the trough, remove the filter paper, and stand the inverted bottle upon, or near, the support. The end of the delivery tube *D* should rest on the bottom of the trough, just under the hole in the support.

Before proceeding, ask the Teacher to inspect the apparatus. Heat the whole test tube gently with a flame about 10 centimeters (or 4 inches) high. When the gas bubbles regularly through the water slip the inverted bottle over the hole in the support. The gas will rise in the bottle and force out the water. Move the flame slowly along the test tube, taking care not to heat the tube too long in one place nor too near the rubber stopper. If the gas is evolved too rapidly, lessen the

heat; if too slowly, increase it; if not at all, examine the stopper and the rubber connecting tube for leaks, and adjust accordingly. When the first bottle of gas is full, remove it, cover it with a piece of wet filter paper, and stand it upon the desk; invert another bottle, remove the filter paper, and slip the bottle over the hole. When five bottles of gas have been collected, immediately remove the end of the delivery tube from the water, lest the cold water be drawn up into the hot test tube as the gas contracts. Perform II at once.

II. *Properties.* Proceed as follows with the oxygen prepared in I. (*a*) Dip a glowing joss stick into one bottle, and observe the change. Remove the joss stick, make it glow again, and repeat as many times as possible. How does the glowing joss stick change? Does the oxygen burn? What property of oxygen does this experiment show?

(*b*) Put a small piece of sulphur in the deflagrating spoon, hold the spoon in the Bunsen flame until the blue flame of the

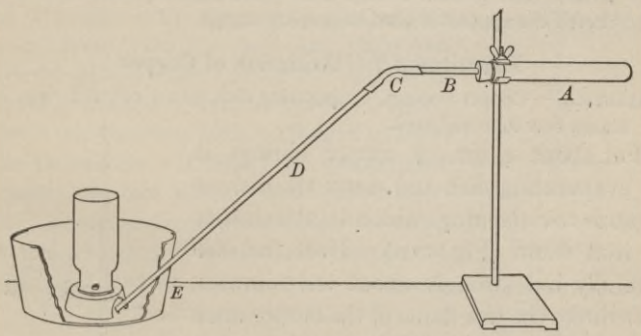

Fig. 108. — Apparatus for Preparing Oxygen.

burning sulphur can be seen, then lower the spoon into a bottle of oxygen. Notice any change in the flame. Waft a little of the gaseous product toward the nose. Of what does the odor remind you? As soon as the results are conclusive, remove the spoon and plunge it into the water in the trough to extinguish the burning sulphur.

(*c*) Hold the charcoal in the flame long enough to produce a faint glow, then lower it into a bottle of oxygen. Observe the result.

Fig. 109.—Iron Thread Attached to End of Copper Wire.

(*d*) Twist one end of the copper wire (used in (*c*)) firmly around the wad of iron thread (Fig. 109), heat the ends of a few strands of the thread an instant in the flame, and quickly lower it into a bottle of oxygen. The iron thread should change conspicuously. If it does not, heat it a second time in the flame, and lower it again into the bottle of oxygen. Observe the result.

(*e*) With the remaining bottle, repeat any of the above experiments.

NOTE. — Clean the test tube used in **6** I with a little warm water.

Required Exercises.— 1. Write a brief account of Exp. **6** I in your note book.

2. Write a brief account of Exp. **6** II, answering all questions.

3. Sketch the apparatus used to prepare oxygen.

Experiment 7 — Oxidation of Copper

MATERIALS. — Copper borings, evaporating dish, gauze-covered ring, iron stand, test tube and cork.

Put about 4 gm. of copper borings in an evaporating dish and stand the dish on a gauze-covered ring, which is attached to an iron stand (Fig. 110). Heat the dish carefully but strongly about ten minutes; then direct the free flame of the burner upon the contents of the dish for about five minutes, stirring occasionally with a glass rod. Describe any marked change in the copper. When the dish is cool, pour the contents into a test tube, cork the test tube tightly, and save for use in Exp. **11**.

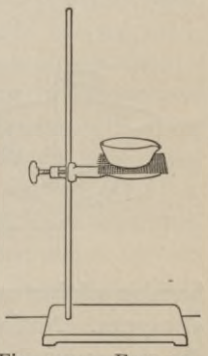

Fig. 110. — Evaporating Dish on a Gauze-covered Ring.

Describe the experiment briefly. What chemical compound was formed? What elements combined?

What general name is given to this kind of chemical change? What special name?

NOTE. — The dish can be cleaned by warming dilute nitric acid in it.

SUPPLEMENTARY EXPERIMENTS

(See note on page 14.)

Experiment 8 — Preparation of Oxygen from Various Substances

(Each pupil need not perform all of this experiment.)

MATERIALS. — Mercuric oxide, lead dioxide, barium dioxide, sodium peroxide, hydrogen peroxide, potassium permanganate, joss stick.

A. *Mercuric Oxide.* Put a little mercuric oxide on the end of a narrow piece of paper creased lengthwise, and slip the powder into a test tube. The powder should nearly fill the round end of the test tube. Hold the test tube in a horizontal position, shake it to spread the powder into a thin layer, and then clamp the test tube in the position shown in Fig. 111. Heat the test tube strongly with the upper part of the Bunsen flame. Do not heat one place, but move the burner back and forth. As soon as a definite change is noticed inside the tube, insert a glowing joss stick. Observe and describe the change. If there is no change, heat strongly, and test again. What gas is liberated? Examine the deposit inside the tube. What is it? If you are in doubt, scrape out a little, and examine again. State the result of the final observation.

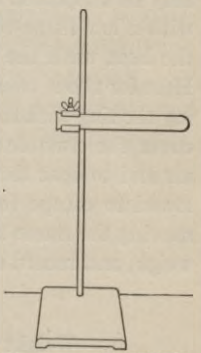

Fig. 111.—Test Tube Clamped in Position for Heating Certain Substances.

B. *Lead Dioxide.* Put a little lead dioxide into another test tube and proceed with the heating as in **A.** Test with the joss stick. Observe and state the result.

C. *Barium Dioxide.* Proceed as in **B** using barium dioxide.

D. *Sodium Peroxide and Water.* Fill a test tube two-thirds full of water and stand it in the test tube rack. Obtain from the Teacher a little sodium peroxide on a creased paper, cautiously slip the sodium peroxide into the water, and then thrust a glowing joss stick into the upper part of the test tube. Observe and state the result.

E. *Hydrogen Peroxide and Potassium Permanganate.* Fill a test tube one-third full of hydrogen peroxide, add half the volume of dilute sulphuric acid, and then several drops of potassium permanganate solution. Test as in **D**. State the result.

Experiment 9 — Effect of Heating a Known Weight of a Metal in Air

MATERIALS. — Porcelain crucible and cover, zinc dust, triangle, scales.

Clean and dry a porcelain crucible and cover, and weigh both on the scales (or on the balance, if desired). Record the weight as shown below. Crease a slip of paper lengthwise, pour zinc dust into the crease and slide the zinc dust into the crucible until about 3 gm. have been added, and then weigh accurately (including the cover). Record as below. Place the covered crucible on the triangle, which may be supported by a ring attached to an iron stand. Heat gently with a low flame to avoid breaking the crucible. Gradually increase the heat until the flame is just above the bottom of the crucible. Heat for about twenty minutes. Lift the cover occasionally by grasping the ring with the forceps. If the zinc glows and a smoke escapes, cover the crucible at once to prevent loss; it is necessary to admit air and to heat the zinc very hot, but little or nothing should be allowed to escape from the crucible. Cool the crucible gradually by moving the flame slowly beneath it. As soon as the crucible is cool, weigh, and record as below. To what is the change in weight due?

RECORD

Weight of crucible, cover, and zinc .....
" " " and cover .....
" " zinc .....
" " crucible and contents before heating .
" " " " " after " ..
Change in weight .....

NOTE. — The crucible can be cleaned with dilute hydrochloric acid.

HYDROGEN

Experiment 10 — Preparation and Properties of Hydrogen

MATERIALS.— Granulated zinc, dilute sulphuric acid, four bottles, filter paper, taper, matches, and the apparatus shown in Fig. 112. *A* is a bottle provided with a two-hole stopper, through which passes the dropping tube *B* and the right-angle bend *C;* the (15 centimeters or 6 inches) tube *D* is attached to the bent tube by the rubber tube *E*. The dropping tube is made as follows: Cut off the top of a thistle tube about 2.5 centimeters (1 inch) below the juncture of the stem and cup, and heat the sharp ends a minute or two in the flame; when cool, slip a *thick-walled* rubber tube (5 centimeters or 2 inches long) over one end of the stem, attach a pinch-clamp to the rubber tube, and connect the tube with the cup, taking care to have the ends of the glass tubes as near together as possible; if properly constructed, the cup will remain upright when full of liquid.

I. *Preparation.* Weigh about 40 gm. of granulated zinc and slip it into the bottle. Insert the stopper with its tubes. Fill the pneumatic trough with water as usual, and adjust the apparatus so that the end of the delivery tube rests on the bottom of the trough under the hole in the support. Fill the bottles with water, and cover with filter paper; invert one in the trough, remove the paper, and stand the inverted bottle upon the support.

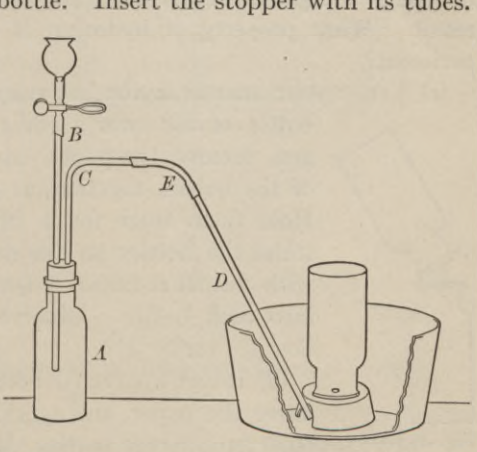

Fig. 112.—Apparatus for Preparing Hydrogen.

Fill the cup with dilute sulphuric acid, and let the acid run

into the bottle by pinching the clamp; if the acid does not flow freely down the tube into the bottle, loosen the stopper for an instant, and as soon as the acid enters the bottle push the stopper into place. The interaction of the zinc and sulphuric acid produces hydrogen, and the gas will bubble through the water in the trough up into the bottle. Collect and remove the bottles of gas as in the Preparation of Oxygen, taking care to cover each bottle tightly with a piece of wet filter paper. If the evolution of gas slackens or ceases, add a little more acid through the dropping tube. Collect four bottles of hydrogen, and perform II at once.

II. *Properties.* Proceed as follows with the hydrogen gas prepared in I. (*a*) Uncover a bottle for an instant to let a little air in, and then drop a lighted match into the bottle. Observe the result.

(*b*) Remove the paper from another bottle of hydrogen, and allow it to remain uncovered for three minutes — by the clock. Then show the presence or absence of hydrogen by dropping a lighted match into the bottle. Observe the result. What property of hydrogen is shown by this experiment?

(*c*) Verify your answer to the last question, thus: Hold a bottle of air over a covered bottle of hydrogen, remove the paper, and bring the mouths of the bottles together, as shown in Fig. 113. Hold them there for a minute or two, then stand the bottles on the desk and cover them with wet filter paper. Drop a lighted match into each bottle. Observe the result. How does (*c*) verify (*b*)?

Fig. 113 — Transferring Hydrogen.

(*d*) Invert a covered bottle of hydrogen, remove the paper, and quickly thrust a lighted taper up into the bottle. Withdraw the taper, then insert and withdraw it several times, and observe carefully (1) whether the hydrogen burns, and, if so, where? and (2) if the taper burns inside

and outside the bottle. Feel of the neck of the bottle; describe and explain.

NOTE. — As soon as this experiment is completed, pour off the acid from any unused zinc. If Exp. **11** is not to be performed soon, wash the zinc several times, and save it for other experiments.

Required Exercises. — 1. Write a brief account of Exp. **10** I.

2. Write a brief account of Exp. **10** II, answering all questions.

3. The apparatus used to prepare hydrogen is called a generator; sketch it (from memory, if possible).

Experiment 11 — Reduction of Copper Oxide by Hydrogen

MATERIALS. — Copper oxide, apparatus shown in Fig. 114.

Put the copper oxide that was prepared in Exp. **7** in an evaporating dish, stand the dish on a gauze-covered ring attached to an iron stand (Fig. 110), and heat gently. Mean-

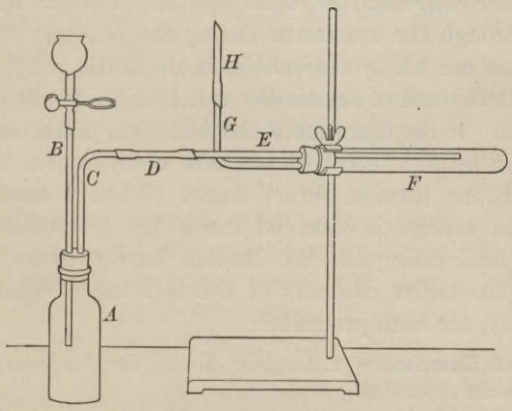

Fig. 114. — Apparatus for the Reduction of Copper Oxide by Hydrogen.

while, arrange the apparatus. The parts lettered *A*, *B*, *C*, *D*, *E*, constitute the hydrogen generator and are the same as those used in Exp. **10** I. *F* is a large test tube fitted with a two-hole stopper; the delivery tube *E* passes through one

hole and extends nearly to the bottom, and the right-angle tube *G* passes just through the other hole; the tube *G* is lengthened by the rubber tube *H*.

Slip the copper oxide into the test tube *F*, hold the test tube in a horizontal position and tap it gently to spread the solid into a long, thin layer. Connect the test tube with the rest of the apparatus, and clamp it into the proper position, taking care not to crush the tube.

Ask the Teacher to inspect the apparatus, and do not proceed until permission is given. After obtaining permission, fill the cup of the generator nearly full with dilute sulphuric acid, pinch the clamp, and let about half the acid run into the generator bottle. Allow the gas to flow steadily for at least two minutes before lighting the Bunsen burner; then introduce a little more acid. Now, heat gently the lower part of the test tube where the copper compound is located. *Do not let the flame come near the rubber tube H.* The gas must flow slowly through the apparatus during the heating; if it does not (as you can tell by the bubbles in the bottle or by smelling the gas at the end of the rubber exit tube), introduce a little more acid. If the test tube *F* should break, pinch the rubber tube *D* an instant to cut off the flow of hydrogen, and then extinguish the Bunsen burner flame. When a marked and permanent change is observed inside the test tube *F*, stop heating, and extinguish the Bunsen burner flame *at once.* Observe the entire contents of the test tube; what, in all probability, are both products?

Required Exercises. — 1. Describe briefly the whole experiment, and sketch the apparatus.

2. What chemical compound was formed in *F*?

3. How was the copper compound changed? What special name is given to this kind of a change?

4. Recall Exp. **7**; in Exps. **7** and **11**, what was oxidized, what was reduced, and what substances accomplished the oxidation and the reduction? Summarize in a few words how Exps. **7** and **11** illustrate oxidation and reduction.

Supplementary Experiments

(See note on page 14.)

Experiment 12 — Preparation of Hydrogen from Various Compounds

(*If desired*, **D** *and* **E** *may be performed later as Exp.* **29 A**.)

Materials. — Magnesium, aluminium, zinc, iron, hydrochloric acid sulphuric acid, sodium hydroxide, sodium, calcium.

A. *Metals and Hydrochloric Acid.* Fill a test tube half full of dilute hydrochloric acid, stand the test tube in the rack, and drop in a small piece of magnesium. In a minute or two test the escaping gas by holding a lighted match (or a low flame) at the mouth of the test tube. What gas is it? What was its source? (If the test is not decisive, add more magnesium, or wait until more gas accumulates in the test tube.) Proceed in the same way with aluminium, zinc, and iron (in the form of filings); use separate test tubes, and heat, if the action is slow. Observe the result in each case, and apply the questions asked about magnesium.

B. *Metals and Sulphuric Acid.* Proceed as in **A** and observe the result in each case. Answer the questions asked in **A.**

C. *Aluminium and Sodium Hydroxide.* Roll two or three pieces of aluminium into a ball, drop it into a test tube, slip in a piece of sodium hydroxide about 2.5 cm. (or 1 in.) long, and add a little water. Warm slightly, if no action results, and test as above. Observe the result. Answer the questions asked in **A.**

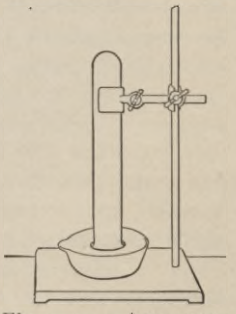

Fig. 115. — Apparatus for collecting the Gas Liberated by the Interaction of Water and Metals.

D. *Sodium and Water. Precaution.* Sodium should be handled cautiously and used strictly according to directions. Small fragments obtained for experiments should be protected by a mortar or dish. If sodium is left from an experiment, it must not be thrown into the refuse jar, but returned to the Teacher. — Fill a porcelain evaporating dish two-thirds full of water. Fill a small test tube

full of water, cover and invert it, and clamp it as shown in Fig. 115. Wrap a small piece of clean sodium loosely in a piece of tea lead about 5 centimeters (2 inches) square, make two or three small holes in the tea lead, and then thrust it under the test tube. A gas will rise into the test tube. Proceed similarly with additional pieces of sodium and *dry* tea lead until the test tube is full of gas; then unclamp it, remove, and invert. Hold a lighted match, for an instant, at the mouth of the tube. Observe the result, especially at the mouth of the tube. What is the gas? What was it source?

E. *Calcium and Water.* Arrange the apparatus as in **D.** Drop two or three pieces of calcium into the water in the dish, and push them under the test tube. As soon as the tube is full, or nearly full, remove the tube, and test the gas as in **D.** State the result. Answer the questions asked in **D.**

PROPERTIES OF GASES

Supplementary Experiment

Experiment 13 — Weight of a Liter of Oxygen

(If desired, this Experiment may be postponed until the pupil has acquired more experience in the laboratory. It is suggested that it be performed while Chapter VII or VIII is being studied.)

Materials. — Potassium chlorate, manganese dioxide, calcium chloride, glass wool or shredded asbestos, and the apparatus shown in Fig. 116. *A* is a large test tube attached to the bent tube *F* by a rubber stopper. *B* is a large bottle to be filled with water; it is provided with a two-hole rubber stopper, through which pass *F* and *C*, the latter being connected with a rubber tube *C′* to which is attached the short glass tube *G*. A Hofmann screw is attached at the point *E*. Another large bottle *D* serves to catch the water forced over from *B* through *CC′* by the oxygen generated in *A*. A hook (*S*) of aluminium wire permits *A* to be hung from the balance beam in weighing.

Fill the space 1 in *A* with a mixture of manganese dioxide and potassium chlorate (about equal parts). Each substance must be powdered and free from organic matter (e.g. paper, cork, straw). The mixture should be dried by heating it in an oven to about 110° C., on a radiator, or on some convenient heated object. Push glass wool, or shredded asbestos (previously ignited to a red heat), into the space 2 in *A*. Put small lumps of calcium chloride into 3 and glass wool into 4. Push the stopper well into the test tube. Wipe *A* carefully with soft paper, and then weigh *AF* on the balance. Weigh the empty, dry, clean bottle *D* to a decigram on the scales.

Fill *B* with water nearly to the neck. Fill *CC′* with water and tighten the Hofmann screw to prevent the water from running out. Insert *F* into the stopper of *B*. Push the stopper into the bottle, slowly at first, then hard; if water rises in *F*, loosen the screw at *E* slightly, remove *A*, and blow gently into *F* to force the water back into *B*. When properly adjusted, the water should be in *B* and *CC′*, but not in *F*. Replace *A*, taking care not to crush the thin glass by

pushing it too hard upon its stopper; open the screw at *E*. If the apparatus is tight, little or no water will flow out. It should be adjusted until air tight. Leave the screw open.

Heat *A* gently with a low flame, keeping the flame back of the space 2. The liberated oxygen will force the water from *B* into *D*. Heat *A* just hot enough to cause a gentle flow of water into *D*. When *D* is about three-fourths full, decrease the heat gradually. While *A* is cooling sufficiently to weigh, stand a thermometer in *D;* also read the barometer. When *A* is cold, raise *B* until the water is at the same level in *B* and *D*, pinch *C'* tight and remove it from *D*. Read and remove the thermometer. Dry *D* on the outside, if necessary, and then weigh it, using the same large weights as before; the gain in weight (in grams) of *D* gives the volume (since 1 gm. of water = 1 cc.) of oxygen liberated. Weigh *AF;* its loss in weight is the weight of the oxygen that passed into *B*.

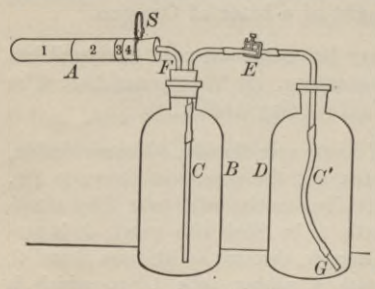

Fig. 116. — Apparatus for Finding the Weight of a Liter of Oxygen.

Reduce the observed volume to the volume it would occupy, if it were at 0 C., 760 mm., and in the dry state. This is done by the formula —

$$V = \frac{V'\,(P' - a)}{760\,(1 + (.00366 \times t))}$$

Substitute the proper values in this formula, and solve for V — the corrected volume of oxygen liberated. (See Part I, **33, 34, 40.**)

Since 1 liter contains 1000 cubic centimeters, then V/1000 is the actual volume of liberated oxygen expressed in liters. The weight of liberated oxygen is found by subtracting the weight of *AF* after heating from its weight before heating. And finally the weight of 1 liter of oxygen in grams is found by dividing the weight of liberated oxygen by its volume.

PROPERTIES OF WATER

Experiment 14 — Water in Food

MATERIALS. — Substances enumerated below.

Heat gently in a dry test tube a small piece of meat. Hold the open end of the test tube lower than the closed end, and take care not to burn the substance. What substance is liberated? Repeat, using a dry test tube in each case and a small piece of one or more of the following: Potato, apple, cranberry, celery, bread, cracker. Observe and state the result in each case.

Experiment 15 — Some Physical Properties of Water

MATERIALS. — Copper wire, ice, thermometer, salt.

A. *Conduction of Heat.* Wind enough copper wire around a small lump of ice to make it sink in water, slip it into a large test tube nearly full of water, and quickly heat the water to boiling near the surface. Observe the result as soon as the water boils. What does this experiment show about the conducting power of water?

B. *Expansion and Contraction.* Fill a large test tube full of water, and insert a one-hole rubber stopper fitted with a short glass tube. Attach the test tube holder and heat the water slowly. Observe any change in the volume as the water increases in temperature. Now cool the water by holding the test tube in a stream of running water and observe any change in the volume. What does this experiment show about the expansion and contraction of water when its temperature changes?

C. *Boiling Point.* Fill a large test tube half full of water, clamp it in an upright position to an iron stand, and heat the water to boiling. Hold the bulb of a thermometer in the escaping steam and note the highest temperature recorded. Slowly

lower the thermometer until the bulb touches the boiling water, note the highest temperature, and then remove the thermometer. Compare the two maximum readings. Average them and record the result.

D. *Freezing Point.* (*a*) Put several small pieces of ice into a 250 cc. bottle, add a little water, and about 10 gm. of coarse salt. Fill a small test tube half full of water, insert a thermometer until the bulb is immersed, and lower the test tube into the mixture of ice and salt. Stir the water with the thermometer, and note the temperature at which ice begins to form in the test tube; remove the test tube, melt the ice, and try again. Make several trials and note each result; take an average of the temperatures observed and record the result.

(*b*) Fill a 250 cc. bottle half full of water, drop in several pieces of ice, and shake for two or three minutes. Insert the thermometer until the bulb is immersed and note the lowest temperature; repeat, and take an average, as in (*a*).

Experiment 16 — Some Chemical Properties of Water

(*If desired,* **A** *may be performed later as Exp.* **29 B.**)

MATERIALS. — Sodium, potassium, calcium, test wire, zinc sulphate solution, sulphur, calcium oxide.

A. *Interaction with Metals.* (*a*) Sodium and potassium. (See *Precaution* in Exp. **12 D.**) Fill an evaporating dish half full of water. Obtain three or four small pieces of sodium from the Teacher; place a mortar over the sodium until needed. Drop a piece of sodium upon the water in the dish, stand back and observe the result, waiting for the slight explosion before approaching the dish again; repeat with the rest of the sodium, piece by piece. When the chemical action is over, stand the dish on a gauze-covered ring attached to an iron stand (see Fig. 110), and heat until the water is entirely evaporated.

Meanwhile, proceed with the potassium. Fill a pneumatic trough half full of water. Obtain a small piece of potassium from the Teacher, and drop the potassium upon the water.

Stand back and observe the result, waiting for a slight explosion as in the case of sodium.

As soon as the water has been evaporated from the dish, examine the residue as follows: (1) Moisten the end of a glass rod, touch the residue with it, and then draw this end across a piece of moistened red litmus paper. Observe the change in color of the litmus paper; this change in color of red litmus paper is always caused by the strong hydroxides — sodium hydroxide in this case. (2) Moisten the looped end of a clean test wire (Fig. 103), touch it to the residue, and hold the end of the wire in the lower and outer part of the Bunsen flame. Observe the color of the flame; it is caused by the sodium in the residue. The production of this color is one of the tests for sodium. (3) Dissolve the residue in 5 cc. of water, pour a little of the solution into a test tube, add a few drops of zinc sulphate solution, and shake. Observe the result. Now pour the rest of the solution into the test tube and shake well. Observe the result. This is a test for the hydroxide part of sodium hydroxide.

Required Exercises. — 1. What property of water is shown by Exp. **16 A** (*a*)?

2. State the chemical change involved in the interaction of sodium and water.

3. The interaction of potassium and water is analogous to that of sodium and water; express the essential chemical change in the form of an equation (using the names of the substances).

(*b*) Calcium. Fill a small test tube nearly full of water, — warm slightly and stand the test tube in the rack. Drop a small piece of clean calcium into the test tube, and observe the result. If the action is not marked, add another piece of calcium or warm the water. In a minute or two, test the gas evolved. What is it? Examine the contents of the test tube for evidence of another product. If the evidence is doubtful, let the action continue and examine the test tube subsequently, especially the lower part.

Recalling the chemical change in (*a*), what chemical change has in all probability taken place in (*b*)?

B. *Combination with Oxides.* (*a*) Put a little water in a bottle. Set fire to a small piece of sulphur in a deflagrating spoon and lower the burning sulphur into the bottle. Let it burn a minute or two, then extinguish it by dipping the spoon into the water. Remove the spoon, cover the bottle with the hand, and shake well. Dip a glass rod into the liquid, touch the moistened end to a piece of blue litmus paper, and observe the change in color. This change in the color of blue litmus is caused by acids; in this case the acid is sulphurous acid, which was produced by the combination of the sulphur oxide and water.

(*b*) Boil a small piece of calcium oxide with a little water in a test tube. Test with red litmus paper. If the result is indifferent, put the paper in the test tube and shake well. Observe the result. Recall, or review, the explanation in **A** (*a*) (1).

Required Exercises. — 1. State briefly the essential chemical change that took place in Exp. **16 B** (*a*). Also in (*b*).

2. State these chemical changes in the form of equations (using the names of the substances).

Experiment 17 — Solubility of Gases

MATERIALS. — As below.

(*a*) Fill a test tube half full of water, close with the thumb and shake the test tube vigorously up and down several minutes. Warm the test tube very gently. What is the immediate evidence of dissolved gas? What effect has increased heat on the dissolved gas?

(*b*) Heat the following in separate test tubes as in (*a*): Faucet water, ammonia solution, hydrochloric acid solution. Do the results resemble those in (*a*)? As soon as the observation is made, pour the liquids down the sink and flush it well with water.

Experiment 18 — Solubility of Liquids

MATERIALS. — Alcohol, kerosene, glycerin, aniline, ether, carbon disulphide.

(*a*) To a test tube half full of water add a little alcohol and shake. Is there evidence of solution? Add a little more and

shake well. Add a third portion and shake. Is there still evidence of solution? Draw a conclusion as to the solubility of alcohol in water.

(*b*) Repeat (*a*), using successively kerosene, glycerin, aniline, ether, and carbon disulphide. Observe the results and conclude accordingly.

(*c*) Tabulate the results of (*a*) and (*b*) under the headings Mutually Soluble, Partly Soluble, Insoluble.

Experiment 19 — Solubility of Solids

MATERIALS. — About 20 gm. of powdered copper sulphate, 6 gm. of powdered potassium chlorate, 1 gm. of calcium sulphate, calcium hydroxide solution, sodium chloride.

A. *General.* (*a*) Label three test tubes, I, II, III. Put 10 cc. of water into each. To I add 1 gm. of powdered copper sulphate, to II add 1 gm. of powdered potassium chlorate, to III add 1 gm. of calcium sulphate. Shake each test tube, and then allow them to stand undisturbed for a few minutes. Is there evidence of solubility in each case? Is there evidence of a varying degree of solubility? If III is doubtful, carefully transfer a portion of the *clear* liquid to an evaporating dish by pouring it down a glass rod (see Int. **6** (1)), and evaporate to dryness. Is there now conclusive evidence of solubility? Save solutions I and II for (*b*).

Tabulate the results of (*a*) as follows, using the customary terms to express the degree of solubility: —

TABLE OF SOLUBILITY OF TYPICAL SOLIDS

Solute	Solvent	Results
1. Copper Sulphate 2. Potassium Chlorate 3. Calcium Sulphate	Water at temperature of laboratory	1. 2. 3.

(*b*) Heat I, and add gradually 4 more gm. of powdered copper sulphate. Does it all dissolve? Heat II and add 4 more gm. of powdered potassium chlorate. Does it all, or most all, dissolve? What general effect has increased heat on the solubility of solids? Save the solutions for (*c*).

(*c*) Heat I and II nearly to boiling, and as the temperature increases add the respective solids. (Do not boil the solution; keep it near the boiling point by frequent heating.) Is there a limit to their solubility? Draw a general conclusion from these typical results.

B. *Special.* (*a*) Fill a test tube half full of clear calcium hydroxide solution, and heat it to boiling. Observe the result. Compare with the cold solution. What effect has heat upon the solubility of calcium hydroxide?

(*b*) Prepare a saturated solution of sodium chloride by heating about 5 gm. in 10 cc. of water; shake frequently, and finally bring the solution to the boiling point, but do not evaporate much of the water. Let the test tube stand a minute, and then pour the solution into another test tube. Observe its general appearance. When cool, examine and compare with the clear, hot solution. Answer as in (*a*).

Experiment 20 — Crystallization

MATERIALS. — Copper sulphate, alum, potassium dichromate, potassium ferrocyanide, sodium chloride, borax.

Prepare a hot, concentrated solution of one or more of the following substances, using about 25 cc. of water and the number of grams indicated: Copper sulphate (25), alum (25), potassium dichromate (15), potassium ferrocyanide (25), sodium chloride (10), borax (5). Pulverize the solid, if it is not provided as a powder. Prepare the solution by boiling the mixture of water and the solid in a large test tube several minutes. Let any undissolved solid settle, and then pour most of the clear solution down a moistened glass rod (see Int. **6** (1)) into an evaporating dish, or another small shallow vessel, taking care not to let any undissolved solid get into

the dish. Suspend a piece of thread across the dish and push it down into the solution. Stand the whole aside to crystallize. Examine at intervals, and when well-shaped crystals have formed, especially on the thread, remove them. Dry the crystals carefully with filter paper. Examine them, using a lens if the crystals are small, and observe the properties, particularly the shape, luster, and color. (Save the crystals for later experiments.)

Experiment 21 — Testing for Water of Crystallization in Various Substances

MATERIALS. — See below.

Test several of the crystallized substances enumerated below for water of crystallization by heating a dry specimen of each in a test tube inclined so that the open end is the lower: Sodium carbonate, potassium dichromate, ferrous sulphate, borax, barium chloride, alum, zinc sulphate, sodium sulphate, calcium sulphate, sodium chloride, potassium nitrate, sugar, magnesium sulphate, potassium bromide, and any of the crystallized substances prepared in Exp. **20**.

Observe in each case (1) the change in appearance of the solid during the heating, (2) relative amount of water liberated (if appreciable), (3) appearance of the residue.

Experiment 22 — Per Cent of Water of Crystallization in Crystallized Copper Sulphate

MATERIALS. — Crystallized copper sulphate, evaporating dish.

Clean and dry an evaporating dish and weigh it to a decigram. Record the weight at once in the notebook. (See below.) Powder some copper sulphate and put it into the dish until about 10 gm. have been added; then weigh to a decigram. Record the weight at once (see below). Stand the dish with its contents on a gauze-covered ring attached to an iron stand (see Fig. 110) and heat gently for five or ten minutes, and then strongly until the blue color disappears and

the substance turns to a powder. Do not touch the substance, and take special pains not to lose any. Cool slowly and weigh as before. Record the weight at once, and calculate the per cent of water of crystallization. Submit the result to the teacher for criticism.

RECORD

Weight of dish and substance before heating	=	gm.
Weight " " " " "	=	gm.
Weight " " " " after "	=	gm.
Weight " " " " "	=	gm.
Weight " water of crystallization	=	gm.
Per cent of water of "	=	per cent

Experiment 23 — Efflorescence

MATERIALS. — As below.

Put a fresh, or a recently broken, crystal of several of the following substances on a piece of filter paper, and leave them exposed to the air for an hour or more: Sodium carbonate, sodium sulphate, borax, ferrous sulphate, alum, potassium ferrocyanide, barium chloride, potassium chromate, magnesium sulphate. Describe any marked change. What does the change, if any, show about the air? About the crystal? To what is the change due?

Experiment 24 — Deliquescence

MATERIALS. — As below.

Put on a glass plate or a block of wood a small piece of several of the following substances: Sodium hydroxide, calcium chloride, potassium hydroxide, magnesium chloride, table salt, rock salt, zinc chloride, potassium carbonate, sodium nitrate. Leave them exposed to the air for an hour or more. Describe any marked change which takes place. What does the change show about the air? About the substance? Compare the general change with that of Exp. **23**. To what is the change due?

Supplementary Experiments

Experiment 25 — Water in Various Substances

Materials. — As below in **A**.

A. *Miscellaneous.* Proceed as in Exp. **14** with wood (different kinds), soft coal, fresh grass or leaves, hay, excelsior, raisins or other kinds of dried fruit. State each result.

B. *Per Cent of Water.* Devise a simple experiment to find the approximate per cent of water in bread, potato, meat, or some other substance. Before proceeding, submit the details to the Teacher for criticism.

Experiment 26 — Preparation and Properties of Distilled Water

Materials. — The condenser, etc., shown in Fig. **117**, water containing a little dirt, calcium chloride, and sodium sulphate.

I. *Preparation.* Fill the flask *C* half full of the water containing the impurities mentioned above, add a few short pieces of glass tubing to ensure even boiling, and connect with the condenser as shown in Fig. 117. Attach the inlet (lower) tube to the faucet, fill the condenser slowly, and regulate the current so that a small stream flows continuously from the outlet tube into the sink or waste pipe. Heat the liquid in *C* gradually, and when it boils, regulate the heat so that the boiling is not too violent. Reject the first 5 or 10 cc. of the distillate, for they may contain impurities derived from the apparatus. As the distillate collects in the clean receiver *D*, proceed as in II.

II. *Properties.* (*a*) Taste a little distilled water. Compare with faucet or well water.

(*b*) Test distilled water for dissolved gases by heating a little in a clean test tube. State the result. Compare with faucet water.

(*c*) Test distilled water for organic matter as follows: Fill a very clean test tube half full of distilled water, add a few drops of concentrated sulphuric acid, and enough potassium permanganate solution to color the mixture a light reddish purple. Mix well by stirring with a clean glass rod. Grasp the test tube with the test tube holder and heat gently until the liquid begins to boil, taking care to remove the test tube from the flame occasionally to prevent the liquid from spurting out. If organic matter is present, the color of the solution

will be changed to brown. Test in the same way some of the impure water used in I. Compare the results.

(*d*) Test separate portions of distilled water for mineral matter. (1) *Chlorides.* Add a few drops of nitric acid and of silver nitrate solution to a little distilled water. Proceed in the same way with some of the impure water used in I. Compare the results. The white, curdy solid is silver chloride, which is formed by the chemical action between silver nitrate and the dissolved chloride. All soluble chlorides produce the same result. (2) *Sulphates.* Add a few drops of barium chloride solution to a little distilled water. Proceed in the same way

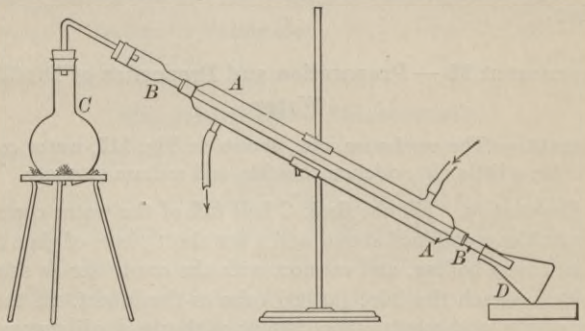

Fig. 117. — Condenser.

with some of the impure water used in I. Compare the results. The white, fine precipitate is barium sulphate, which is formed by the chemical action between barium chloride and the dissolved sulphate; its formation is a test for any sulphate in solution. (3) *Calcium (or lime) compounds.* Add a few drops of ammonium oxalate solution to some distilled water and also to some of the impure water used in I. Compare the results. The white precipitate is calcium oxalate. Its formation serves as a test for dissolved calcium compounds.

(*e*) If time permits, test samples of water from various sources for organic and mineral matter.

Experiment 27 — Solubility of a Given Solid

MATERIALS. — Solution of potassium dichromate, evaporating dish, gauze-covered ring and iron stand, water bath.

Weigh an evaporating dish on the scales, and record the weight in the notebook (see below). Obtain from the Teacher about 50 cc.

of a concentrated solution of potassium dichromate of known concentration. Transfer about 25 cc. into the weighed dish by a graduate, noting exactly the volume taken. (Ask for instructions if this operation is not familiar.) Weigh the dish and contents, and record the weight. Stand the dish on a water bath and evaporate to dryness. While the solution is evaporating, the form of record may be prepared as shown below; complete the evaporation by transferring the dish to a gauze-covered ring (Fig. 110) and heating strongly. When the dish is cool, weigh, and record the weight as shown below. Heat again on the gauze, cool, and weigh; if the two weights are the same (or nearly so), accept the first weighing, but if the weights are considerably different, heat intensely, cool, and weigh until the weight is nearly constant.

Complete the entries in the form of record, and calculate the weight of the solid held in solution by 100 gm. of water.

RECORD

(*a*) Weight of dish .....
(*b*) Volume of solution .....
(*c*) Weight of dish and contents before heating ....
(*d*) Weight of dish and contents after heating .....
(*e*) Weight of solute $(d - a)$.....
(*f*) Weight of solvent $(c - d)$ .....

Experiment 28 — Supersaturation

MATERIAL. — Sodium thiosulphate.

Fill a test tube half full of crystallized sodium thiosulphate and add two or three cubic centimeters of water. Warm slowly. As solution occurs, heat gradually to boiling. When all the solid has dissolved, pour the solution into a warm, clean, dry test tube, insert a cork or a wad of cotton in the test tube, and let it stand undisturbed until cool. Observe the contents and compare with Exp. **20**. Then drop in a small crystal of sodium thiosulphate and watch for any simple but definite change. What happens? Observe and state the final result.

COMPOSITION OF WATER

Experiment 29 — Qualitative Composition of Water

MATERIALS. — As in Exp. **12 D** and **E** for **A**, and in Exp. **16 A** for **B**; also, for **C**, chlorine tube fitted with cork, chlorine water, mortar or porcelain dish, iron stand and clamp, joss stick.

A. *Hydrogen.* Recall, perform, or repeat (if necessary) Exp. **12 D** and **E**. State the essential result of each experiment. What evidence do these experiments give about the composition of water?

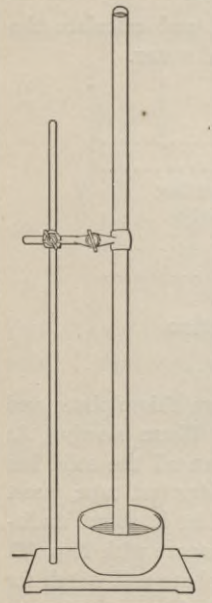

Fig. 118. — Apparatus for Showing that Oxygen is a Constituent of Water.

B. *Hydrogen and Oxygen.* Recall, perform, or repeat (if necessary) Exp. **16 A**. State the essential result. What additional evidence does this experiment give about the composition of water?

C. *Oxygen.* Obtain 250 cc. of chlorine water from the Teacher. If fresh chlorine water is not available, construct a chlorine generator, as described in Exp. **33 I**, and prepare about 250 cc. of chlorine water by causing the gas to bubble through a bottle of water until the water smells strongly of the gas.

Fill the tube with chlorine water, cover the open end with the thumb or finger, invert the tube, and immerse the open end in a mortar or an evaporating dish, which should be nearly full of chlorine water (Fig. 118). Clamp the tube in an upright position, and stand the whole apparatus where it will receive the direct sunlight for several hours. Bubbles of gas will soon appear, rise, and collect at the top. When sufficient

gas for a test has collected, unclamp the tube, cover the open end with the thumb or finger, invert the tube, and put a glowing joss stick into the gas. Repeat as long as any of the gas remains. State the result.

Experiment 30 — Electrolysis of Water

MATERIALS. — Hofmann apparatus, sulphuric acid, joss stick, taper, matches, platinum tip or short piece of capillary glass tubing. (Directions for making the platinum tip may be found in the author's Experimental Chemistry, page 340.)

Fill the Hofmann apparatus (Fig. 119) with water containing 10 per cent of sulphuric acid, so that the water in the reservoir tube stands a short distance above the gas tubes after the stopcock in each has been closed. Connect the platinum terminal wires with a battery of at least three cells. As the action proceeds, small bubbles of gas rise and collect at the top of each tube. Allow the current to operate until the smaller volume of gas is 8 to 10 cubic centimeters. Measure the height of each gas column. Assuming that the tubes have the same diameter, the volumes are in approximately the same ratio as their heights. How do the volumes compare?

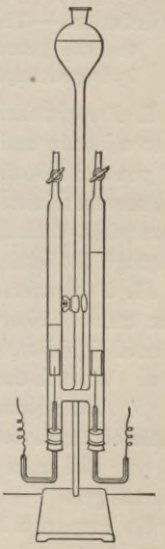

Fig. 119. — Hofmann Apparatus for the Electrolysis of Water.

Test the gases as follows: (*a*) Hold a glowing joss stick near the top of the tube containing the smaller quantity of gas, cautiously open the stopcock to allow the water (or air) to run out of the glass tip, and then let out a little gas upon the glowing joss stick. Repeat several times. What is the gas? (*b*) Open the other stopcock long enough to force out the water (or air) in the glass tip; close the stopcock, and, by means of a short rubber tube, attach the platinum tip or the capillary tube

close to the end of the glass tip. Open the stopcock again, let out a little gas slowly, then hold a lighted match for an instant at the end of the tip, and immediately thrust a taper into the small and almost colorless flame. Repeat several times. What is the gas?

Required Exercises. — 1. Describe the whole experiment and sketch the apparatus.

2. What does this experiment show about the composition of water?

Supplementary Experiment

Experiment 31 — Preparation and Properties of Hydrogen Dioxide

Materials. — Three gm. of barium dioxide, manganese dioxide, potassium permanganate solution, joss stick, lead nitrate solution, hydrogen sulphide solution.

I. *Preparation.* Pour about 25 cc. of dilute hydrochloric acid into a bottle and cool in running water. Add slowly about 3 gm. of powdered barium dioxide; stir constantly during the mixing and for several minutes after. Let the mixture stand until the solid settles somewhat, then filter. If the filtrate is not clear, repeat the filtration through the same paper until it is clear.

II. *Properties.* (*a*) Heat a little of the filtrate from I; observe the result. Now add a little powdered manganese dioxide to the heated liquid and observe the result. Test the escaping gas for oxygen. What is the result?

(*b*) Add several drops of potassium permanganate solution to a little of the filtrate from I and observe the result. Is a gas evolved? If not, add more potassium permanganate solution, and test the gas for oxygen.

(*c*) Prepare a little lead sulphide by adding a few drops of hydrogen sulphide solution to dilute lead nitrate solution. Shake well, add hydrogen dioxide solution (preferably the commercial solution), and warm gently. Observe the result.

(*d*) Examine the inner end of the cork stopper of a bottle of hydrogen dioxide. Explain.

LAW OF CONSTANT COMPOSITION

Supplementary Experiment

(See note to Exp. **13**.)

Experiment 32 — The Combination of Oxygen with Magnesium

Materials. — Porcelain crucible and cover, powdered magnesium, forceps, pronged tripod (or iron ring and triangle), crucible block.

Clean and dry the crucible and cover, and weigh both together on the balance. Record the weight in the notebook as shown below. Put from .4 to .5 gm. of magnesium in the crucible, and weigh again (including cover). Record the weights thus: —

Weight of crucible, cover, and magnesium .....
Weight of crucible and cover .....
Weight of magnesium .....

Stand the crucible on the tripod, as shown in Fig. 120 (or on a triangle supported by a ring), and heat for five minutes with a flame which just touches the bottom of the crucible. Grasp the cover firmly by the ring with the clean forceps, cautiously lift it, and if the magnesium glows, cover the crucible instantly. Repeat this operation at frequent intervals, gradually increasing the heat, until the glow ceases to spread through the mass; then adjust the cover so that a small opening is left between the cover and the crucible, and heat strongly for ten or fifteen minutes. If the contents has ceased to glow, heat the crucible, uncovered, for five or ten minutes. Take care not to upset the cover by accident or insecure handling with the forceps. At no time, should the flame touch the cover of the crucible; generally speaking, the flame should reach as high outside as the magnesium does inside.

Fig. 120.—Covered Crucible Supported on a Tripod.

Fig. 121.—Crucible Block for Carrying a Crucible.

Cool the crucible gradually. When cool enough to touch, it is cool enough to weigh. In carrying the crucible to and from the balance, it should be placed in the crucible block (Fig. 121). Weigh and record in the notebook thus: —

Weight of crucible, cover, and contents, after heating .....
Weight of crucible, cover, and contents, before heating .....
Weight of oxygen which has combined with the magnesium ..

Heat the uncovered crucible again strongly for five or ten mintues, cool, and weigh as before. If the weight is not the same, continue until the last two weights are approximately equal. Record each weight.

From the weights of the magnesium taken and the oxygen found, calculate the ratio in which the two elements combined. Submit the result to the Teacher for criticism before throwing away the contents of the crucible.

NOTE. — The crucible, if blackened, can be cleaned by heating a little sodium hydroxide in it and then washing thoroughly with water.

Experiment 33 — Preparation and Properties of Chlorine

(Perform this experiment in the hood.)

MATERIALS. — Concentrated hydrochloric acid, 30 gm. of manganese dioxide, wad of iron thread, cotton, calico, paper with writing in lead pencil and in ink, litmus paper (both colors), taper, and a piece of copper wire 15 cm. long. The apparatus is shown in Fig. 122. *A* is a 250 cc. Erlenmeyer flask which stands on a gauze-covered ring; the parts lettered *B*, *C*, *D*, *E* have been used in preceding experiments. There are also needed four bottles like *G*, a wooden block *F* (about 10 cm. or 4 in. square) with a hole in the center, four glass plates to cover the bottles.

I. *Preparation.* Weigh the manganese dioxide upon a piece of paper creased lengthwise, and slip it into the flask. Arrange the apparatus as shown in Fig. 122. Introduce enough concentrated hydrochloric acid through the dropping tube *B* to cover the manganese dioxide. Heat the flask *A* gently with a small flame. Chlorine is evolved as a greenish yellow gas, and passes into the bottle *G*, which should be removed when full (as seen by the color) and covered with a glass plate; the bottle may be easily removed by holding the block *F* in one hand and pulling the bottle *G* aside, bending the whole delivery tube at the same time at the rubber connection *D*. If the evolution of gas slackens, introduce more acid. Collect four bottles, and proceed at once with II.

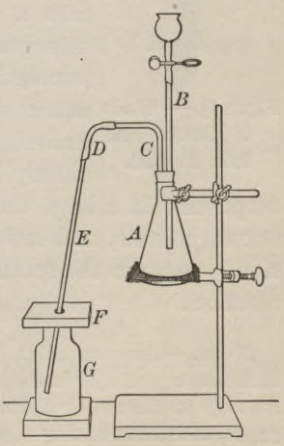

Fig. 122. — Apparatus for Preparing Chlorine.

II. *Properties.* (*a*) Twist one end of the copper wire around a wad of iron thread (Fig. 123), heat the edge of the wad for an instant in the flame, and quickly lower it into a bottle of chlorine. Observe the result. Dissolve the contents of the bottle in a little water, filter if not clear, and test the clear solution for a chloride (see Exp. **26** II (*d*) (1)). State the result.

(*b*) Into a bottle of dry chlorine put a piece of calico, litmus paper (both colors), and paper containing writing in black and in red ink. Allow the whole to remain undisturbed for a few minutes and then observe the change in the materials, if any. Add several drops of water, shake the bottle, and then observe the change. Draw a general conclusion from the whole experiment.

Fig. 123. — Wads of Cotton and Iron Thread.

(*c*) Lower a burning taper a short distance into a bottle of chlorine, and observe the two products as the taper burns. Draw a conclusion. Verify it thus: Twist the other end of the copper wire used in (*a*) around a piece of cotton (Fig. 123); cautiously heat about 10 cubic centimeters of turpentine in a large test tube,[1] saturate the cotton with the hot turpentine, and lower the cotton into a bottle of chlorine. Observe the result, especially at the beginning of the reaction.

NOTE. — As soon as II (*c*) is performed, pour the contents of the flask into a waste jar in the hood. The bottle used in the latter part of (c) may be cleaned by adding water, a little sand, and several pieces of paper, and then shaking vigorously.

[1] Hold the test tube with the holder. Remember that turpentine ignites easily. If the turpentine catches fire, press a damp towel over the mouth of the test tube.

Experiment 34 — The Characteristic Property of Bleaching Powder

MATERIALS. — Bleaching powder, dilute sulphuric acid, colored cloth, unbleached cloth, glass rod, evaporating dish, two bottles.

Put a little bleaching powder into an evaporating dish, and add enough water to make a thin paste. Add 10 cubic centimeters of dilute sulphuric acid to a bottle half full of water. Fill the other bottle nearly full of water. Tear off a small piece of the colored cloth for a sample. Dip the rest of the colored cloth into the bleaching powder and then into the acid, passing it back and forth several times. Finally wash the cloth thoroughly in the bottle of water, squeeze out the excess of water, let the washed cloth dry somewhat, and then compare its color with that of the sample. Describe the change in the appearance of the cloth.

Proceed in the same way with the unbleached cloth, and state the result.

Experiment 35 — Preparation and Properties of Hydrogen Chloride and Hydrochloric Acid

(*Perform this experiment in the hood.*)

MATERIALS. — The *apparatus* shown in Fig. 122; 20 grams of sodium chloride, concentrated sulphuric acid, joss stick, litmus paper (blue), ammonium hydroxide.

I. *Preparation.* (*a*) Hydrogen chloride. Put 8 cubic centimeters of water into a small bottle or an evaporating dish, cautiously add 12 cubic centimeters of concentrated sulphuric acid, and stir until the two are mixed. While this mixture is cooling, weigh the sodium chloride, slip it into the flask, and arrange the apparatus as shown in Fig. 122. Introduce half the cold acid mixture through the tube, let it settle through the sodium chloride, and then introduce the remaining acid. Heat the flask gently with a low flame, as in the preparation of chlorine. Hydrogen chloride is evolved, and passes into the bottle, which should be removed when full, as directed under chlorine. A piece of moist blue litmus paper

held at the mouth of the bottle will show when it is full. Collect three bottles of the gas, cover each, when filled, with a glass plate, and set aside until needed for II.

(*b*) Hydrochloric acid. As soon as the third bottle of gas has been collected, removed, and covered, put in its place a bottle one fourth full of water. Adjust the delivery tube *E* so that the lower end is a short distance above the surface of the water. Continue to heat the flask at intervals, and the gas will be absorbed by the water. Shake the bottle occasionally. Meanwhile perform II.

II. *Properties of hydrogen chloride.* Proceed as follows with the gas prepared in I (*a*): — (*a*) Insert a blazing joss stick once or twice into one bottle, and observe the result. Compare the behavior of hydrogen chloride with that of hydrogen and oxygen under similar conditions.

(*b*) Hold a piece of wet filter paper near the mouth of the same bottle. Observe and describe the result. What is the cause?

(*c*) Invert a bottle of the gas, and stand it in a vessel of water (e.g. the pneumatic trough). Observe any change inside the bottle after a few minutes. What property of the gas does the result illustrate? Verify the observation by a simple test applied to the contents of the bottle.

(*d*) Drop into the remaining bottle of gas a piece of filter paper wet with ammonium hydroxide. Describe the result. What is the name of the product?

(*e*) State other properties of hydrogen chloride which you have observed, e.g. color, odor, density, behavior with litmus.

III. *Properties of hydrochloric acid.* Remove the bottle in which the hydrogen chloride is being absorbed, and study the aqueous solution of the gas as follows: — (*a*) Determine its general properties, e.g. taste (cautiously), action with litmus, and with magnesium. State the results.

(*b*) Add to a test tube half full of the hydrochloric acid a few drops of nitric acid and of silver nitrate solution. Describe the precipitate. What is its name? Shake the test tube

filter part of the contents, and expose the precipitate upon the paper to the sunlight. Describe the change in the precipitate which soon occurs. To the remaining contents of the test tube add considerable ammonium hydroxide, and shake. Describe the result.

NOTE. — As soon as III (*b*) is performed, add water to the flask, shake well, and pour the contents into a waste jar in the hood.

Experiment 36 — Tests for Hydrogen Chloride, Hydrochloric Acid, and Chlorides

(*a*) Recall properties which would serve as a test for hydrogen chloride.

(*b*) Apply (*a*) to hydrochloric acid.

(*c*) Suggest a test for a soluble chloride. Apply it to several chlorides, especially some not used in previous experiments.

Experiment 37 — General Properties of Acids

MATERIALS. — Dilute sulphuric, nitric, and hydrochloric acids, glass rod, litmus paper (both colors), magnesium.

Fill three test tubes one-third full of water; add a few drops of concentrated sulphuric acid to one, of concentrated hydrochloric acid to another, and of concentrated nitric acid to the third. Shake each test tube thoroughly, and label them in some distinguishing manner. Determine the general properties of the acids as follows: —

(*a*) Dip a clean glass rod into each acid successively and *cautiously* taste it. Describe the taste by a single word.

(*b*) Dip a clean glass rod into each acid successively and put a drop on both kinds of litmus paper. Describe the change. The striking change is characteristic of acids.

(*c*) Slip a small piece of magnesium into the test tubes containing the sulphuric and hydrochloric acids. If no chemical action results, warm gently. Test the most obvious product by holding a lighted match inside of each tube. What gas comes from the hydrochloric and sulphuric acids?

(*e*) Summarize the general results of this experiment.

Experiment 38 — General Properties of Bases

MATERIALS. — Sodium hydroxide and potassium hydroxide solutions, ammonium hydroxide, litmus paper (both colors), glass rod.

Determine the general properties of bases as follows: —

(*a*) Rub a little of each solution between the fingers, and describe the feeling.

(*b*) *Cautiously* taste each liquid by touching to the tip of the tongue a rod moistened with each, and describe the result.

(*c*) Test each solution with litmus paper. Describe the result.

(*d*) Summarize the general results of this experiment. Compare acids and bases as to taste, and to reaction with litmus.

Experiment 39 — A Property of Many Salts

MATERIALS. — Litmus paper (both colors), glass rod, dilute solutions of chemically pure sodium chloride, potassium nitrate, potassium sulphate, barium chloride, potassium chlorate, potassium bromide, and strontium nitrate.

Test the solutions with litmus paper. Describe the result in each case. Compare the litmus reaction of these salts with the reaction of acids and bases.

Experiment 40 — Neutralization

MATERIALS. — Sodium hydroxide (solid), hydrochloric acid, blue litmus paper, glass rod, evaporating dish, gauze-covered ring.

Dissolve a small piece of sodium hydroxide in an evaporating dish one-third full of water. Add a little dilute hydrochloric acid, and stir well; continue to add the acid, until a drop of the well mixed solution taken from the dish upon a clean glass rod just reddens blue litmus paper. Then evaporate the solution to dryness by heating the dish on a gauze-covered ring (Fig. 110). Since the residue retains traces of the excess of hydrochloric acid added, it is necessary to evaporate all of this acid before applying any test. Heat the dish until the yellow color disappears, then moisten the

whole residue carefully with a litte warm water, and heat again to evaporate the last traces of acid; it is advisable to add and evaporate two portions of water.

Test a portion of the residue with moist litmus paper to find whether it has acid, basic, or neutral properties. Taste a little. Test (*a*) a solution of a little of the residue for a chloride, and (*b*) a portion of the solid residue for sodium by heating a little on a test wire in the flame. What is the residue?

Supplementary Experiments

Experiment 41 — Preparation of Chlorine from Various Substances

(*Each pupil need not perform all of this experiment.*)

Materials. — Sodium chloride, manganese dioxide, concentrated hydrochloric acid, potassium chlorate, potassium permanganate, potassium dichromate, lead tetroxide, lead dioxide.

A. Put a little sodium chloride and manganese dioxide in a test tube, mix thoroughly by shaking, add a little dilute sulphuric acid, and warm gently. Observe the color of the liberated gas, its odor (very cautiously), and its action upon moist litmus paper. What is the gas?

B. Put a few crystals of potassium chlorate in a test tube, add a little dilute hydrochloric acid, and warm gently. Observe and test the gaseous product as in **A.** What is the gas?

C. Put a few crystals of potassium permanganate in a test tube, add not more than 5 cc. of concentrated hydrochloric acid, and observe and test the gaseous product as in **A.** What is the gas?

D. Proceed as in **C**, using potassium dichromate. Warm gently. What gas is produced?

E. (*a*) Proceed as in **D**, using lead tetroxide (red lead). What gas is produced? (*b*) Repeat (*a*), using lead dioxide.

Experiment 42.— Preparation of Hydrogen Chloride from Various Substances

(*Each pupil need not perform all of this experiment.*)

MATERIALS. — Concentrated hydrochloric acid, concentrated sulphuric acid, silver nitrate solution, litmus paper, ammonium chloride, barium chloride, calcium chloride.

A. Put a little concentrated hydrochloric acid into a test tube, add a few drops of concentrated sulphuric acid, and test the escaping gas with (*a*) moist blue litmus paper, (*b*) moist filter paper, and (*c*) a glass rod to the end of which a little silver nitrate solution adheres. State the results. What is the gas.

B. Put a little ammonium chloride into a test tube, add a few drops of concentrated sulphuric acid, warm slightly, if necessary, and test the escaping gas as in **A.** State the results. What is the gas?

C. Repeat **B**, using several chlorides, e.g. barium chloride, calcium chloride. State the results. Draw a general conclusion.

Experiment 43 — Aqua Regia

MATERIALS. — Gold leaf, concentrated nitric and hydrochloric acids, glass rod.

Touch a small piece of gold leaf with the end of a moist glass rod, and wash the gold leaf into a test tube by pouring a few cubic centimeters of concentrated hydrochloric acid down the rod. Warm gently. Does the gold dissolve? Wash another piece of gold leaf from a clean glass rod very carefully into another test tube with concentrated nitric acid. Heat as before. Does the gold dissolve? Pour the contents of one tube cautiously into the other. Warm gently, if no change occurs. Does the gold dissolve?

Required Exercises. — 1. What compound of gold is formed by its interaction with *aqua regia?*

2. Would chlorine water act like *aqua regia* upon gold? (If in doubt, try the experiment.)

Experiment 44 — Litmus Reaction of Some Common Substances

MATERIALS. — Lemon juice, vinegar, sweet and sour milk, washing soda, borax, wood ashes, faucet water, baking soda, sugar, cream of tartar, alum, soap, tooth-powder, the juice of any ripe fruit and any unripe fruit, household ammonia, potash, limewater, pickles, jelly, grape juice.

Apply the litmus test to the substances enumerated above. Make a solution of each of the solids before testing. Tabulate the results under the terms, Acid, Basic, Neutral.

Experiment 45 — Preparation and Properties of Nitrogen

MATERIALS. — Apparatus as shown in Fig. 124, three bottles, joss stick, iron thread, small piece of sulphur and a deflagrating spoon, 10 grams of ammonium chloride and 10 grams of sodium nitrite.

I. *Preparation.* Weigh the two substances, put them in the flask, and add 50 cc. of water. Arrange the apparatus as shown in Fig. 124. Fill the cup of the dropping funnel with water, and then ask to have the apparatus inspected.

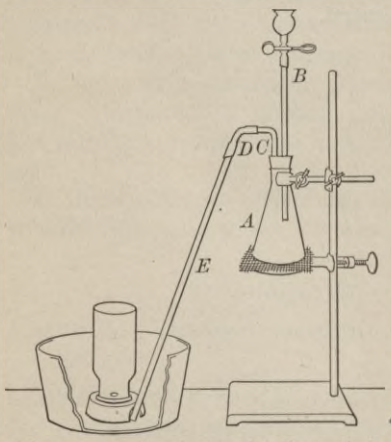

Fig. 124. — Apparatus for Preparing Nitrogen.

Heat the flask gently with a low flame and as soon as the nitrogen bubbles regularly through the water, slip the collecting bottle over the hole in the support. Heat gently, but enough to keep the gas bubbling slowly through the water. Collect three bottles of nitrogen. *Caution.* — If the mixture in the flask begins to froth or the gas comes off too rapidly, remove the flame and let in a little water; if it continues to froth, pinch the clamp and let out the excess of gas. As soon as the frothing ceases, close the clamp and continue to heat. Remove the delivery tube as soon as the three bottles of nitrogen have been collected. Proceed at once with II.

II. *Properties.* (*a*) Thrust a *blazing* joss stick into a bottle of the gas. Observe and state the result.

(*b*) Put a small piece of sulphur in a deflagrating spoon, light the sulphur, lower it into a bottle of nitrogen, and keep

it there about half a minute. Observe the result. Withdraw, and observe the result. State the results.

(*c*) Wind one end of a copper wire around a wad of iron thread, kindle it along one edge, and quickly thrust the glowing iron into a bottle of nitrogen. Observe and state the result.

Required Exercises. — 1. Describe briefly the preparation of nitrogen.

2. Sketch the apparatus, if time permits.

3. Compare the characteristic properties of nitrogen with those of oxygen found by similar experiments.

Experiment 46 — Preparation and Properties of Ammonia Gas and Ammonium Hydroxide

(*Perform this experiment in the hood.*)

MATERIALS. — 15 grams of lime (calcium oxide), 15 grams of ammonium chloride, 3 bottles, 2 glass plates, pneumatic trough filled as usual, litmus paper, joss stick, filter paper. The *apparatus* is shown (in part) in Fig. 125. The flask *A* is provided with a one-hole rubber stopper to which is fitted the right-angle bend *C* connected with a glass tube *B* (12 centimeters or 5 inches long) by the rubber tube *D*.

I. *Preparation.* (*a*) Ammonia gas. Weigh the lime and ammonium chloride separately, and mix them thoroughly on a piece of paper. Slip the mixture into the flask, and add a little water, thereby transforming the calcium oxide into calcium hydroxide. Quickly insert the stopper with its tubes, and clamp the flask as shown in Fig. 125.

Slip the glass delivery tube *B* into a bottle, invert the bottle, and hold it so that the tube is in the position shown in the figure. Heat the flask gently with a low flame. Ammonia gas will pass up into the bottle, which should be removed, when full, and covered with a glass plate. A piece of moist red litmus paper held near the mouth will show (by change in color) when the bottle is full. *Do not smell at the mouth of the bottle.* Collect two bottles and set them aside until needed for II.

(*b*) Ammonium hydroxide. As soon as the last bottle has been collected, rearrange the apparatus to absorb the ammonia gas in water, as in the case of hydrochloric acid (see Exp. **35** I (*b*)). Replace the glass tube *B* by the delivery tube *E*, which should pass through the wooden block *F* into a bottle *G* one-fourth full of water, so that the end is just above the surface of the water. Continue to heat the flask gently at intervals, and the gas will be absorbed by the water. Shake the bottle occasionally. Meanwhile perform II.

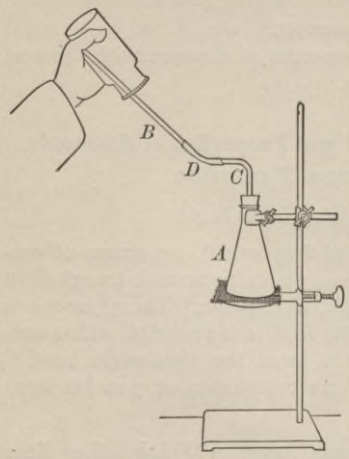

Fig. 125. — Apparatus for Preparing Ammonia.

II. *Properties of ammonia gas.* Proceed as follows with the ammonia gas prepared in I (*a*): — (*a*) Test the gas in one bottle with a blazing joss stick. Observe the result. Compare the behavior of ammonia gas with that of hydrogen, oxygen, and hydrogen chloride under similar circumstances.

(*b*) Invert the same bottle in the pneumatic trough, and shake it vigorously, taking care to keep the mouth under water. Observe any change noticed inside the bottle after a few minutes. What property of the gas is revealed? Is it a marked property? Test the contents of the bottle with litmus paper (both colors), and state the result.

(*c*) Pour a few drops of concentrated hydrochloric acid into an empty, warm, dry bottle. Rotate the bottle until the inside is well moistened with the acid. Cover it with a glass plate, invert it, and stand it upon a covered bottle of ammonia gas. Remove both plates at once, and hold the bottles together by grasping them firmly about their necks. Observe the result.

Describe the result, giving the evidence of the chemical action. What is the white substance?

(*d*) State other properties of ammonia gas you have observed, e.g. color, odor, density, and behavior with litmus paper.

III. *Properties of ammonium hydroxide.* Remove the bottle in which the ammonia gas is being absorbed in I (*b*), and proceed with the resulting ammonium hydroxide as follows:—

(*a*) Determine the general properties, e.g. taste and odor (cautiously), feeling, behavior with litmus paper.

(*b*) Warm a little in a test tube. What gas is evolved? Continue the heating, and test the escaping gas frequently by the odor (cautiously); state the result.

(*c*) Put a few cubic centimeters of the ammonium hydroxide in an evaporating dish, stand the dish in the hood or in the open air, and in an hour (or before the liquid evaporates completely) test the solution by the odor. State the final result.

NOTE. — As soon as the bottle of ammonium hydroxide is removed from *E* (in the generating apparatus) the stopper of the flask should be loosened; subsequently the contents of the flask should be thrown into a waste jar in the hood.

Experiment 47 — Preparation of Nitric Acid

Precaution. Nitric acid is very corrosive, and may cause a serious burn if it comes in contact with the skin.

MATERIALS. — Glass stoppered retort, iron stand, ring, gauze, bottle, 30 grams of sodium nitrate, 20 cubic centimeters of concentrated sulphuric acid, funnel.

Weigh the sodium nitrate and slip it into the retort through the tubulure. Fill the bottle nearly full of water. Put a large empty test tube into the bottle, insert the neck of the retort into the test tube, and clamp the apparatus as shown in Fig. 126. Stand a funnel in the tubulure of the retort so that the end is well inside the bulb, and pour the acid very carefully through the funnel. Remove the funnel and insert the stopper of the retort tightly. Heat the retort gently as long as any

nitric acid runs down the neck into the test tube. Then unclamp the retort, and remove the test tube carefully. Leave the nitric acid in the test tube until needed for Exp. **48**, corking the test tube unless the acid is to be used soon.

NOTE. — Allow the contents of the retort to cool, add a little water, boil until the solid in the bulb is reduced to a small bulk or dissolved, and pour it into a waste jar in the hood.

Experiment 48 — Some Properties of Nitric Acid

MATERIALS. — Concentrated and dilute nitric acid, quill toothpick, sulphur, zinc, magnesium.

A. *Concentrated.* (*a*) Observe the color of the concentrated nitric acid prepared in Exp. **47**. Compare it with the concentrated nitric acid in several bottles in the laboratory and with the typical specimen of concentrated nitric acid placed upon the side shelf by the Teacher. State the result.

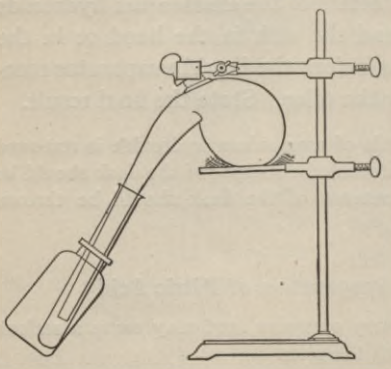

Fig. 126. — Apparatus for Preparing Nitric Acid.

(*b*) Hold a piece of wet filter paper at the mouth of the test tube (or a bottle) of concentrated nitric acid. Observe and state the result. Compare the behavior of nitric acid with that of concentrated hydrochloric acid.

(*c*) Repeat (*b*), using a piece of filter paper moistened with ammonium hydroxide. What is the name of the product?

(*d*) Pour 5 cubic centimeters of concentrated nitric acid very carefully into a test tube, drop in a piece of a quill toothpick, and observe any change in the color of the quill. Heat very gently, and observe the effect upon the quill. State the final result.

(*e*) Put about 1 gram of sulphur in a test tube, add carefully 5 cubic centimeters of concentrated nitric acid, attach the test tube holder, and boil very cautiously — in the hood — for a few minutes. Add 10 to 15 cubic centimeters of water, filter the solution, if it is not clear, and test the filtrate for a sulphate by adding barium chloride solution. State the result.

(*f*) Stand three test tubes in the test tube rack, put a piece of zinc into one, copper into another, and magnesium ribbon (rolled into a ball) into the third. Add a little concentrated nitric acid to each test tube. Observe the result. Test the gaseous product for hydrogen, and state the result.

B. *Dilute.* (*a*) Recall the litmus test. State it. Prepare some very dilute nitric acid by pouring a few drops of the ordinary dilute acid into a test tube half full of water, dip a glass rod into the diluted acid, and touch the rod very cautiously to the tongue. State the result.

(*b*) Recall, perform, or repeat (if necessary) one or more experiments illustrating the formation of salts of nitric acid. State the results of these experiments.

(*c*) Add dilute nitric acid to zinc, to copper, and to magnesium, as in **A** (*f*). State the results.

Required Exercises. — 1. What property of nitric acid was shown by **A** (*b*)? By (*d*)? By (*e*)?

2. How does the action in **A** (*b*) and (*c*) compare with that of hydrochloric acid under similar circumstances?

3. Apply question 2 to **A** (*f*). (If in doubt, try the experiment.)

Experiment 49 — Test for Nitric Acid and Nitrates

MATERIALS. — Concentrated nitric and sulphuric acids, ferrous sulphate, sodium nitrate.

A. To a test tube one-fourth full of water add a little concentrated nitric acid and shake. Add an equal volume of concentrated sulphuric acid. Shake until the acids are well mixed, then cool by holding the test tube in running water. Make a cold, dilute solution of fresh ferrous sulphate, and

pour this solution carefully down the side of the test tube upon the nitric acid mixture. Where the two solutions meet, a brown or black layer will appear, consisting of a compound formed by the interaction of the nitric acid and the ferrous sulphate.

B. This test can also be used for a nitrate. Proceed as above with a concentrated solution of sodium nitrate in place of nitric acid. Record the result.

Experiment 50 — Preparation and Properties of Nitric Oxide and Nitrogen Dioxide

MATERIALS. — 10 grams of copper (borings or fine pieces of sheet metal), concentrated nitric acid, pneumatic trough filled as usual, three bottles, three glass plates, matches, piece of copper wire (15 centimeters or 6 inches long); and the *apparatus* shown in Fig. 127.

Put the copper into the bottle, and arrange the apparatus to collect the gas over water (Fig. 127). Adjust the delivery tube, fill three bottles with water, and invert them in the trough. Dilute 25 cubic centimeters of concentrated nitric acid with an equal volume of water, and introduce just enough of this dilute acid through the dropping tube into the bottle to cover the copper. If the action is too vigorous, add water through the dropping tube; if too weak, add a little of the dilute nitric acid. Collect three bottles of the gas. Cover them with glass plates and stand them aside until needed.

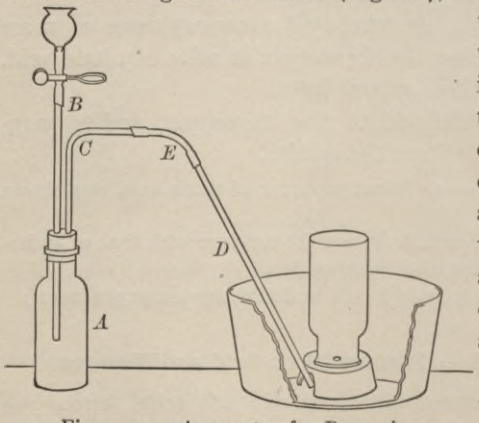

Fig. 127. — Apparatus for Preparing Nitric Oxide.

Proceed with the nitric oxide as follows: —

(*a*) Observe its general properties while covered.

(*b*) Uncover a bottle. Observe the result. Is the brown gas, which is formed, identical in color with the one observed in the generator at the beginning of the experiment?

(*c*) Uncover a bottle, let the brown gas form, then pour in about 25 cubic centimeters of water, cover with the hand and shake vigorously, still keeping the bottle covered. Why does the brown gas disappear?

(*d*) With the third bottle, determine whether the gases will burn or support combustion. A convenient flame is a burning match fastened to a copper wire. Plunge it quickly to the bottom at first and gradually raise it into the brown gas. State the result.

NOTE. — As soon as (*d*) is performed, filter the blue liquid in the generator bottle, and save the filtrate for Exp. **51**.

Required Exercises. — 1. Summarize the properties of nitric oxide. Of nitrogen dioxide.

2. What is the general chemical relation of the two gases to each other? To the air?

3. Why cannot nitrogen dioxide be collected by displacement of water?

Experiment 51 — Properties of Nitrates

MATERIALS. — Copper nitrate (or the solution from Exp. **50**), lead nitrate.

Pour about 50 cubic centimeters of the filtrate from Exp. **50** into an evaporating dish, stand the dish on a gauze-covered ring and evaporate the solution (in the hood) to about half the original volume. Set the solution aside to crystallize, and meanwhile perform (*b*). When the crystals have formed, or as soon after as convenient, remove them, and dry them by pressing between filter paper. If the filtrate from Exp. **50** was not saved, use copper nitrate from the laboratory bottle.

(*a*) Put a little of the copper nitrate in a test tube, attach the holder, heat gently, and observe the result, especially the

color of the gaseous product and of the final solid product. Test the gaseous product for oxygen; state the result. Devise an experiment to determine the qualitative composition of the solid product; submit the details to the Teacher before proceeding.

(*b*) Pulverize a little lead nitrate and heat it in a test tube as in (*a*). State the results.

Supplementary Experiments

Experiment 52 — Preparation of Nitrogen from Various Substances

Materials. — Ammonium dichromate, sand, sodium nitrate, potassium nitrate, barium nitrate, powdered iron.

Prepare nitrogen by one or more of the following methods: —

A. *Ammonium Dichromate.* Put about 2 grams of ammonium dichromate in a test tube, add 5 grams of dry clean sand, and mix the two substances thoroughly by shaking. Attach a test tube holder, heat the mixture gently, and test the escaping gas for nitrogen. State the result.

B. *Nitrates and Iron.* Mix thoroughly about 1.5 grams of sodium nitrate, 1.5 grams of potassium nitrate, 2 grams of barium nitrate, and 10 grams of iron; each substance must be dry and powdered. Put the mixture in a test tube, attach a test tube holder, spread the mixture along the test tube, and heat gently. Test the escaping gas for nitrogen. State the result.

Experiment 53 — Preparation of Ammonia Gas from Various Substances

(*Each pupil need not perform all of this experiment.*)

Materials. — Gelatin, soda-lime, substances enumerated in **A** (*b*), ammonium sulphate, sodium hydroxide solution, ammoniacal liquor.

A. *Nitrogenous Substances.* (*a*) Mix a little gelatin and soda-lime on a piece of paper, slip the mixture into a test tube, attach a test tube holder, heat, and test the escaping gas with moist red litmus paper. State the result.

(*b*) Repeat (*a*), using soda-lime with hair, feather, leather scraps, pieces of horn, or hide powder. Observe and state the results.

B. *Ammonium Salts.* (*a*) Dissolve a little ammonium chloride in water, add a little sodium hydroxide solution, warm gently, and test (cautiously) the liberated gas by its odor. What is the gas?

(*b*) Repeat (*a*), using ammonium sulphate and sodium hydroxide or potassium hydroxide solution. State the result.

(*c*) Mix and grind together in a mortar a little ammonium sulphate and calcium oxide (lime). Test (by the odor) the gaseous product, and state the result.

C. *Ammoniacal Liquor.* Add powdered calcium oxide (lime) to a test tube half full of ammoniacal liquor, warm gently, and test the escaping gas for ammonia. State the result.

Experiment 54 — Interaction of Nitric Acid and Metals

MATERIALS. — Zinc, copper, tin, iron, concentrated nitric acid.

Stand four test tubes in the test-tube rack. Slip into one a few pieces of zinc, into another a small piece of tin, into the third a small quantity of copper borings, and into the fourth a small quantity of clean iron filings. Add to each test tube in succession enough concentrated nitric acid to cover the metal. Observe the changes, particularly (1) the vigor of the action, (2) the properties of the solid products, especially color and solubility, and (3) properties of the gaseous products. Tabulate these observations.

Required Exercise. — Name the solid product of the reaction in each case. The gaseous product.

Experiment 55 — Preparation and Properties of Sodium Nitrite

MATERIALS. — 5 grams of sodium nitrate, 5 grams of lead, iron crucible, glass rod.

Heat the mixture of lead and sodium nitrate in an iron crucible, which is supported on the ring of an iron stand. Stir the melted mass occasionally with a glass rod, and continue the heating until most of the lead has disappeared. Allow the mass to cool, cover it with water, heat the water to boiling, let the crucible cool, and then filter; add a little water to the residue in the crucible, boil, and filter this portion. This operation extracts the sodium nitrite. Add to the combined

filtrates several drops of concentrated sulphuric acid. Observe the result. How does the result compare with the action of concentrated sulphuric acid on sodium nitrate?

Required Exercises. — 1. What chemical change did the sodium nitrate undergo?

2. What is the test for a nitrite?

3. What is the name of the yellowish residue?

Experiment 56 — Preparation and Properties of Nitrous Oxide

MATERIALS. — 10 grams of ammonium nitrate, pneumatic trough, wad of iron thread, copper wire, three bottles, three glass plates, sulphur, deflagrating spoon, joss stick. The apparatus is shown in Fig. 128. The parts *A*, *C*, *D*, *E* have been used before; *F*, *G*, *H* are exactly the same as *C*, *D*, *E* respectively; *B* is a large test tube.

Construct and arrange the apparatus as shown in Fig. 128. Put 10 grams of ammonium nitrate in the flask *A*. The large test tube *B* remains empty. The end of *H* rests on the bottom of the pneumatic trough, which is filled as usual. Be sure the apparatus is gas-tight.

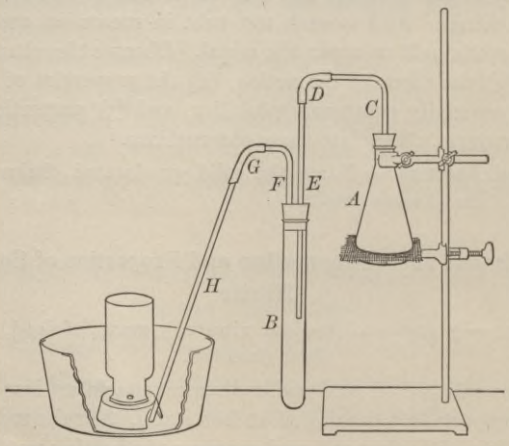

Fig. 128. — Apparatus for Preparing Nitrous Oxide.

I. *Preparation.* Heat the flask gently with a low flame, and readjust the apparatus if it leaks. The ammonium nitrate melts at first and then appears to boil. Regulate the heat so that the evolution

of the nitrous oxide will be slow. Notice the fumes which form in *A*, and the liquid which collects in *B*. Prepare three bottles of nitrous oxide, covering each with a glass plate as soon as removed from the trough. When the last bottle has been collected and covered, remove the end of the delivery tube from the trough.

Proceed at once with II.

II. *Properties.* Test the gas as follows: —

(*a*) Allow a bottle to remain uncovered for a few seconds. How does nitrous oxide differ from nitric oxide?

(*b*) Thrust a glowing joss stick into the same bottle of gas. Observe the result. Is the gas combustible? Does it support combustion?

(*c*) (1) Put a piece of sulphur in a deflagrating spoon, light it, and lower the burning sulphur *at once* into another bottle of gas. Observe the result. (2) Twist one end of the copper wire around a wad of iron thread. Heat the edge of the wad an instant in the flame and then lower it *quickly* into a bottle of the gas. Observe the result. Recall a similar experiment with oxygen. Compare the two results.

Required Exercises. — 1. Describe briefly the preparation of nitrous oxide.

2. Summarize the essential properties of nitrous oxide.

3. What are the fumes noticed in *A*?

4. What in all probability is the other product (seen in *B*) of the chemical change in this experiment? Could it have been an impurity in the ammonium nitrate?

5. How could you distinguish ammonium nitrate from other nitrates?

6. How could you distinguish nitrous oxide from (*a*) the other oxides of nitrogen, (*b*) air, (*c*) oxygen, (*d*) hydrogen, (*e*) nitrogen, (*f*) carbon dioxide?

7. Sketch the apparatus, if time permits.

Experiment 57 — Per Cent of Oxygen and Nitrogen in Air

MATERIALS. — Solutions of pyrogallic acid (10 per cent) and potassium hydroxide (50 per cent), pneumatic trough half filled with water, 250 and 25 cubic centimeter graduated cylinders. The *apparatus* (Fig. 129) consists of a bottle holding about 250 cubic centimeters provided with a tightly fitting one-hole rubber stopper through which passes a glass plug. The plug, which is made by closing both ends of a glass tube about 10 centimeters (4 inches) long, should fit tight.

The volume of the bottle is found thus: — Fill the bottle full of water from the pneumatic trough. Push the stopper into the bottle as far as it will go, insert the glass plug until the inner end is flush with the inner surface of the stopper, and then draw a line around the stopper with a lead pencil to mark its position. Remove the stopper. Pour water from the bottle into the 250 cubic centimeter graduate until the graduate is full (to the 250 cc. mark) or the bottle is empty; read the volume. If the bottle holds more than 250 cubic centimeters, the last portion of the water in the bottle may be poured into the 25 cubic centimeter graduate. Record the total volume of the bottle as shown below.

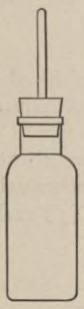

Fig. 129. — Apparatus for finding Per Cent of Oxygen and Nitrogen in Air.

Measure exactly 10 cubic centimeters of pyrogallic acid in the 25 cubic centimeter graduate, and pour it into the bottle. Add 20 cubic centimeters of potassium hydroxide solution, insert the rubber stopper quickly to the proper mark, and then push the glass plug through the stopper until the inner end is flush with the inner surface of the stopper. Shake the bottle

vigorously a few minutes, and then invert it and watch the surface of the liquid for bubbles of air, which will enter if the apparatus leaks. If a leak is detected, ask the Teacher for directions before proceeding. If the apparatus is tight, continue the shaking for about half an hour. During this operation the oxygen is absorbed by the solution.

Place the bottle on its side beneath the water in the pneumatic trough, inclining it slightly so that the lower edge of the bottle rests upon the bottom of the trough and the hole in the stopper is *beneath* the surface of the water; grasp the bottle firmly by the neck and stopper, and gradually pull out the plug, taking care (1) not to pull out the stopper and let any of the solution run out, and (2) to keep the hole in the stopper constantly below the surface. After the water has stopped running in, insert the plug, lift out the bottle, and measure carefully the volume of the final liquid in the bottle.

Record and calculate as follows: —

(a) Volume of original solution .....

(b) Capacity of bottle.....

(c) Volume of air taken (b − a) .....

(d) Final volume of liquid .....

(e) Volume of water which entered (d − a) .....

(f) Per cent of water which entered (e ÷ c) .....

The per cent of entering water equals the per cent of gas absorbed, therefore

(g) Per cent of oxygen .....

(h) Per cent of nitrogen (100 − g) .....

NOTE. — This experiment disregards the argon and carbon dioxide in the air.

Experiment 58 — Water Vapor in the Air

(*a*) Perform, recall, or repeat (if necessary) Exp. **24** (Deliquescence). What does the result show about the air?

(*b*) Place a piece of lime upon a glass plate or a block of wood and let it remain exposed to the air an hour or more. State the result. Does this experiment verify the result in (*a*)? If so, how?

(*c*) Devise other experiments to show that air contains water vapor. Submit the details to the Teacher before performing the experiment.

Experiment 59 — Carbon Dioxide in the Air

MATERIALS. — Calcium hydroxide solution, barium hydroxide solution, bottle, air blast apparatus (for (*b*)).

(*a*) Pour 25 cc. of clear calcium hydroxide solution into a bottle and let it stand exposed to the air an hour or more. Examine the surface of the liquid. State the change that has occurred. Explain the change.

(*b*) If an air blast apparatus is available, force air through a bottle half full of clear barium hydroxide solution until the liquid is conspicuously changed. Describe and explain the change.

(*c*) What do (*a*) and (*b*) show about the air?

SUPPLEMENTARY EXPERIMENT

Experiment 60 — Testing Air

(*a*) Apply Exps. **58** and **59** to the air in different parts of the building or to the air outside the building. Start the tests at the same time and obtain comparable results. State the results.

(*b*) Apply Exp. **58** to the air on several days, especially days when the weather varies considerably.

(*c*) If a hygrometer is available, use it in determining the relative humidity of the air out doors and inside the laboratory.

(*d*) Apply Exp. **59** to the air in the laboratory, out doors, and in a recitation room which is in use. Proceed with the testing as in (*a*) (this experiment).

Experiment 61 — Equivalent of Zinc to Hydrogen

The object of this experiment is to find the number of grams of zinc chemically equivalent to one gram of hydrogen.

MATERIALS. — The apparatus used in Exp. **10 I**, zinc, thermometer, barometer.

Arrange the apparatus (Fig. 130) to collect a gas over water, and have it inspected by the Teacher. Weigh a piece of zinc on the accurate balance. Weigh between .45 and .5 gm., taking care to weigh it exactly. Record the weight at once in the notebook (as below). Put the weighed zinc into the generator bottle *A*. Fill the bottle with water and insert the stopper with all its tubes. Next fill the remainder of the apparatus with water by first filling the cup with water and then admitting it repeatedly until all air is forced out of the bottle and tubes; take care never to let the water in *B* fall below the lower opening of the cup. Then fill a collecting bottle (250 cc.) with water and invert it upon the support in the wooden trough; put the end of the delivery tube under the support and ask for a final inspection. Heat about 50 cc. of dilute sulphuric acid in a test tube. Fill the cup and introduce the hot acid in separate portions slowly

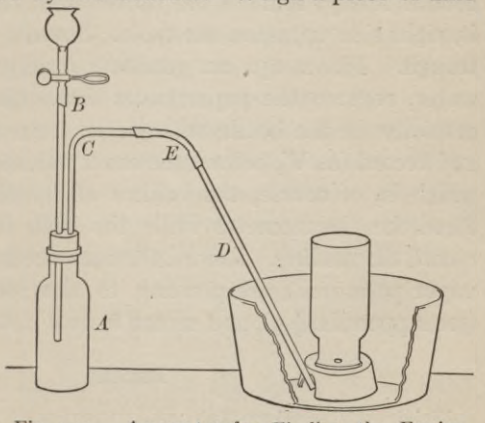

Fig. 130. — Apparatus for Finding the Equivalent of Hydrogen of Zinc.

into the bottle *A*, taking the same care as before. Hydrogen will be slowly liberated, and will collect in the receiving bottle. Let the action continue until all the zinc disappears. Then force over into the receiving bottle all gas remaining in the apparatus by admitting water carefully as before. Lay a piece of dry filter paper upon the bottom of the bottle, grasp the bottle firmly, carefully joggle it to dislodge any gas bubbles which may be underneath the support, slide the bottle from the support, and lower it into the water until the water is about the same level inside and outside the bottle; then slip two pieces of filter paper beneath the bottle, cover the mouth firmly, remove the bottle from the trough and stand it, right side up, upon the table. Stand a thermometer in the trough. Fill a 250 cc. graduate exactly to the mark with water, remove the paper cover from the bottle, and very carefully fill the bottle with water from the graduate; read and record (as V′, below) the exact volume of water added — which is, of course, the volume of hydrogen gas liberated. Read the thermometer while the bulb is in the water, and record the reading. Record the barometer reading. Find the vapor pressure corresponding to the recorded temperature (see Appendix, § **4**), and record it as *a* below.

RECORD

Weight of zinc taken (Zn) . . . . . .
Observed volume of hydrogen (V′) . . . .
Temperature (t) . . . . . .
Pressure (P) . . . . . .
Vapor pressure (*a*) . . . . . .
Corrected volume of hydrogen (V) . . . .
Equivalent of zinc (E) . . . . . .

Calculation. Reduce the observed volume (V′) of hydrogen to the volume (V) it would have at 0° C, 760 mm., and dry state by the formula given in Part I, § **40**, viz. —

$$V = \frac{V' (P - a)}{760 (1 + (.00366 \times t))}$$

Since 1000 cc. of dry hydrogen weigh .0898 gm., the weight of the corrected volume (V) is found by 1000: V:: .0898: X. And the weight of zinc equivalent (E) to one gram of hydrogen is found by X: Zn:: 1: E.

Submit the result to the Teacher for criticism (before taking the apparatus apart, if convenient).

Experiment 62 — Equivalent of Magnesium to Hydrogen

MATERIALS. — A 100 cc. tube and wooden trough, magnesium ribbon, thermometer, barometer.

Weigh accurately between .065 and .075 gm. of magnesium ribbon, preferably in a single piece. Have the wooden trough half full of water. Pour 8 cc. of concentrated hydrochloric acid into the 100 cc. tube and fill the tube completely with cold water. Put the magnesium into the tube, cover the end of the tube with the thumb or finger, invert the tube, stand it in the trough, but keep the end loosely closed to prevent the magnesium from slipping out. As the acid reaches the magnesium, action begins vigorously. Hydrogen rises in the tube and usually carries the magnesium with it. Watch the operation, and agitate the tube to prevent the magnesium from sticking to the inside. The action is very rapid and must be watched constantly, being over in about two minutes. If a piece of magnesium should stick to the inside of the tube, close the end of the tube tightly, lift it from the water, incline it enough to loosen the magnesium, and then quickly straighten the tube and put the end beneath the water.

When all the magnesium has disappeared, close the end of the tube, remove the tube to a tall jar of water, and let it stand five minutes; then, without touching the tube with the bare hands, adjust the height so that the water levels are the same inside and outside of the tube, and read the volume. Read the barometer and the thermometer (keeping the bulb in the water). Calculate the equivalent of magnesium as in Exp. **61**.

Supplementary Experiments

Experiment 63 — Equivalent of Iron to Copper

The object of this experiment is to find the weight of copper precipitated by a known weight of iron.

Materials. — Beaker, glass rod, iron powder, copper sulphate solution of known strength, alcohol.

Prepare or obtain about 50 cc. of a copper sulphate solution which contains .1 gm. of copper to 1 cc. Weigh a clean dry beaker. Weigh it in accurately about 2 gm. of iron powder. Add slowly about 25 cc. of the copper sulphate solution. The iron precipitates the copper as a fine powder. Stir occasionally with the glass rod. About one hour is needed for complete precipitation. When it is judged that all the iron has been used up, let the copper settle, and pour off the liquid down the rod into a dish, taking care not to lose any copper. Add water to the beaker, stir, let settle, and decant as before. If the wash water contains particles of copper, let it settle, pour off the water and add the copper to the beaker. Wash until the washings give no test for a sulphate (i.e. no white precipitate of barium sulphate upon addition of barium chloride). Finally add a little alcohol and heat to dryness very cautiously on a piece of asbestos. When dry and cool, weigh quickly before the copper oxidizes.

Calculation. Assume 31.8 as the equivalent of copper and calculate the equivalent of iron.

Experiment 64 — Equivalent of Aluminium to Hydrogen

Materials. — As in Exp. **61**.

Proceed as in Exp. **61** (Equivalent of Zinc), but (*a*) weigh out about .17 gm. of aluminium (taking care to weigh exactly the amount used) and (*b*) use hot concentrated hydrochloric acid instead of dilute sulphuric acid. Record and calculate as in Exp. **61**.

Experiment 65 — Equivalent of Calcium to Hydrogen

Materials. — As in Exp. **62**.

Proceed as in Exp. **62**, but use about .115 gm. of calcium. Record and calculate as in Exp. **62**.

SOLUTION — ACIDS, BASES, SALTS

Experiment 66 — Chemical Behavior of Electrolytes in Solution

MATERIALS. — Solutions of silver nitrate, hydrochloric acid, ammonium chloride, barium chloride, calcium chloride, magnesium chloride, sodium chloride, potassium chloride, potassium chlorate, potassium perchlorate, chloroform.

(*a*) Test separately dilute solutions of each of the following substances for ionic chlorine (i.e. for chloride ions) by adding a few drops of silver nitrate solution, and state the result in each case: Hydrochloric acid, ammonium chloride, barium chloride, calcium chloride, magnesium chloride, sodium chloride, potassium chloride.

(*b*) Test a solution of potassium chlorate for chloride ions. State the result.

(*c*) Repeat (*b*), using a solution of potassium perchlorate instead of potassium chlorate. State the result.

(*d*) Shake a little chloroform with water, and test as in (*b*). State the result.

Required Exercises. — 1. What *ions* are in a solution of all chlorides?

2. What *ions* are in a solution of potassium chlorate? Of silver nitrate?

3. Explain the general result in (*a*) and the results in (*b*), (*c*), and (*d*) in terms of the theory of electrolytic dissociation.

Experiment 67 — Chemical Behavior of Electrolytes in Solution

MATERIALS. — Solutions of barium chloride, sulphuric acid, copper sulphate, sodium sulphate, aluminium sulphate, magnesium sulphate, zinc sulphate.

Test dilute solutions of the following for sulphate ions by adding to each separately a few drops of barium chloride solution, and state the result in each case: Sulphuric acid,

copper sulphate, sodium sulphate, aluminium sulphate, magnesium sulphate, zinc sulphate.

Required Exercises. — 1. What *ions* are in solutions of all sulphates?
2. Explain the general result obtained above in terms of the theory of electrolytic dissociation.

Experiment 68 — General Properties of Acids, Bases, and Salts

MATERIALS. — As in Exps. **37**, **38**, **39**, **40**.

Recall and state the general properties of acids, bases, and salts, or repeat (if necessary) Exps. **37**, **38**, **39**, **40**.

Experiment 69 — The Litmus Reaction of Different Salts

MATERIALS. — Acid sodium phosphate, acid sodium sulphate, potassium (or sodium) nitrite, sodium acetate, potassium iodide, sodium carbonate, potassium carbonate, potassium dichromate, sodium sulphate, copper sulphate, ferric chloride.

Prepare, or obtain, dilute solutions of the salts mentioned above, and test them with both kinds of litmus paper.

Required Exercises. — 1. Classify these salts under the headings *Normal*, *Acid*, and *Basic*.
2. Name the salts used above that undergo hydrolysis. Interpret hydrolysis by the theory of electrolytic dissociation.

Experiment 70 — Electrolysis of Copper Sulphate

MATERIALS. — Dilute solution of copper sulphate, small battery jar (or beaker), two electrodes (pieces of electric light carbon) and connection wires, battery of four or more cells (or other source of electric current).

Fill the battery jar about two-thirds full of dilute copper sulphate solution. Wind one end of a piece of the wire around one end of each electrode and hang the electrodes in the solution by bending the wire over the edge of the jar (or by the device shown in Fig. 32, Part I). Before turning on the current (or making the final connection), examine each electrode and note the absence of any deposit. (After the apparatus is

set up, the Teacher should mark the anode and cathode.) Turn on the current and observe what takes place at the anode. When the current has run about ten minutes, shut it off, and examine each electrode. Compare with their appearance before the electrolysis took place. Upon which electrode is there a deposit? What is the deposit?

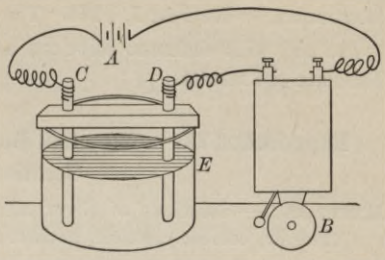

Fig. 131. — Apparatus for Showing the Behavior of Solutions toward an Electric Current.

Sketch the apparatus, and describe the electrolysis of copper sulphate in terms of the theory of electrolytic dissociation, using the sketch in your interpretation.

Experiment 71 — Electrolysis of Sodium Sulphate

MATERIALS. — Sodium sulphate solution, litmus solution (preferably neutral), U-tube clamped to an iron stand, narrow aluminium electrodes (to fit the U-tube) and connection wires, battery of four or more cells (or other source of electric current).

Fill the U-tube two-thirds full of sodium sulphate solution, and add enough litmus solution to produce a faint color after shaking. Attach the U-tube to the iron stand, insert the electrodes, and note the color of the solution in each arm of the U-tube. (After the apparatus is set up, the Teacher should mark the anode and cathode.) Turn on the current and let it run until there is a change in color in each arm of the U-tube. Note this color and note also whether gas is liberated in each arm of the U-tube.

Sketch the apparatus (except the battery) and interpret the electrolysis of sodium sulphate by the theory of electrolytic dissociation, using the sketch in your interpretation.

Supplementary Experiments

Experiment 72 — Electrolytes and Non-Electrolytes

Materials. — See Part I, § **156.** The apparatus is shown in Fig. 131.

Proceed with different solutions as described in Part I, § **156.** Tabulate the results.

Experiment 73 — Chemical Behavior of Electrolytes in Solution

Materials. — Solutions of silver nitrate, silver sulphate, potassium chloride, barium chloride, barium nitrate, potassium sulphate.

A. (*a*) Add a few drops of potassium chloride solution to a little silver nitrate solution. Shake well and observe the result.

(*b*) Repeat (*a*), using potassium chloride and silver sulphate solutions. Compare the results. Are the precipitates identical?

B. (*a*) Proceed as in **A** (*a*) with potassium sulphate and barium chloride solutions. Observe the result.

(*b*) Proceed as in **B** (*a*) with potassium sulphate and barium nitrate solutions. Compare the result with that in **B** (*a*). Are the precipitates identical?

Required Exercises. — 1. What have solutions of silver nitrate and silver sulphate in common? Solutions of barium chloride and barium nitrate?

2. Name the ionic substances in the solutions in **A.** In **B.**

Experiment 74. — Electrolysis of Potassium Iodide

Materials. — Starch, potassium iodide, mortar and pestle, filter paper, sheet of metal (tin or iron), battery of two or more cells.

Grind together in a mortar a lump of starch and a crystal of potassium iodide. Add enough water to make a thin liquid. Dip a strip of filter paper into the mixture, and spread the wet paper upon the sheet of metal. Press the end of the wire attached to the zinc (of the battery) upon the metal, and draw the other wire across the sheet of paper. The marks are caused by iodine which is liberated from the potassium iodide and colors the starch.

Required Exercises. — 1. Describe briefly this experiment.

2. Iodine is a non-metal. Are iodine ions anions or cations? At what electrode is iodine liberated?

Experiment 75 — Electrolysis of Water

Recall the experiment showing the electrolysis of water (see Exp. **30**).

Required Exercises. — 1. State briefly the explanation of the electrolysis of water in terms of the theory of electrolytic dissociation.

2. Are hydrogen ions anions or cations? To what electrode do hydrogen ions migrate?

3. Is oxygen a primary or a secondary product of the electrolysis of water?

4. If oxygen ions were formed in the solution, (*a*) would they be anions or cations, and (*b*) to what electrode would they migrate?

Experiment 76 — Colored Ions

MATERIALS. — Copper sulphate, copper nitrate, copper bromide, nickel chloride, nickel sulphate, cobalt chloride, cobalt nitrate, potassium dichromate, ammonium dichromate, sodium dichromate, potassium chromate, potassium permanganate.

A. *Copper Ions.* Prepare a dilute solution of each of the copper compounds mentioned above by dissolving a little of the solid in a test tube half full of water. Compare the colors.

B. *Nickel Ions.* Prepare, or obtain from the Teacher, a dilute solution of each of the nickel compounds, and compare the colors.

C. *Cobalt Ions.* Proceed as in **B** with the cobalt compounds.

D. *Miscellaneous.* Determine the color of dichromate ions. Of chromate ions. Of permanganate ions.

Required Exercise. — Name several kinds of colorless ions.

Experiment 77 — Migration of Ions

MATERIALS. — Battery (or other source of an electric current), U-tube, two strips of aluminium to fit the U-tube, potassium dichromate solution, copper sulphate solution.

A. *Potassium Dichromate.* Fill a U-tube two thirds full of dilute potassium dichromate solution and clamp it in an upright position to an iron stand. Insert the electrodes and allow the current to flow about ten minutes. Observe the color of the solution when the current starts, the gradual change in color in each arm of the U-tube as the current continues, and the difference in color in the two arms when the current stops.

B. *Copper Sulphate.* Proceed as in **A** with dilute copper sulphate solution.

Required Exercises. — 1. Describe the experiment and sketch the apparatus.

2. Give the name and formula of all the ions and state the electrodes to which each kind of ion migrates.

3. Give the name and formula of the colored ions.

Experiment 78 — Neutralization by Titration

The object of this experiment is to find the number of grams of the compound HCl in 1 cubic centimeter of a solution of hydrochloric acid (i.e. HCl dissolved in water) by neutralizing the acid with a solution of sodium hydroxide of known concentration.

MATERIALS. — Two burettes (Fig. 132), two beakers, a glass rod, phenol-phthalein solution, and solutions of hydrochloric acid and sodium hydroxide (the latter of known concentration and obtained from the Teacher).

Fill each burette (or start with each full) — one with the acid solution and one with the base solution, as marked. Place the waste beaker under each burette in turn and allow the solution to run out slowly until the bottom of the meniscus rests on the O line when the eye is on a level with the same line. (See Fig. 132.) Set the waste beaker aside. Put a clean beaker under the base burette and let exactly 15 cc. run into the beaker; record as in I below. Remove the beaker, add 2 or 3 drops of phenol-phthalein solution, put the beaker under the acid burette and let the acid solution run in slowly, stirring constantly with the clean rod until the red color just disappears and the solution becomes colorless. Read the exact volume of acid solution added and record as in I. Pour the solution out of this beaker, wash the beaker, and proceed, as before, with a second 15 cc. of NaOH solution. Record as in II. Wash the beaker and proceed with a third 15 cc. of NaOH solution. Record as in III.

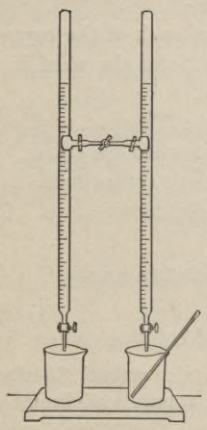

Fig. 132. — Burettes. (Enlarged Section (on page 9) Shows the Curved Surface of the Solution. Correct Reading of the Volume of the Solution is along Line I.)

RECORD

I.	NaOH sol. 0	− 15 = 15		
	HCl " 0	− =	1 cc. NaOH sol. =	cc. HCl sol.
II.	NaOH sol. 15	− 30 = 15		
	HCl "	− =	1 cc. NaOH sol. =	cc. HCl sol.
III.	NaOH sol. 30	− 45 = 15		
	HCl "	−	1 cc. NaOH sol. =	cc. HCl sol.

Calculation: — (*a*) Write the equation, including the weights of the NaOH and HCl.

(*b*) Find (from I, II, III) the average number of cc. of HCl solution equal to 1 cc. of NaOH solution.

(*c*) 1 cc. of NaOH solution contains ? gm. (ask Teacher) NaOH.

(*d*) From the value in (*c*) and the relative values of the solutions together with the values in the equation, calculate the number of gm. of the compound HCl in 1 cc. of the acid solution. Submit the result to the Teacher for criticism.

Experiment 79 — Preparation of Salts

(*Each pupil need not perform all of this experiment.*)

MATERIALS. — Calcium, calcium oxide, calcium carbonate, calcium chloride, silver nitrate solution, evaporating dish, gauze-covered ring.

A. *Acid and a Metal.* Put a small piece of clean calcium in an evaporating dish, add a little dilute hydrochloric acid, stand the dish on a gauze-covered ring, and heat the dish gently until the calcium disappears, adding more acid if necessary. Then evaporate the solution to dryness in the hood, taking care to heat gently toward the end of the evaporation to prevent spattering. Add just enough water to moisten the residue, and evaporate again to dryness. Heat the residue until no more fumes of hydrochloric acid are evolved. Let the dish cool, and loosen the contents with a glass rod. Test portions of the residue for (*a*) calcium and (*b*) a chloride as follows: (*a*) Touch a clean, moist test wire to a small piece of the residue, and hold it in the outer and lower edge of the Bunsen flame. The yellow-red color imparted to the flame is caused by the calcium, and is one test for this element. (*b*) Dissolve a little of the residue in a test tube half full of water, and apply the usual test for a chloride to this solution. State the result.

Required Exercises. — 1. What is the name and formula of the residue formed in this experiment? Write the equation for the reaction.

2. Suggest an experiment to verify the answer to 1.

3. Suggest experiments to prove that the compound is neither an acid nor a base.

4. Cite two or more experiments, already performed, which illustrate this method of salt formation.

B. *Acid and an Oxide.* Proceed as in **A,** using hydrochloric acid and a small piece of calcium oxide. Before evaporating to dryness filter the solution, if it is not clear. Test the final residue as in **A** and state the result.

Required Exercises. — As in **A** (except 4).

C. *Acid and a Salt.* (*a*) Proceed as in **A,** using hydrochloric acid and several small pieces of calcium carbonate. Test the final residue (as in **A**) obtained by evaporating the clear solution. State the result.

(*b*) Put a little sodium chloride in an evaporating dish, add 25 cc. of dilute sulphuric acid, stand the dish on a gauze-covered ring, and evaporate the solution to dryness in the hood. Toward the end of the evaporation, it may be necessary to remove the burner, turn down the flame, and heat very gently by moving the burner slowly back and forth beneath the dish. As soon as the danger of spattering is over, heat strongly as long as white choking fumes are evolved; this operation removes the last portions of sulphuric acid and completes the chemical change. Let the dish stand on the gauze until cool enough to handle. Then remove it, and loosen the solid with a glass rod or a knife. Test portions of the residue for sodium and a sulphate as follows: Proceed with the flame test for sodium as in **A** (*a*), and observe and state the result. Apply the usual test for a sulphate to a solution of the residue, and state the result.

Required Exercises. — 1. For (*a*), as in **A.**

2. For (*b*), as in **A** 1 and 3.

D. *Two Salts.* Add a little silver nitrate solution to a little calcium chloride solution, and describe the result.

Required Exercises. — As in **A** (except 4).

E. *Acid and Base.* Recall two or more experiments in which a salt was formed by the interaction of an acid and a base, and name all the compounds involved in the reactions. Write the equation for reaction in (*a*) the ordinary form and (*b*) the ionic form.

CARBON

Experiment 80 — Distribution of Carbon

MATERIALS. — Sand (or clay) crucible, sand, wood, cotton, starch, sugar, glass tube (or rod), candle, block of wood.

(*a*) Cover the bottom of the crucible with a thin layer of sand. Put on the sand a small piece of wood, a small, compact wad of cotton, and a lump of starch. Fill the crucible loosely with dry sand, and slip it into the ring of an iron stand. Heat with a flame which extends well above the bottom of the crucible until the smoking ceases (approximately 20 minutes). After the crucible has cooled sufficiently to handle, pour the contents out upon a block of wood or an iron pan. Examine the contents. What is the residue? What is hereby shown about the distribution of carbon?

While the crucible is heating, proceed as follows:

(*b*) Heat a little sugar in a test tube until the vapors cease to appear. What is the most obvious product?

(*c*) Close the holes at the bottom of a lighted Bunsen burner, and hold a glass tube in the upper part of the flame long enough for a thin deposit to form. Examine it, name it, and state its source.

(*d*) Hold a glass tube in the flame of a candle which stands on a block of wood, and compare the result with that in (*c*).

Experiment 81 — Properties of Coal

MATERIALS. — Anthracite and bituminous coal, lignite, crucible, large graduated cylinder.

(*a*) Examine specimens of anthracite and bituminous coal, and lignite, and state the characteristic properties, e.g. relative hardness, color, luster.

(*b*) Pulverize a little of each variety, heat gently at first in a crucible or a test tube, and observe the result, especially the

liberation of carbonaceous volatile matter and moisture; then heat strongly and observe the immediate result; continue the heating until little or no black residue remains. Summarize the results.

(*c*) Determine the specific gravity of coal by the method given in Exp. **88** (*b*). State the result.

(*d*) If fossils from a coal bed are available, examine and describe them.

Experiment 82 — Properties of Charcoal

MATERIALS. — Wood charcoal (lump and powder), animal charcoal, copper wire, crucible, vinegar, hydrogen sulphide solution, test tube fitted with a cork.

(*a*) Examine a typical specimen of wood charcoal and state its characteristic properties. Do the same with animal charcoal. Put a little animal charcoal in a crucible and heat it strongly. Meanwhile proceed with the wood charcoal. Wind the end of a nichrome test wire around a small piece of charcoal, hold it in the flame, and observe the result, especially the ease or difficulty of ignition, presence or absence of flame and of smoke, formation of ash. Compare the results with those obtained in Exp. **81** (*b*). When the animal charcoal has been heated thirty or more minutes, examine the residue. What is it?

(*b*) Fill a test tube one-fourth full of powdered animal charcoal as follows: Fold a narrow strip of smooth paper so that it will slip easily into the test tube; place the powder at one end of the troughlike holder, slowly push the paper into the test tube, holding both tube and paper in a horizontal position; now hold the tube upright, and the powder will slip from the paper. Add 10 cubic centimeters of hydrogen sulphide solution, and cork securely. If the tube leaks, make the opening gas-tight with vaseline. Shake thoroughly. After ten or fifteen minutes, remove the stopper and smell of the contents. Is the odor much less offensive? Repeat, unless a definite result is obtained. What property of animal charcoal is illustrated by this experiment?

(*c*) Fill a test tube one fourth full of powdered animal charcoal as in (*b*), add 10 cubic centimeters of vinegar, shake thoroughly for a minute, and then warm gently. Filter into a clean test tube. Compare the color of the filtrate with that of the original vinegar. Describe briefly. What property of animal charcoal is illustrated by this experiment?

Experiment 83 — Preparation and Properties of Carbon Dioxide

MATERIALS. — Calcium carbonate, dilute hydrochloric acid, joss stick, candle fastened to a wire, calcium hydroxide solution, four bottles. The *apparatus* is shown in Fig. 133.

I. *Preparation.* Put six or more lumps of calcium carbonate into the bottle, and arrange the apparatus to collect

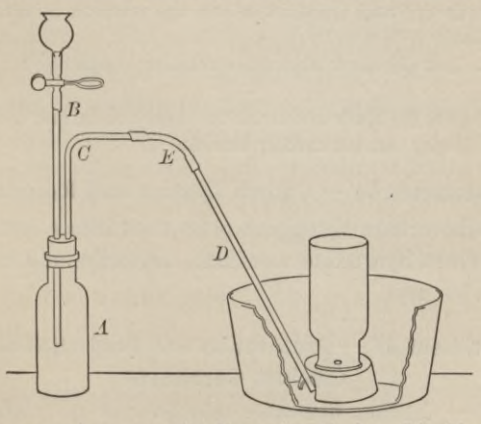

Fig. 133. — Apparatus for Preparing Carbon Dioxide.

the gas over water, as previously directed. Introduce enough dilute hydrochloric acid through the dropping tube to cover the calcium carbonate. Collect four bottles, cover with glass plates or filter paper, and stand aside till needed. Proceed at once with II.

II. *Properties.* (*a*) Plunge a blazing joss stick several times into a bottle. State the result.

(*b*) Lower a lighted candle into a bottle of air, and quickly invert a bottle of carbon dioxide over it, holding the bottles mouth to mouth. State the final result.

(*c*) Pour a little calcium hydroxide solution into a bottle of carbon dioxide, cover it with the hand, and shake it vigorously. Describe and explain the result.

(*d*) Fill a bottle of carbon dioxide one-third full of water, cover it tightly with the hand, and shake it vigorously. Invert the bottle, still covered, in the pneumatic trough. Observe and state the result.

NOTE. — As soon as (*d*) is performed wash the acid from the marble and save the solid for other experiments.

Required Exercises. — 1. Describe briefly the preparation of carbon dioxide.

2. What do (*a*) and (*b*) show about the relation of carbon dioxide to combustion?

3. What does (*b*) show about the relative weight of carbon dioxide and air?

4. What does (*d*) show about the solubility of carbon dioxide?

5. What is the test for carbon dioxide?

Experiment 84 — Carbon Dioxide and Respiration

Exhale the breath through a glass tube into a test tube half full of calcium hydroxide solution. Describe and explain the result.

Experiment 85 — Preparation and Properties of Acid Calcium Carbonate

MATERIALS. — Calcium hydroxide solution and the carbon dioxide generator used in Exp. **83**.

Pass carbon dioxide into a test tube half full of calcium hydroxide solution until the precipitate at first formed disappears. Filter, if the liquid is not perfectly clear. Heat the test tube gently and observe carefully all the changes. State the results of heating the clear solution.

Required Exercises. — 1. What is the name of the first precipitate?

2. Into what soluble compound was this precipitate formed by interaction with carbon dioxide?

3. Into what was the soluble compound formed by heating?
4. Write equations for the two essential reactions in Exp. **85**.

Experiment 86 — Testing for Carbonates

MATERIALS. — Barium hydroxide solution, glass tube, baking soda, washing soda, baking powder, native chalk, tooth powder, white lead, whiting, old mortar (or plaster).

Test the substances enumerated above for the presence of a carbonate as follows: Put a little of the solid in a test tube, add a little water and dilute hydrochloric acid, and shake; then hold the glass tube, which has been dipped into barium hydroxide solution, inside the test tube for a minute or two about 3 centimeters above the mixture. If the action is not marked, gently warm the test tube. State the result in each case.

Experiment 87. — Preparation and Properties of Acetylene

MATERIALS. — Calcium carbide, acetylene burner (for (*c*)).

(*a*) Examine a typical specimen of calcium carbide and state its characteristic physical properties.

(*b*) Fill a test tube nearly full of water, stand it in a rack, and drop in two or three very small pieces of calcium carbide. Acetylene is evolved. After the action has proceeded long enough to expel the air, light the gas by holding a lighted match at the mouth of the tube. Observe and record the nature of the flame.

(*c*) Attach an acetylene burner by a short rubber tube to a short glass tube inserted in a one-hole rubber stopper. Put 10 cubic centimeters of water in a test tube, drop in a small lump or two of calcium carbide, insert the stopper, and light the gas cautiously. Describe the flame.

SUPPLEMENTARY EXPERIMENTS

Experiment 88 — Properties of Graphite

MATERIALS. — Native and artificial graphite.

(*a*) Examine a specimen of native and of artificial graphite, and state the characteristic properties of each, especially the hardness,

color, and luster. Rub a piece of graphite with the finger, and describe the feeling; draw a piece slowly across a sheet of paper, and state the result.

(*b*) If a compact lump of graphite is available, determine its specific gravity by the following method: Tie a thread around the solid, and weigh it on the scales to a decigram. Slip it carefully into a graduated cylinder (Fig. 134) previously filled with water to a known point and note the increase in the volume of water. This increase in volume is equal to the volume of the solid. Calculate the specific gravity by dividing the weight of the solid by the weight of an equal volume of water (assuming the weight of 1 cubic centimeter of water to be 1 gram). State the result.

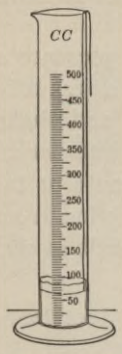

Fig. 134.—Apparatus for Finding the Specific Gravity of a Solid.

(*c*) Wind the end of a nichrome test wire (Fig. 103) around a small piece of graphite and hold the graphite in the hottest part of the flame for a minute or two; observe whether the graphite ignites readily. Continue the heating for five or more minutes and state the result.

(*d*) Examine available samples of graphite products, e.g. stove polish, plumbago crucibles, core of a lead pencil, electrodes, lubricants. Suggest a simple method of testing them for graphite; verify it by an experiment.

Experiment 89 — Preparation of Carbon Dioxide by Different Methods

(*Each student need not perform all of this Experiment.*)

MATERIALS. — Charcoal, copper wire (30 centimeters long), candle, magnesium carbonate, sodium carbonate, sodium bicarbonate.

A. *Combustion of Carbon.* Wind one end of the copper wire around a small lump of charcoal, heat the charcoal in the flame, and lower it into a bottle. Let it remain for several minutes. Remove it, and test the gas in the bottle for carbon dioxide. State the result.

B. *Carbonaceous Substances.* Attach the candle to the copper wire, light the candle, and lower it into a bottle. Let it burn a minute or two, then remove it, and test as in **A.** State the result. Allow a

piece of wood and of paper to burn in separate bottles, and test as in **A.** State the results.

C. *Carbonates and Acids.* Put a little magnesium carbonate into a test tube, add dilute hydrochloric acid, and test for carbon dioxide by lowering into the escaping gas a tube which has been dipped into barium hydroxide solution. Observe and state the change in the drop of barium hydroxide solution. Repeat, using sodium carbonate and dilute sulphuric acid; also sodium bicarbonate and dilute sulphuric acid. State the results.

D. *Heating Carbonates.* Heat a little sodium bicarbonate in a test tube, and test for carbon dioxide as in **C.**

Experiment 90 — Carbonic Acid

MATERIALS. — Solutions of sodium hydroxide and phenol-phthalein, bottle, and a carbon dioxide generator.

Construct and arrange the carbon dioxide generator as in Exp. **83.** Fill a bottle half full of water, add a few drops of a solution of phenol-phthalein and just enough sodium hydroxide solution to color the liquid a faint pink. Allow a *slow* current of carbon dioxide to bubble through the liquid in the bottle, until a definite change is produced in the absorbing liquid. Describe and explain it.

Experiment 91 — Preparation and Properties of Carbon Monoxide

MATERIALS. — Oxalic acid, concentrated sulphuric acid, calcium hydroxide solution, pneumatic trough filled as usual, three bottles, three glass plates. The *apparatus* is shown in Fig. 135.

Precaution. Carbon monoxide and oxalic acid are poisonous. Hot sulphuric acid is dangerous. Perform this experiment with unusual care.

I. *Preparation.* Put 10 grams of oxalic acid in the flask *A*, and add 25 cubic centimeters of concentrated sulphuric acid. Put enough calcium hydroxide solution in *B* to cover the end of the tube *E*. The end of *H* should rest on the bottom of the pneumatic trough just beneath the hole in the support. Heat the flask *A* gently, and carbon monoxide will be evolved. A small flame must be used, because the gas is rapidly evolved as the heat is increased. It is advisable to remove or lower the flame as bubbles appear in the tube *B*, — regulate the heat by the effervescence. Collect all the gas, but do *not*

use the first bottle, covering the bottles with glass plates as they are filled, and setting them aside temporarily. When the last bottle has been collected and covered, loosen the stopper in *B*, remove the end of *H* from the water in the trough, and if gas is still being evolved, stand the generating apparatus in the hood. Proceed at once with II.

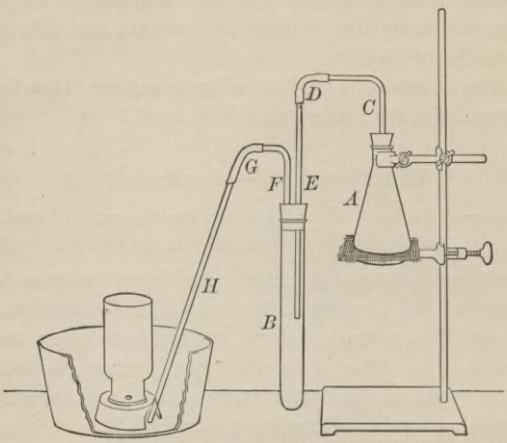

Fig. 135. — Apparatus for Preparing Carbon Monoxide.

II. *Properties.* Test the gas thus: (*a*) Notice that it is colorless. (*b*) Hold a lighted match at the mouth of a bottle for an instant. Note the flame, especially its color. After the flame has disappeared, drop a lighted match into the bottle. Describe the result. Draw a conclusion and verify it by (*c*).

(*c*) Burn another bottle of gas, and after the flame has disappeared pour calcium hydroxide into the bottle and shake. Explain the result.

Required Exercises. — 1. Describe briefly the preparation of carbon monoxide.

2. Summarize the observed properties of carbon monoxide.

3. What gas besides carbon monoxide was produced?

Experiment 92 — The Principle of the Davy Safety Lamp

(*a*) Press a wire gauze down upon a Bunsen flame. Where is the flame? Remove the gauze, let it cool (or use another gauze),

lower it upon the flame, and hold a lighted match just above the gauze. Now where is the flame?

(*b*) Extinguish the flame. Turn on the gas, hold the gauze in the escaping gas, about 15 centimeters (6 inches) above the top of the burner, and thrust a lighted match into the gas above the gauze. Where is the flame? Lower the gauze slowly and describe the final result.

(*c*) Hold the gauze in the flame in one position for a minute or two. Where is the flame at the end of this time? Why?

Required Exercises. — 1. Define kindling temperature.

2. State exactly how this experiment illustrates kindling temperature.

Experiment 93 — Properties of Carborundum

Examine specimens of different varieties of carborundum and state the characteristic properties of each, especially the hardness.

ILLUMINATING GAS — FLAME

Experiment 94 — Preparation and Properties of Illuminating (Coal) Gas

MATERIALS. — Soft coal, litmus paper, filter paper, lead nitrate solution.

Arrange an apparatus like the *A*–*B* part shown in Fig. 108. Fill the large test tube *A* two-thirds full of coarsely powdered soft coal, insert the stopper with its delivery tube *B*, and clamp the test tube carefully to the iron stand as shown in Fig. 108. Heat the whole tube gently at first, and gradually increase the heat, but avoid heating either end very hot.

(*a*) As soon as the gas begins to escape, hold at the end of the tube *B* a piece of filter paper which has been moistened with lead nitrate solution; observe the effect upon the paper. The discoloration is caused by lead sulphide which is produced by the interaction of lead nitrate and the sulphides in the liberated gas.

(*b*) Lay a piece of moistened red litmus paper on the end of the tube *B* and continue to heat strongly. Observe any change in the litmus paper. To what compounds in the gas is the change due?

(*c*) Heat strongly, and light the gas at the end of the tube *B*. Observe and describe the flame.

(*d*) Discontinue heating, let the apparatus cool somewhat, disconnect, and break open the test tube. Examine the contents. State the properties of both solid and liquid products; what is the name of each?

Experiment 95 — Candle Flame

MATERIALS. — Candle, two blocks of wood, bottle, piece of stiff white paper, calcium hydroxide solution, matches, a lead pencil, copper wire (15 centimeters or 6 inches long).

Attach a candle to a block of wood by means of a little melted candle wax, and proceed as follows:

(*a*) Hold a cold, dry bottle over the lighted candle. Describe the result produced inside the bottle. What is the product? What is its source? Remove the bottle, pour a little calcium hydroxide solution into it, and shake. Describe and explain the result. What are the two main products of a burning candle?

(*b*) Blow out the candle flame, and immediately hold a lighted match in the escaping smoke. Does the candle relight? Why? What is the general nature of this smoke? How is it related to the candle wax? How does (*b*) contribute to the explanation of (*a*)?

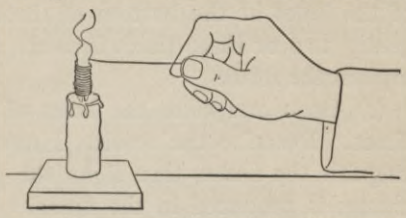

Fig. 136. — Effect of Cooling a Candle Flame.

(*c*) Press a piece of stiff white paper for an instant down upon the candle flame almost to the wick. Repeat several times with different parts of the paper. What does the paper show about the structure of the flame?

(*d*) Roll one end of the copper wire around a lead pencil to form a spiral about (2 centimeters or 1 inch) long. Press the spiral down slowly upon the candle flame (Fig. 136). Repeat after cooling the wire. What is the result? Why?

Optional Exercises. — 1. Draw a candle flame, showing the parts.

2. What is the essential difference between a candle flame and a Bunsen burner flame?

3. Is there any essential difference between a candle and a gas or a lamp flame?

4. Why do candles and lamps often smoke?

Experiment 96 — Bunsen Burner and Bunsen Burner Flame

MATERIALS. — Bunsen burner, glass tube, powdered charcoal, pin copper wire.

A. *Bunsen Burner.* Take apart a Bunsen burner and study the construction. Write a short description of the burner. Sketch the essential parts.

B. *Bunsen Burner Flame.* (*a*) Close the holes at the bottom of a lighted burner and hold a glass tube in the upper part of the yellow flame. Note the black deposit. What is it? Where did it come from? Open the holes and move the blackened tube up and down in the colorless Bunsen flame. What becomes of the deposit?

(*b*) Dip a glass tube a short distance into some powdered wood charcoal, place the end containing the charcoal in one of the holes at the bottom of the lighted burner, and blow gently two or three times into the other end. Describe and explain the result.

(*c*) Open and close the holes of a lighted burner several times. Describe the result. Pinch the rubber tube to extinguish the flame, then light the gas at the holes. What change is produced in the flame? What is the object of the holes?

(*d*) Hold a match across the top of the tube of a lighted Bunsen burner. When the match begins to burn, remove and extinguish it. Note where it is charred, and explain the result. Press a piece of wire gauze down upon the flame. Describe the appearance of the gauze. The same fact may be shown by sticking a pin through a (sulphur) match, suspending it across the burner, and then lighting the gas. The position of the match is shown in Fig. 137. Turn on a full current of gas before lighting it. What does the whole of experiment (*d*) show about the structure of the lower part of the Bunsen flame? Verify your answer by (*e*).

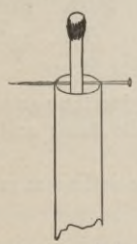

Fig. 137. — Sulphur Match Suspended Across the Top of a Bunsen Burner.

(*e*) Hold one end of a glass tube (about 15 centimeters or 6 inches long) in the Bunsen flame about 2 centimeters (1 inch) from the top of the burner tube. Hold a lighted match for an instant at the upper end of the tube; raise or lower the tube slightly (still keeping the end in the flame) and observe the result. What

does the result show about the structure of the Bunsen flame? How does it verify (*d*)?

(*f*) Find the hottest part of the flame, when a full current of gas is burning, by holding a copper wire in the flame. Measure its distance, approximately, from the top of the burner tube.

(*g*) Examine a slightly imperfect Bunsen burner flame — one which shows clearly the outlines of the inner part. What is the general shape of each main part? Draw a vertical and a cross section of the flame.

Experiment 97 — Reduction and Oxidation with the Blowpipe

(*Each pupil need not perform all of this Experiment.*)

MATERIALS. — Blowpipe, blowpipe tube, charcoal, lead oxide, sodium carbonate, sodium sulphate, wood charcoal, silver coin, zinc, lead, tin.

Slip the blowpipe tube into the burner. Light the gas and lower the flame until it is about 4 centimeters (1.5 inches) high. Rest the tip of the blow pipe (Fig. 138) on the top of the tube, placing the tip just within the flame. Put the other end of the blowpipe between the lips, puff out the cheeks, inhale through the nose, and exhale into the blowpipe, using the cheeks somewhat as bellows. Do not blow in puffs, but produce a continuous flow of air by steady and easy inhaling and exhaling. The operation is natural and simple, and, if properly performed, will not make one out of breath. The flame should be an inner blue cone surrounded by an outer and almost invisible cone, though its shape varies with the method of production (Fig. 139). Practice until the flame is produced voluntarily and without exhaustion.

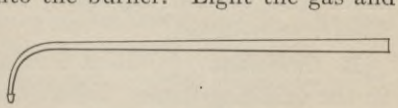

Fig. 138. — Blowpipe.

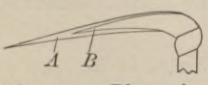

Fig. 139.— Blow pipe Flame—*A* (oxidizing) and *B* (reducing).

A. *Reduction.* (*a*) Make a shallow hole at one end of the flat side of a piece of charcoal. Fill the hole with a mixture of equal parts of powdered sodium carbonate and lead oxide, and heat the mixture in the reducing flame. In a short time bright, silvery globules will appear on the charcoal. Let the mass cool, and pick out the largest globules. Put one or two in a mortar, and strike with a pestle. Are they soft or hard? Malleable or brittle? How do the properties compare with those of metallic lead? What has become of the oxygen?

(*b*) Grind together in a mortar a little sodium sulphate and wood charcoal, adding at intervals just enough water to hold the mass together. Heat some of this paste in the reducing flame as in (*a*). Scrape the fused mass into a test tube, boil in a little water, and put a drop of the solution on a bright silver coin. If a dark brown stain is produced, it is evidence of the formation of silver sulphide. Repeat, if no such stain is produced. The silver sulphide is formed by the interaction of silver and sodium sulphide. Explain how the experiment illustrates reduction.

B. *Oxidation.* (*a*) Heat a small piece of zinc on charcoal in the oxidizing flame. Direct the flame so that most of the product will form a coating on the charcoal. What is the product? Observe the color of the coating on the charcoal when hot and cold. Record the result.

(*b*) Heat a piece of lead as in (*a*). Observe the color of the coating when hot and cold. Record the result.

(*c*) Heat a small piece of tin in the oxidizing flame. Observe and record as in (*b*).

Optional Exercises. — 1. Name the products formed in **B.**

2. Sketch a blowpipe.

3. Sketch a flame showing the oxidizing and reducing parts.

Supplementary Experiments

Experiment 98 — Combustion of Illuminating Gas

Materials. — Pointed glass tube, calcium hydroxide solution, bottle.

Remove the Bunsen burner from the rubber connection tube and replace it by a glass tube with a small opening. Light the gas, and

lower a small flame into a cold, dry bottle. Observe at once the most definite result inside the bottle. Remove and extinguish the flame, pour a little calcium hydroxide solution into the bottle, and shake. What are the two products of the combustion of illuminating gas?

Experiment 99 — Properties of the By-Products of the Manufacture of Illuminating Gas

MATERIALS. — Tar, ammoniacal liquor, coke, gas carbon.

A. *Tar.* Examine a specimen of tar and state its characteristic properties.

B. *Ammoniacal Liquor.* (*a*) Proceed as in **A**, using ammoniacal liquor.

(*b*) Recall, perform, or repeat (if necessary) Exp. **53 C.**

C. *Coke and Gas Carbon.* (*a*) Proceed as in **A**, using coke and gas carbon.

(*b*) Proceed with coke and with gas carbon as in Exp. **88.**

(*c*) Compare with the results obtained in Exp. **88** (*c*).

Experiment 100 — Testing Illuminating Gas

(*a*) Test samples of illuminating gas for carbon dioxide, sulphides (Exp. **94** (*a*)), and ammonia. State the results.

(*b*) Suggest a test for carbon monoxide. Submit the details to the Teacher, before proceeding.

(*c*) Test illuminating gas for moisture.

Experiment 101 — Testing Metals with the Blowpipe

Obtain "unknowns" from the Teacher and test as in Exp. **97 B.**

Experiment 102 — Welsbach Burner, Mantle, and Flame

MATERIALS. — Welsbach burner and mantle.

Examine a Welsbach burner and compare its structure with that of the Bunsen burner. Connect the burner with the gas supply, light the gas, and compare the flame with the Bunsen burner flame. Are the burners and flames essentially different?

Examine a Welsbach mantle carefully. Suspend the mantle on the end of an iron wire (e.g. the handle of a deflagrating spoon), and hold the mantle in the Bunsen burner flame. State the result.

Experiment 103 — Composition of Organic Compounds

MATERIALS. — Meat, gelatin, glue, leather, albumin, mustard, sugar.

A. *Carbon.* (*a*) Recall, perform, or repeat (if necessary) the experiment showing the distribution of carbon (Exp. **80**).

(*b*) Heat a very small piece of meat in a test tube and state the final result. (See also Exp. **104** (*d*) and **117 A.**)

B. *Nitrogen.* Proceed as in Exp. **117 B,** using various organic substances, e.g. gelatin, glue, meat, leather, peas, beans, nuts, leaves. State each result.

C. *Sulphur.* Proceed as in Exp. **117 C,** using various organic substances, e.g. albumin, mustard. State each result.

D. *Phosphorus.* Proceed as in Exp. **117 D,** using various organic substances, e.g. albumin, casein, seeds, cereals, nuts. State each result.

E. *Hydrogen and Oxygen.* Heat a little dry sugar in a test tube and notice the deposit of water in the upper part of the test tube.

Experiment 104 — Properties of Sucrose (Cane Sugar)

MATERIAL. — Cane sugar.

(*a*) Examine different varieties of sucrose and state the characteristic properties.

(*b*) Put a little sucrose in the upper end of a test tube, hold the test tube in a horizontal position, and heat very gently by moving it back and forth above the flame. As soon as the sugar is melted, pour a little out upon a glass plate. Examine it later and describe the cooled mass. Add more sugar, heat as usual, and notice the change in color of the substance. Note the odor and also the deposit of water in the upper part of the test tube. Heat still further, and describe

the substance finally obtained. When the test tube is cool, break it and examine the residue. What is it? Verify your answer by a simple test.

(*c*) If time permits, prepare crystals of sucrose by suspending a thread in a concentrated solution. Describe the crystals.

(*d*) Put a little cane sugar in a test tube, add enough concentrated sulphuric acid to cover it, and mix by shaking. Observe the result after a few minutes. If the change is not conspicuous, warm slightly. What in all probability is the final solid substance?

Experiment 105 — Properties of Dextrose (Glucose)

MATERIALS. — Glucose, solutions of silver nitrate and sodium hydroxide.

(*a*) Examine different varieties of dextrose, e.g. glucose, grape sugar, and state the characteristic properties. Taste and compare the sweetness with that of sucrose.

(*b*) Proceed as in Exp. **104** (*b*), using grape sugar instead of sucrose. Compare the results, especially the color and odor.

(*c*) Put a little grape sugar in a test tube, add concentrated sulphuric acid, and examine after a short time. Compare with Exp. **104** (*d*).

(*d*) For fermentation, see Exp. **127**.

(*e*) For Fehling's test, see Exp. **106**.

(*f*) Clean a test tube thoroughly by boiling dilute sodium hydroxide solution in it, and washing several times with water. Put 10 cubic centimeters of silver nitrate solution in the clean test tube, and add ammonium hydroxide slowly until the precipitate at first formed redissolves, taking care to mix the solutions. Add a little grape sugar solution and warm gently. Silver will be deposited as a bright film inside the test tube.

(*e*) If a polariscope is available, examine a solution of dextrose according to directions given by the Teacher.

Experiment 106 — Fehling's Test for Sugar

MATERIALS. — Copper sulphate, Rochelle salt, sodium hydroxide, and sugar solutions.

(*a*) Mix equal (and small) volumes of copper sulphate and Rochelle salt solutions in a test tube, and boil carefully; then add enough sodium hydroxide solution to make the mixture strongly alkaline.[1] Add a little glucose solution, and boil until a decided change is produced. The precipitate is cuprous oxide. Describe it.

(*b*) Repeat (*a*), using cane sugar solution instead of glucose. State the result.

Experiment 107 — Testing for Glucose

MATERIALS. — Fehling's solution and the substances enumerated below.

Apply Fehling's test for glucose (and similar sugars) to cheap candy, maple sugar, molasses, table sirups, jelly, jam, etc. Prepare and use clear solutions. State the result in each case.

Experiment 108 — Properties of Starch

MATERIALS. — Starch, microscope, Fehling's solution, iodine solution.

(*a*) Examine different kinds of starch with a microscope, if one is available. Describe them. If time permits, make drawings.

(*b*) Examine with a microscope thin slices of peas or beans which have been soaked about eight hours in water. Describe.

(*c*) Examine a thin slice of potato with a microscope. Describe.

(*d*) Prepare a starch mixture by boiling about 1 gram of powdered starch for a few minutes in a test tube containing

[1] This mixture, which is called Fehling's solution, may be prepared accurately as follows: Dissolve 34.64 gm. of crystallized copper sulphate in 500 cc. of water — solution No. 1; dissolve 180 gm. of Rochelle salt (sodium potassium tartrate) and 70 gm. of sodium hydroxide in 500 cc. of water — solution No. 2. Filter, if not clear. Mix the two solution (equal volumes) just before using.

50 cubic centimeters of water; stir or agitate the mixture during the boiling. Make three tests with the starch mixture (the third is (*e*) below). (1) Pour most of it into an evaporating dish which stands on a gauze-covered ring and boil, add 1 cubic centimeter of concentrated sulphuric acid, mix well, and boil for at least ten minutes; add water occasionally to replace that lost by evaporation. Meanwhile proceed with the second test. (2) Dilute the rest of the original starch mixture with water and test it with Fehling's solution. Observe and state the final result. As soon as the mixture in (1) has been boiled at least ten minutes, take out a little, add sodium hydroxide solution to alkaline reaction and apply Fehling's test. Note the result. Continue the heating for ten or more minutes, and test again. State the final result.

(*e*) Prepare a dilute iodine solution by dissolving a few crystals of iodine in 10 cubic centimeters of alcohol. Add a few drops of the iodine solution to a dilute, cold starch mixture. Observe the blue color. (This test for starch is delicate, and dilute mixtures should be used.)

Experiment 109 — Properties of Alcohol

MATERIALS. — Alcohol, camphor, shellac, rosin, porcelain dish.

A. *Ethyl Alcohol.* (*a*) Determine cautiously the odor and taste of alcohol. Drop a little on a glass plate or on a piece of paper, and watch it evaporate. Is its rate of evaporation more rapid than that of water?

(*b*) Weigh a measured quantity (about 25 cubic centimeters) of alcohol and calculate its specific gravity.

(*c*) Alcohol dissolves many organic substances. Try camphor, powdered shellac, or rosin. Describe the result. Verify the solvent power of alcohol by adding water to the solutions. Describe the result.

(*d*) Burn a little alcohol in a dish and observe the nature of the flame. What are the products of combustion?

B. *Methyl Alcohol.* Repeat **A**, using methyl alcohol.

Experiment 110 — Properties of Acetic Acid

Treat acetic acid as follows: (*a*) Taste (cautiously), and describe.

(*b*) Test with litmus paper, and describe the result.

(*c*) Warm a little in a test tube, and smell (cautiously). Describe the odor.

Experiment 111 — Test for Acetic Acid and Acetates

Cautiously add a few drops of concentrated sulphuric acid to equal (and small) volumes of acetic acid and ethyl alcohol. Shake the mixture and warm gently. The pleasant, fruitlike odor is due to ethyl acetate.

NOTE. — This experiment is also a test for alcohol.

Experiment 112 — Properties of Vinegar

(*a*) Show, experimentally, that a sample of vinegar contains acetic acid.

(*b*) Evaporate a little vinegar to dryness on a water bath and note the residue. Stand the dish on a gauze-covered ring and heat gently. Note the ash. Test the ash for (1) a carbonate and (2) potassium. Perform (2) by heating a little of the ash with a test wire; potassium compounds color the flame a delicate lilac.

Experiment 113 — Testing Baking Powder

MATERIALS. — Baking powder, vinegar, sour milk, lemon juice, iodine solution, sodium hydroxide, ammonium oxalate solution, and the substances needed for **B, C, E, G.**

A. *Carbonates.* (*a*) Put a little baking powder in a test tube, add a few drops of dilute hydrochloric acid, and test the escaping gas with a tube which has been dipped into barium hydroxide solution. State the result.

(*b*) Put a little baking powder in a test tube, add 15 to 20 cubic centimeters of water, and shake well. Let the action continue a short time, and then test as in (*a*). State the result.

(*c*) Add to a little baking powder sour substances, e.g. vinegar, sour milk, lemon juice, and state the result.

B. *Tartrates.* Prepare a cold solution of baking powder by shaking about 3 grams of the substance with 25 cubic centimeters of water, filter, if not clear, and use the clear solution in this and succeeding experiments (except **D** and **G**). Clean a test tube by boiling sodium hydroxide solution in it and then washing thoroughly with water, and then proceed as in Exp. **105** (*f*), using the baking powder solution instead of glucose. Tartrates, if present, will reduce the silver compound to silver, which will coat the inside of the test tube.

C. *Chlorides and Sulphates.* Apply the usual tests for these to small portions of the baking powder solution (prepared in **B**). In each case acid must be added to acid reaction and the solution boiled before testing — dilute nitric for chlorides and dilute hydrochloric for sulphates. State the result.

D. *Starch.* Apply the iodine test for starch to a little baking powder mixed with water. (See Exp. **108** (*e*)). State the result.

E. *Phosphates.* Warm a little of the baking powder solution with a little concentrated nitric acid, and test as in Exp. **117 D.** State the result.

F. *Ammonium Compounds.* Boil a few cubic centimeters of the baking powder solution with an equal volume of sodium hydroxide solution. The presence of ammonium compounds is shown by the liberation of ammonia gas, which can be detected by its odor and its action on red litmus paper. State the result.

G. *Aluminium Compounds.* (1) Proceed as in Exp. **209** (*c*) using a little baking powder instead of an aluminium compound. (2) Heat some baking powder in a porcelain dish. Add hot water, boil, filter, and add considerable ammonium chloride to the filtrate. A whitish flocculent precipitate of aluminium hydroxide is produced. State the result.

H. *Calcium Compounds.* Boil a few cubic centimeters of the clear baking powder solution with dilute hydrochloric

acid (to remove the carbon dioxide), add ammonium hydroxide to alkaline reaction, filter if not clear, and then ammonium oxalate solution. If calcium compounds are present, a white precipitate (calcium oxalate) will be formed.

Experiment 114 — General Properties of Fats

MATERIALS. — Fats, liquids as in (*c*).

(*a*) Examine several kinds of fat, e.g. lard, tallow, butter, and note the consistency, color, odor, taste, and any other characteristic property.

(*b*) Put a small quantity of fat on a piece of filter paper, drop a little alcohol or ether on another part of the same paper, and compare the results after a few minutes.

(*c*) Are fats soluble in water, alcohol, ether, gasoline, and carbon tetrachloride? Try the effect of one or more of these liquids (e.g. gasoline) separately on several fats. State the result.

(*d*) Test rancid fat for acid by shaking the fat with a little alcohol and then adding a few drops of neutral litmus or phenol-phthalein solution (or a piece of sensitive litmus paper) to the solution. State the result.

Experiment 115 — Preparation of Soap

MATERIALS. — Sodium hydroxide, lard, salt; for **C** potassium hydroxide, alcohol, cotton-seed oil.

Prepare soap by one of the following methods: **A.** Dissolve 10 grams of sodium hydroxide in 75 cubic centimeters of water, add 30 grams of lard, and boil the mixture in a metal dish for an hour or more; add water occasionally to replace that lost by evaporation. Then add 20 grams of fine salt in small portions. Stir constantly during the addition of the salt. Let the mass cool, and then remove the soap, which will form in a cake at the surface.

B. Dissolve 13 to 15 grams of sodium hydroxide in 100 cubic centimeters of water, add 100 cubic centimeters of castor oil,

and boil for about half an hour. Add 20 grams of salt, and then proceed as in **A.**

C. Dissolve 1 gram of potassium hydroxide in 10 cubic centimeters of alcohol, add a little lard or cotton-seed oil, and stir constantly while the mixture is being heated cautiously to sirupy consistency. Allow the solution to cool. The jelly-like product is soap.

Experiment 116 — Properties of Soap

MATERIALS. — Soap, sulphuric acid, calcium sulphate, magnesium sulphate, and acid calcium carbonate solutions.

Test as below the soap prepared in Exp. **115** (or another sample, if desired).

(*a*) Leave soap shavings exposed to the air for several days. What does the result show about the presence of water in the soap?

(*b*) Test soap solution with litmus paper. State the result. Put a few drops of phenol-phthalein solution on dry soap. State the result. This is a test for "free alkali."

(*c*) Add considerable dilute sulphuric acid to a soap solution. The precipitate is a mixture mainly of palmitic and stearic acids. Describe it.

(*d*) To a little soap solution in separate test tubes add calcium sulphate and magnesium sulphate solutions. Describe the result. Boil for a few minutes and describe the result. Prepare a solution of acid calcium carbonate by passing carbon dioxide into limewater until the precipitate is redissolved (see Exp. **85**). Add some of the solution to a soap solution, and describe the result. Boil, as above, and describe the result.

Experiment 117 — Composition of Proteins

MATERIALS. — Albumin, soda-lime, sodium hydroxide solution, lead acetate solution, sodium carbonate, potassium nitrate, ammonium molybdate solution.

A. *Carbon.* Put a few small pieces of dry egg albumin in a test tube. Heat gently at first and finally increase the heat.

Notice the characteristic odor of the burning albumin. Notice also the change in color.

B. *Nitrogen.* Put a small amount of dry egg albumin in a test tube and add five times its bulk of soda-lime. Mix by shaking. Heat gently and test the escaping vapors with moist red litmus paper. Explain the result.

C. *Sulphur.* Put a small quantity of dry egg albumin in a test tube. Add 5 to 10 cc. of dilute sodium hydroxide solution and a few drops of lead acetate solution. Boil the mixture a few moments and notice the change in color. The black (or brown) compound is lead sulphide.

D. *Sulphur and Phosphorus.* Put a small quantity of dry egg albumin in a porcelain dish and add about five times its bulk of fusion mixture, i.e. equal quantities of powdered sodium carbonate and potassium nitrate. Stand the dish on a gauze-covered ring attached to an iron stand. Heat cautiously at first and finally increase the heat sufficiently to produce mild deflagration. Continue the heat until the mixture becomes nearly colorless. Let the dish cool. Meanwhile boil some water in a test tube and dissolve the residue in the boiling water. Filter the solution if it is not clear, and divide into two parts. To one part add concentrated hydrochloric acid drop by drop, boil until effervescence ceases, and then add barium chloride solution. What is the white precipitate? Explain its formation. To the other portion add concentrated nitric acid drop by drop, boil until effervescence ceases, and then add a little ammonium molybdate solution. Warm slightly. A yellow precipitate of ammonium phospho-molybdate should be formed.

Experiment 118 — Tests for Proteins

MATERIALS. — Albumin and the specified solutions.

A. *Color Reactions.* (*a*) Prepare a dilute solution of egg albumin. To about 5 cc. add an equal volume of sodium hydroxide solution. Then add drop by drop a *dilute* copper sulphate solution. A violet color is produced.

(*b*) To 5 cc. of albumin solution add an equal volume of concentrated nitric acid. Heat gently until a yellow precipitate or a yellow solution is obtained. Cool in running water and add an excess of sodium hydroxide solution. An orange color is produced.

B. *Precipitation.* (*a*) To 5 cc. of albumin solution add concentrated nitric acid slowly, pouring the acid down the inside of the tube so the two solutions will not mix. A white cloudy precipitate is formed at the surface of the two liquids.

(*b*) Add a few drops of mercuric chloride solution (POISON) to a little albumin solution. Observe the white precipitate.

(*c*) Proceed as in (*b*), using alum solution instead of mercuric chloride solution.

C. *Coagulation.* Put about 5 cc. of undiluted egg albumin in a test tube and heat gently. Observe and state the result.

Experiment 119 — Testing Food

MATERIALS. — Samples of food from the table in Part I § **258**.

A. *Nutrients.* Apply tests for carbohydrate, fat, and protein to various kinds of food. In testing for fat, shake the crushed food with gasoline, pour off the gasoline into a dish, let it evaporate, and examine the residue. (Keep gasoline away from flames.) State the results in each case.

B. *Water.* Proceed as in Exp. **14** with various kinds of food.

C. *Mineral Matter.* Heat a sample in an evaporating dish or on a piece of porcelain until all traces of carbon are removed. The white or whitish residue is mineral matter. Further tests may be made for a chloride or sulphate or for different metals, e.g. sodium (flame test), calcium (Exp. **113 H**), aluminium (Exp. **209** (*c*)), potassium (flame test).

Experiment 120 — Testing Flour

MATERIALS. — Flour, cheese cloth.

A. *Fat.* Apply a test for fat to dry flour. State the result.

B. *Carbohydrate and Protein.* Put a little flour on a small piece of cheese cloth and tie the cloth into a bag. Put the closed bag in an evaporating dish half full of water and move the bag about in the water, squeezing it occasionally. Finally, remove the bag and wash it thoroughly in running water. Apply tests for starch and protein to (1) the solid left in the bag and (2) the solid that settles in the dish. State each result.

C. *Water and Mineral Matter.* Proceed as in Exp. **119 B,** and **C.** State each result.

D. Devise an experiment to show that carbon dioxide is formed during bread making. Before proceeding, submit the details to the Teacher. (Suggestion. — See Exp. **127** I.)

Supplementary Experiments

Experiment 121 — Preparation of Invert Sugar (Dextrose and Levulose) from Sucrose

Materials. — Cane sugar, Fehling's solution.

Add a few drops of concentrated hydrochloric acid to about 25 cubic centimeters of cane sugar solution and boil several minutes. Neutralize with sodium hydroxide solution and test with Fehling's solution. State the result.

Experiment 122 — Testing for Sugar in Vegetables and Fruits

Materials. — Fehling's solution and the substances enumerated below.

Apply Fehling's test to a clear solution obtained from each of the following: Apple, banana, orange, carrot, turnip, raisins, and other available vegetables and fruits. Prepare the solution by cutting or grinding the substance into very small pieces, or adding a little water, and squeezing the soft mass in a piece of cheese cloth. State the result in each case.

Experiment 123 — Detection of Starch by Iodine

Materials. — Dilute solution of iodine, mortar and pestle, potato, rice, bread.

(*a*) Test potato, rice, and bread for starch by grinding a little of each separately with water in a mortar, and then adding a few

drops of the extract to a very dilute solution of iodine. State the result in each case.

(*b*) Proceed with the testing as in (*a*), using substances not positively known to contain starch, such as baking powder, leaves of different kinds of trees, roots of vegetables, popped corn, straw. State the result.

Experiment 124 — Conversion of Starch into Sugar by an Enzyme

MATERIALS. — Cracker or bread, Fehling's solution.

(*a*) Grind a small piece of cracker or bread in a mortar with a little water, and test the mixture with Fehling's solution. State the result.

(*b*) Chew a piece of cracker or bread for a minute or two, add a little water, and test the clear solution with Fehling's solution. Compare with the result in (*a*).

Experiment 125 — Properties of Dextrin

MATERIALS. — Dextrin, tannin, Fehling's solution, toasted bread.

(*a*) Examine dextrin and state its characteristic properties. Taste a little and compare its sweetness with that of sucrose and dextrose.

(*b*) Dissolve dextrin in a little water and note the properties of the solution. Apply some of the solution to one side of a piece of paper, fold over the coated side, press together, and examine after a short time. State the final result. Dilute the rest of the solution and use in (*c*) and (*d*).

(*c*) Add tannin to part of the dextrin solution from (*b*). Observe and state the result.

(*d*) Apply Fehling's test to dextrin solution. State the result.

(*e*) Soak toasted bread in water, filter, and test the filtrate for dextrin (as in (*c*) and (*d*)).

Experiment 126 — Properties of Guncotton, Collodion, and Celluloid

MATERIALS. — Guncotton, cotton, collodion, celluloid.

(*a*) Examine guncotton and state its obvious properties. Rub it between the fingers and compare the feeling with that produced by ordinary cotton. Burn a little guncotton and ordinary cotton, and compare the results.

(*b*) Pour or brush a little collodion solution on a glass plate. As soon as the solvent has evaporated, examine and describe the resulting film of collodion. Ignite a small piece of the film, and observe and state the result.

(*c*) Examine celluloid and state its characteristic properties, especially the odor. Set fire to a small piece, and observe and state the result.

Experiment 127 — Preparation and Properties of Ethyl Alcohol

MATERIALS. — Grape sugar, yeast, calcium hydroxide solution, animal charcoal, sodium hydroxide. The *apparatus* consists of a large bottle provided with a one-hole stopper fitted with a delivery tube which reaches to the bottom of a small bottle.

I. *Preparation.* Put 500 cubic centimeters of water in the bottle, add 60 grams of grape sugar, and shake until dissolved. Break a fresh yeast cake into small pieces, grind it to a paste with a little water, and add it to the sugar solution. Fill the small bottle half full of calcium hydroxide solution, and carefully cover this solution with a little kerosene. Stand the apparatus where the temperature is 25° to 30° C.

Fermentation begins at once, and carbon dioxide — one of the products — bubbles through the calcium hydroxide solution, which is protected from the action of carbon dioxide in the air by the kerosene. The operation should be allowed to continue three or four days. The alcohol must be separated by distillation.

II. *Properties.* The distillation is performed with the apparatus used in Exp. **26**. Fill the flask half full of the liquid from I, add a few pieces of pipestem (or granulated zinc, or glass tubing) to prevent "bumping," and distil about 50 cubic centimeters. Save the distillate. Replace the residue in the flask by more liquid from I, distil again, and repeat this operation until all the liquid has been used. Replace the one-hole stopper with a two-hole stopper, insert the bent tube into one hole and a thermometer into the other so that the bulb just touches the surface of the combined distillates, which should now be distilled. Heat gently, and collect in a separate receiver the distillate which is formed when the temperature reaches about 95° C. This distillate contains most of the alcohol. Test as follows: (*a*) Note the odor.

(*b*) Drop a little into a warm dish, and hold a lighted match over it. If it does not burn, it shows that the alcohol is too dilute. Put a little in a dish, warm gently, and light the vapor. Describe the result.

(*c*) To the remainder add a crystal or two of iodine and just enough sodium hydroxide solution to dissolve the iodine. Warm gently several minutes and then cool. The yellow product is iodoform and its formation is a test for alcohol.

Experiment 128 — Preparation and Properties of Formaldehyde

MATERIALS. — Methyl alcohol, copper wire, forceps, formalin, silver nitrate solution.

(*a*) Put a few cubic centimeters of methyl alcohol in a test tube and stand the test tube in a rack. Wind a piece of copper wire into a spiral around a glass rod or lead pencil. Slip the spiral from the rod, grasp one end with the forceps, and heat the wire red-hot in the flame. Then quickly drop it into the methyl alcohol. The pungent vapor which is suddenly produced is largely the vapor of formaldehyde.

(*b*) Proceed as in Exp. **105** (*f*), using formalin instead of glucose solution.

(*c*) Let gelatin or albumin stand in formalin for several days. Observe and state the change in the solid.

Experiment 129 — Properties of Ether

MATERIALS. — Ether, evaporating dish, glass plate, wax.

Precaution. *Ether vapor is easily ignited, and ether should never be brought near a flame unless the directions so state.*

(*a*) Pour a little ether into a dish or test tube and observe the odor and volatility. Taste cautiously. Pour a drop upon a glass plate or a block of wood. How does its rate of evaporation compare with that of alcohol? Pour a little upon the hand and describe the result.

(*b*) Add a bit of wax to a few cubic centimeters of ether, and shake well. Observe the result. If the result is doubtful, pour the liquid carefully upon a glass plate, and observe the final result. Draw a conclusion regarding the solvent power of ether.

(*c*) Put a *few* drops of ether in an evaporating dish, and cautiously bring a Bunsen flame near it. Describe the result.

Experiment 130 — Physical Properties of Sulphur

(*If desired,* (c) *may be omitted and performed later as Exp.* **132**.)

MATERIALS. — Sulphur, graduated cylinder.

(*a*) Examine specimens of brimstone and flowers of sulphur, and state the characteristic properties of each.

(*b*) Determine the specific gravity of sulphur by the method given in Exp. **88** (*b*).

(*c*) Fill a test tube one fourth full of small lumps of sulphur and heat carefully until all the sulphur is melted. Observe the color and consistency of the melted sulphur. Increase the heat, and observe as before. Continue to heat until the sulphur boils and then observe as before. Let the test tube cool, and save it for Exp. **132**. Summarize the observations made when sulphur was heated.

NOTE. — If the test tube should break during the heating, extinguish the burning sulphur with sand.

Experiment 131 — Preparation of Crystallized Sulphur

MATERIALS. — Sulphur (roll), carbon disulphide, evaporating dish.

A. *Monoclinic.* Fix a folded filter paper firmly in a funnel, and place the funnel in a test tube which stands in a rack. Fill another test tube two-thirds full of roll sulphur, heat it at first throughout its length, next gradually increase the heat until all the sulphur is melted, and then quickly pour it upon the filter paper. Let it cool until crystals appear just below the surface, and then pour out the remaining melted sulphur. Remove the paper and adhering sulphur, and cut, or break, open the cone of crystallized sulphur. Observe and record the properties of the crystals, especially the shape, size, color, luster, brittleness, and any other characteristic property.

Allow the best crystals to remain undisturbed for a day or two; then examine again, and record any marked changes.

B. *Orthorhombic.* Put about 3 grams of powdered roll sulphur in a test tube and add about 10 cubic centimeters of carbon disulphide — remember to keep the carbon disulphide away from flames. Shake until most of the sulphur is dissolved, then filter the solution (or pour the clear liquid) into an evaporating dish to crystallize. It is advisable, and often absolutely necessary, to stand the dish in the hood or out of doors, where there is no flame and where the offensive vapor will be quickly removed. Allow the liquid to evaporate; watch the crystallization toward the end, if convenient, and when the liquid has evaporated almost entirely, remove and dry the best crystals. Examine them as in **A** and record their properties.

Experiment 132 — Preparation of Amorphous Sulphur

MATERIALS. — Sulphur, test tube, evaporating dish.

Put a few pieces of roll sulphur in a test tube (see Exp. **132** (*c*)), heat carefully until the sulphur boils, and then quickly pour the molten sulphur into a dish of cold water. This is the plastic variety of amorphous sulphur. Note its properties. Preserve, and examine it after twenty-four hours. Describe it, and compare its properties with those previously observed. Pulverize a small piece and test its solubility in carbon disulphide. State the result.

Experiment 133 — Chemical Properties of Sulphur

MATERIALS. — Sulphur, deflagrating spoon, bottle, iron thread.

(*a*) Set fire to a little sulphur in a deflagrating spoon, and lower the spoon into a bottle. *Cautiously* waft the fumes toward the nose, and observe and describe the odor. What is the product of burning sulphur? What does its formation show about the combining power of sulphur?

(*b*) Fill a test tube one-fourth full of sulphur and press iron thread down upon the sulphur until the test tube is nearly

full. Heat the test tube strongly until the sulphur boils or there is marked evidence of chemical action. Remove the test tube from the flame as soon as the reaction begins. Observe and describe the result. What is the name of the product of the chemical change?

(*c*) Expose moist sulphur to the air for an hour or more. Shake with water, filter, and apply the test for a sulphate to the filtrate. State the result. What property of sulphur is illustrated by this experiment?

Experiment 134 — Preparation and Properties of Sulphur Dioxide and Sulphurous Acid

MATERIALS. — Sodium sulphite, concentrated sulphuric acid, litmus paper, three bottles, two glass plates, joss stick, colored flower. The *apparatus* is shown in Fig. 140.

I. *Preparation.* (*a*) *Sulphur Dioxide.* Put about 10 grams of sodium sulphite in the flask, cover it with water, and insert the stopper with its tubes. Adjust the apparatus as shown in Fig. 140. Fill the cup with concentrated sulphuric acid, press the pinchcock a little, and let the acid flow *drop by drop* upon the sodium sulphite. Sulphur dioxide gas is evolved and passes into the bottle, which should be removed when full, as previously described. Moist blue litmus paper held for an instant at the mouth of the bottle will show (by change in color) when the latter is full. Collect two bottles of gas, cover each with a glass plate, and set aside until needed.

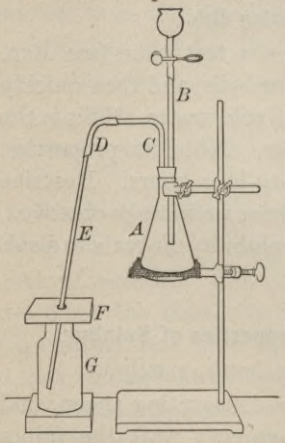

Fig. 140. — Apparatus for Preparing Sulphur Dioxide.

(*b*) *Sulphurous Acid.* As soon as the second bottle of gas has been removed and covered, put in its place a bottle one fourth full of water. Adjust its height (if necessary) by wooden

blocks, so that the end of the delivery tube is just above the surface of the water. Continue to add the acid *drop by drop*, at intervals. Shake the bottle occasionally. Meanwhile proceed as in II with the sulphur dioxide gas already collected.

II. *Properties of Sulphur Dioxide Gas.* (*a*) Observe and state the most obvious physical properties, e.g. color, odor (cautiously), density.

(*b*) Hold a blazing joss stick in the same bottle of the gas for a few seconds. Does the gas burn or support combustion?

(*c*) Stand the bottle (used in (*a*)) mouth downward in a vessel of water. Shake, still keeping the mouth submerged. State the result. Test the solution with litmus paper. Is the resulting liquid acid, alkaline, or neutral?

(*d*) Moisten a colored flower with a few drops of water, hang it in the remaining bottle of sulphur dioxide, holding it in place by putting the stem between the glass and a cork. Observe and describe any change in the color of the flower. (If a flower is not available, use colored paper.)

III. *Properties of Sulphurous Acid.* Test as follows the solution of sulphurous acid prepared in I (*b*): (*a*) Observe the odor and the taste *cautiously*. State the result in each case.

(*b*) Apply the litmus test, and state the result.

(*c*) Divide the solution into two parts. Save one for (*d*). Into the other put a piece of magnesium. State the result.

(*d*) Pour a few drops of potassium permanganate solution into the other portion of the sulphurous acid solution. Observe and state the result. What chemical change has the sulphurous acid undergone? If in doubt, suggest an experiment which will answer the question.

Experiment 135 — Properties of Sulphuric Acid

MATERIALS. — Concentrated sulphuric acid, small graduated cylinder, hydrometer, thin stick of wood, sugar.

(*a*) Weigh a 25 cubic centimeter graduated cylinder, pour in concentrated sulphuric acid to a convenient height, and weigh again. Read the volume of the acid. From the weight

and volume of the acid, calculate its specific gravity. Verify the result by reading the hydrometer which floats in a sample of the same acid. (This apparatus should be arranged for the class by the Teacher.)

(*b*) Add an equal volume of concentrated sulphuric acid to a test tube one-fourth full of water, and observe the change in temperature. Save the solution for (*c*) and (*d*).

(*c*) (1) Write some letters or figures with the sulphuric acid from (*b*) on a sheet of white paper, and move the paper back and forth over a low flame, taking care not to set fire to the paper. As the water evaporates the dilute acid becomes concentrated. Observe and describe the result. (Paper is largely a compound of carbon, hydrogen, and oxygen, and the hydrogen and oxygen are present in the proportion to form water.) Explain the general chemical change in this experiment. (2) Warm the acid in the test tube saved from (*b*), stand a stick of wood in the acid, and allow it to remain for fifteen minutes or more. Then remove the stick and wash off the acid. Describe and explain the change in the wood. (3) Proceed as in Exp. **104** (*d*).

(*d*) *Perform in hood.* Put a few drops of concentrated sulphuric acid in an evaporating dish, support the dish on a gauze-covered ring attached to an iron stand, and heat intensely. Observe and describe the result. Stop heating as soon as the result is obtained and let the dish cool before removing it.

Experiment 136 — Tests for Sulphuric Acid, Sulphates, and SO_4-ions

MATERIALS. — Sulphuric acid, sodium sulphate, barium chloride solution, calcium sulphate, charcoal, powdered charcoal, blowpipe, silver coin.

A. *Sulphuric Acid.* Recall a test for concentrated sulphuric acid. How could the same test be utilized in the case of dilute sulphuric acid?

B. *Sulphuric Acid and Soluble Sulphates,* i.e. solutions

containing SO_4-ions. Add barium chloride solution to the solution of the acid or the sulphate, and boil with dilute hydrochloric acid. If no sulphur dioxide gas is liberated and an insoluble precipitate remains, then the original solution contained SO_4-ions. (See Exp. **134**.)

C. *Insoluble Sulphates.* Proceed as in Exp. **97 A** (*b*), using calcium sulphate (or any insoluble sulphate).

Supplementary Experiments

Experiment 137 — Sulphur Matches

(*a*) Examine a sulphur match. Do you detect any sulphur? Where?

(*b*) Light a sulphur match, and observe the entire action, as far as the sulphur is concerned. Describe it.

(*c*) What is the function of the sulphur in a burning match?

Experiment 138 — Preparation and Properties of Hydrogen Sulphide

Materials. — Ferrous sulphide, dilute hydrochloric acid, three bottles, three glass plates, stoppered bottle, litmus paper. The *apparatus* is shown on Fig. 141.

Precaution. *Hydrogen sulphide is a poisonous gas and has an offensive odor. It should not be inhaled nor allowed to escape into the laboratory. Perform in the hood all experiments with hydrogen sulphide.*

I. *Preparation.* Construct and arrange an apparatus like that shown in Fig. 141. Fill the bottle *A* one fifth-full of coarsely powdered ferrous sulphide, insert the stopper tightly, and adjust the apparatus so that the end of the delivery tube will be under the support of the pneumatic trough. Introduce a little dilute hydrochloric acid through the dropping tube. Hydrogen sulphide gas is rapidly evolved. If the evolution of gas slackens or stops, add more hydrochloric acid. Collect three bottles, removing each as soon as full and covering with a glass plate. Set aside until needed. When all the bottles have been filled with gas, proceed at once with II.

II. *Properties.* Study as follows the hydrogen sulphide gas prepared in I: (*a*) Waft a very *little* of the gas cautiously toward the nose, and describe the odor. This odor is characteristic of hydrogen sulphide, and is a decisive test. Has the gas color?

(*b*) Test the gas from the same bottle with both kinds of moist litmus paper. Is hydrogen sulphide acid, alkaline, or neutral?

(*c*) Hold a lighted match to the mouth of the same bottle. Observe the color of the flame. Observe cautiously the odor of the prod-

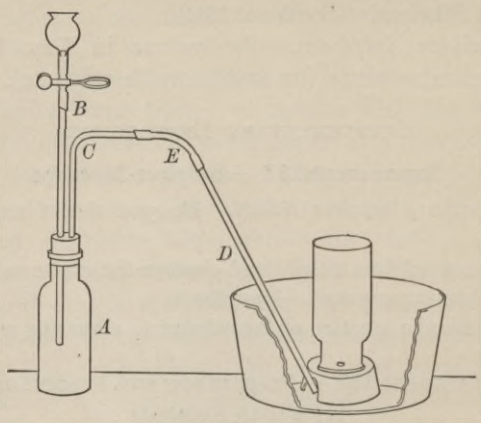

Fig. 141. — Apparatus for Preparing Hydrogen Sulphide.

uct of the burned gas; to what compound is the odor due? What, then, is *one* constituent of hydrogen sulphide?

(*d*) Burn another bottle of hydrogen sulphide and hold a cold bottle over the burning gas. What additional experimental evidence does this result give regarding the composition of hydrogen sulphide?

(*e*) Repeat any of the above with the remaining bottle of the gas.

Required Exercises. — 1. Summarize briefly the properties of hydrogen sulphide gas.

2. State the experimental evidence of its composition.

Experiment 139 — Preparation and Properties of Sulphides

MATERIALS. — Hydrogen sulphide water, clean copper wire, clean sheet lead, bright silver coin, lead oxide (litharge); solutions of lead nitrate, arsenic trioxide (in hydrochloric acid), tartar emetic, zinc sulphate.

(*a*) Obtain a bottle half full of hydrogen sulphide water, and hold successively at the mouth, or in the neck, of the bottle (1) a clean copper wire, (2) a bright strip of lead, and (3) an untarnished silver

coin. Describe the result in each case. These compounds are sulphides of the respective metals; give the name of each.

(*b*) Put a little litharge — the brownish yellow oxide of lead — in a test tube, cover it with hydrogen sulphide water, and warm gently. The product is lead sulphide. Describe it. Explain the chemical change.

(*c*) Add hydrogen sulphide water to lead nitrate solution. The product is lead sulphide. Observe the color.

(*d*) Proceed as in (*c*) with the arsenic solution. Observe the color of the arsenic sulphide.

(*e*) Proceed as in (*c*) with the tartar emetic solution. Tartar emetic is a compound of antimony. Observe the color of the antimony sulphide.

(*f*) Proceed as in (*c*) with the zinc sulphate solution. Observe the color of the zinc sulphide.

Experiment 140 — Properties of Sulphurous Acid

Prepare a solution of sulphurous acid, or obtain some from the Teacher, and proceed as follows: —

(*a*) Put about 15 cubic centimeters of sulphurous acid into an evaporating dish, support the dish on a gauze-covered ring attached to an iron stand in the hood, heat gradually and note the odor of the liberated gas. Blow the gas out of the dish frequently, and then smell of the liquid. Boil until most of the liquid is evaporated, and test the remainder with litmus paper. What is the effect of heat upon the sulphurous acid?

(*b*) Put 15 cubic centimeters of sulphurous acid into a bottle, and let it stand exposed to the air for several days. Add a little water, boil a minute or two, and then test the solution for a sulphate.

Experiment 141 — Tests for Sulphur

MATERIALS. — Sulphur, iron sulphide (ferrous sulphide), a soluble sulphate, calcium sulphate, albumin.

A. *Free Sulphur.* Burn a little sulphur in a deflagrating spoon or on the end of a glass rod. Observe the color of the flame and the odor of the gaseous product.

B. *In Sulphides.* See Exps. **138, 139.**

C. *In Sulphates.* See Exp. **136.**

D. *In Organic Compounds.* See **117 C, D.**

Experiment 142 — Preparation of Crystallized Borax

MATERIALS. — Borax, thread.

Prepare about 50 cubic centimeters of a hot, concentrated solution of borax. Pour the clear liquid into an evaporating dish, and let the solution cool. Crystals of borax will form; well-shaped crystals may be obtained by suspending a piece of thread in the solution and removing it with the adhering crystals before the water entirely evaporates. Remove and dry the crystals.

Experiment 143 — Properties of Borax

MATERIALS. — Borax; crystallized borax for (*b*).

(*a*) Dissolve a little borax in water, drop a piece of red litmus paper into the solution, and let the whole stand about ten minutes. Observe and explain the result.

(*b*) Test borax crystals and borax powder for water of crystallization, and state the result. Expose to the air for an hour or more some of the borax crystals prepared in Exp. **142**.

(*c*) Apply the flame test to a little borax on the end of a clean test wire. What element is contained in borax according to this test?

(*d*) Dissolve a little borax in water, add a few cubic centimeters of ethyl alcohol and of concentrated sulphuric acid, and mix well. Test for boron by dipping a clean test wire into the solution and holding it in the outer part of the Bunsen flame. State the result.

Experiment 144 — Tests with Borax Beads

(*Each pupil need not perform all of this Experiment.*)

MATERIALS. — Powdered borax, test wire, cobalt nitrate solution, copper sulphate solution, manganese sulphate solution.

Heat the looped end of the clean test wire and dip it into powdered borax. Heat the adhering borax in the flame,

rotating the wire slowly, until no further change occurs; continue to dip it into the borax and heat in the flame until a small, more or less transparent, bead is formed.

A. *Cobalt Compounds.* Moisten a borax bead with cobalt nitrate solution. Heat the bead in the oxidizing part of the Bunsen flame (Fig. 142); rotate the bead while heating it, otherwise it may drop off the wire. Observe the color of the cold bead. If it is black, melt a little more borax into the bead; if faintly colored, moisten again with the cobalt solution. The color is readily detected by looking at the bead against a white object in a strong light, or by examining it with a lens. When the color has been definitely determined, heat the bead in the reducing flame (Fig. 142). Compare

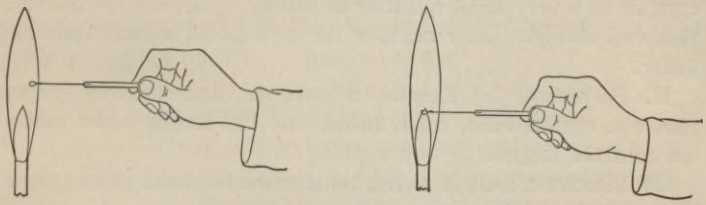

Fig. 142. — Heating a Borax Bead in the Oxidizing Flame (left) and the Reducing Flame (right).

the color of the cold bead with the previous observation. State the result. Remove the bead from the wire by dipping it, white hot, into water; the sudden cooling shatters the bead, which may then be easily rubbed or scraped from the wire.

B. *Copper Compounds.* Make another bead on a clean wire, moisten it with copper sulphate solution and heat it in the oxidizing flame; and then in the reducing flame. Compare the colors of the cold beads, and state the result.

C. *Manganese Compounds.* Make another bead on a clean wire, moisten it with manganese sulphate solution, and proceed as in **B**. Compare the colors of the cold beads, and state the result.

D. *Miscellaneous.* Obtain unknown solutions from the Teacher and test them with a borax bead.

Supplementary Experiments

Experiment 145 — Preparation and Properties of Boric Acid

Material. — Powdered borax.

I. *Preparation.* Heat about 25 cubic centimeters of water nearly to boiling in a large test tube, and slowly add about 10 grams of powdered borax; heat until the borax is dissolved. Pour about 5 cubic centimeters of concentrated hydrochloric acid slowly into the hot solution of borax, mix well by stirring, and then stand the test tube in the test-tube rack to cool, or cool it in a stream of water. Crystals of boric acid will separate from the solution. Filter (with a filter pump, if one is available), and wash the crystals while upon the filter paper with a little cold water. Redissolve a portion of the crystals in a very small quantity of boiling water, and let the solution cool slowly. Later examine the crystals for crystal form and luster.

II. *Properties.* (*a*) Examine a specimen, and state the properties, e.g. crystal form, color, luster, and the feeling when rubbed between the fingers.

(*b*) Dissolve a little in water, test the solution with litmus paper, and state the result.

(*c*) Proceed as in Exp. **143** (*d*), using boric acid instead of borax.

SILICON — GLASS

Experiment 146 — Properties of Silicon

MATERIALS. — Silicon, sodium hydroxide, 500 cc. (or 250 cc.) graduate.

(*a*) Examine a specimen of silicon. Observe and state the color, luster, texture, brittleness, hardness (compared with glass), and any other characteristic physical property.

(*b*) Determine the specific gravity by the method described in Exp. **88** (*b*). State the result.

(*c*) Prepare a concentrated solution of sodium hydroxide by dissolving about 8 grams of the solid in 10 cubic centimeters of water. Add about 1 gram of powdered silicon, heat the mixture to boiling, and test the escaping gas with a blazing joss stick or lighted match. What is the gas?

Experiment 147 — Test for Silicon

MATERIALS. — Lead dish, powdered calcium fluoride, sand, test wire.

Put a little sand and calcium fluoride in a lead dish, add a little concentrated sulphuric acid, and stir with a match until well mixed. Dip the looped end of the test wire into water so as to form a film of water within the loop, and hold the loop at several points near the mixture in the dish until the water becomes white. If no change occurs, stir the mixture and hold the loop over the place where there is evidence of chemical action. What is the white substance in the water?

State in words the chemical changes that led to the formation of the white substance in the loop. Write the equations for these changes.

SUPPLEMENTARY EXPERIMENTS

Experiment 148 — Preparation and Properties of Silicic Acid

MATERIALS. — Sodium silicate solution, hydrochloric acid.

Put 10 cubic centimeters of sodium silicate solution in an evaporating dish, and add 10 or 15 cubic centimeters of dilute hydrochloric

acid, stirring constantly. The jellylike precipitate is silicic acid. Rub some between the fingers and state the result. Stand the dish on a gauze-covered ring attached to an iron stand and evaporate the solution to dryness in the hood. As the mass hardens, stir it with a glass rod. Toward the end, add more hydrochloric acid and evaporate to complete dryness. Then heat intensely for five minutes. The residue is silicon dioxide mixed with chlorides of sodium and potassium. When the dish is cool, add about 50 cubic centimeters of water, stir well, and filter; wash the residue once or twice, dry it, remove as much as possible from the paper, and heat it carefully in an evaporating dish for about five minutes. This residue is largely silicon dioxide. Rub some between the fingers or across a glass plate. Is any grit detected? Collect some within the loop of a test wire and heat it intensely in the flame for several minutes. State the result.

State the chemical changes that occur in changing sodium silicate into the final residue.

Experiment 149 — The Cycle of Silicon Dioxide

MATERIALS. — Powdered silicon dioxide, sodium carbonate, test wire.

Grind about 1 gram of silicon dioxide to a very fine powder (or obtain the powdered substance from the Teacher). Heat about 8 grams of crystallized sodium carbonate in an evaporating dish until the water of crystallization has been driven off. Mix the silicon dioxide and anhydrous sodium carbonate thoroughly by grinding them together in a mortar. Heat the looped end of the test wire, dip it into the mixture and heat the substance in the flame, rotating the wire slowly as in the preparation of a borax bead; continue to dip the bead into the mixture and to heat intensely until a moderate sized bead is formed. Heat this bead until there is no further evidence of chemical action. While the bead is still soft, shake it from the wire into a mortar. Prepare five or six beads in the same way, and powder them. Transfer the powder to a test tube, add a little water, and boil; filter, if the solution is not clear. Add dilute hydrochloric acid, drop by drop, shaking constantly, until the solution is strongly acid. Evaporate this acid solution to dryness in the hood, and proceed from this point as in Exp. **148**.

State the chemical changes by which the silicon dioxide was transformed into the final substance.

Experiment 150 — Testing for Silicon

MATERIALS .— Lead dish, powdered calcium fluoride, test wire, infusorial earth, pumice (powder), scouring soap, glass (small fragments), carborundum (powder).

Apply the test for silicon to the substances enumerated above, as in Exp. **147** (omitting the sand, of course). State the result in each case.

Experiment 151 — Properties of Glass

MATERIALS. — Soft, hard, and flint glass.

(*a*) Examine specimens of soft, hard, and flint glass, and observe their characteristic properties.

(*b*) Heat soft glass and hard glass separately in the Bunsen flame, and observe and explain the result.

(*c*) Devise an experiment to show that flint glass contains lead, Before proceeding, submit the details to the Teacher.

(*d*) Determine the specific gravity of glass by the method given in Exp. **88** (*b*).

(*e*) Suggest a simple experiment to show that glass contains silicon.

(*f*) Grind some soft glass (carefully!) to a fine powder (or obtain some powdered glass from the Teacher), transfer it to a bottle, fill the bottle one fourth full of water, add a few drops of phenol-phthalein solution, cork the bottle tightly, and shake well. Examine after a few days. State and explain the result.

FLUORINE — BROMINE — IODINE

Experiment 152 — Preparation and Properties of Hydrogen Fluoride

MATERIALS. — Lead dish, glass plate, paraffin, powdered calcium fluoride, concentrated sulphuric acid.

Precaution. *Do not inhale hydrogen fluoride. It is a corrosive poison. An aqueous solution of the gas — commercial hydrofluoric acid — burns the flesh frightfully. Perform this experiment with unusual care.*

Warm a glass plate about 10 centimeters (4 inches) square by dipping it into hot water or by moving it slowly above a flame. Coat one surface uniformly with a thin layer of paraffin wax. Scratch letters, figures, or a diagram through the wax with a pin or pointed glass rod. The wax should be removed through to the glass, and the lines should be rather coarse.

Put about 5 grams of powdered calcium fluoride in a lead dish and add just enough concentrated sulphuric acid to form a thin paste. Stir the mixture with a match. Hold a piece of moist blue litmus paper in the escaping gas just above the surface of the mixture; state the result. Place the glass plate, wax side down, upon the lead dish and stand the whole apparatus in the hood for several hours, or until some convenient time. Remove the plate and scrape off the wax with a knife. The last portions can be removed by rubbing with a cloth moistened with alcohol or turpentine. Do not attempt to melt off the wax over the flame. If the experiment has been properly performed, the plate will be etched where the glass was exposed to the hydrogen fluoride gas. Write the equations for the essential chemical changes in this experiment.

NOTE. — The lead dish should be cleaned in the hood by scraping the contents carefully into a waste jar and washing the whole dish with water.

Experiment 153 — Preparation and Properties of Bromine

MATERIALS. — Potassium bromide, manganese dioxide, dilute sulphuric acid, bottle of water, test-tube holder. The *apparatus* (Fig. 143) consists of a large test tube provided with a one-hole rubber stopper to which is fitted the bent glass tube; the total length of the glass tube is about 30 centimeters (12 inches).

Precaution. *Bromine is a corrosive liquid, which forms, at the ordinary temperature, a suffocating vapor. All experiments in which bromine is used or bromine vapor is evolved should be performed in the hood.*

Put about 10 gm. of potassium bromide in the test tube, add an equal weight of manganese dioxide, and also 10 cubic centimeters of dilute sulphuric acid. Insert the stopper and its tube, attach the test-tube holder, and warm gently. Bromine vapor soon appears in the test tube and, if the heat is sufficient, the vapor will escape from the delivery tube. Regulate the heating so that this vapor will condense and collect in the lower bend of the delivery tube. Both vapor and liquid are bromine. When no further boiling produces bromine vapor in the test tube, transfer the bromine from the delivery tube into a bottle half full of water. This operation can be done easily by holding the end of the delivery tube over the mouth of the bottle and heating the test tube slightly; the expanding gases will force the liquid bromine out of the bend into the bottle. Observe and record the physical properties of this bromine, especially the color, solubility in water, specific gravity, volatility, and physical state. Determine the odor *cautiously*. As soon as these observations have been made, cork the bottle tightly and shake it vigorously. Observe the result, and draw a conclusion about the solubility of bromine in water. Save the bottle and contents for Exp. **154**.

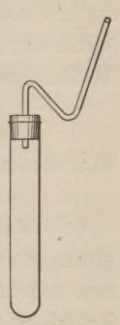

Fig. 143. — Apparatus for Preparing Bromine.

NOTE. — Wash the delivery tube free from all traces of bromine, taking care to get none on the hands. Throw the contents of the test tube into a waste jar in the hood and wash the tube.

Experiment 154 — Preparation and Properties of Magnesium Bromide

MATERIALS. — Bromine water (saved from Exp. **153** or obtained from the Teacher), magnesium, chlorine water.

Shake the corked bottle of bromine water until most or all of the bromine is dissolved. Remove the cork carefully, add a little powdered magnesium, insert the cork, and shake well. Let the excess of magnesium settle, and observe the result. If the change is inconspicuous, add more magnesium, and shake. Pour the liquid into a test tube, and observe the appearance; compare it with the color of the original bromine water. Now add chlorine water drop by drop, shaking frequently, until a decided change in color takes place. To what is this color due? State the chemical changes that took place upon the addition of (*a*) magnesium and (*b*) chlorine water. Write the equations for these chemical changes.

Experiment 155 — Tests for Bromine in Bromides

MATERIALS. — Potassium bromide, silver nitrate solution, carbon disulphide.

(*a*) Add a little concentrated sulphuric acid to a little potassium bromide in a test tube; warm slightly if the action is not marked. Observe the result, especially the color of the liquid or of the vapor just above the liquid. What element does it suggest?

(*b*) To a solution of a bromide, add a little silver nitrate solution, and shake. Observe the properties of the precipitate, especially the color and texture. Determine the solubility in ammonium hydroxide by warming a little of the precipitate in ammonium hydroxide. State the result. Compare the properties of silver bromide with those of silver chloride (Exp. **36**).

(*c*) To a solution of a bromide, add a little chlorine water and a few drops of carbon disulphide, and shake. The carbon disulphide will be colored yellow or brown by the liberated bromine.

Experiment 156 — Preparation and Properties of Iodine

MATERIALS. — Potassium iodide, manganese dioxide, mortar and pestle, concentrated sulphuric acid, funnel, cotton.

I. *Preparation.* Grind together in a mortar about 10 gm. of potassium iodide and about twice this weight of manganese dioxide. Put the mixture in a test tube, moisten with water, and add a few cubic centimeters of concentrated sulphuric acid. Clamp the test tube vertically to an iron stand. Close up the inner end of the stem of the funnel with a small plug of cotton. Hold the funnel firmly over the mouth of the test tube, and heat the test tube gently. The vapor of the liberated iodine will fill the test tube, and crystals may collect in the upper part of the test tube and in the funnel. (If the crystals collect in the test tube, force them into the funnel by heating the test tube gently near the top.) Continue to heat until enough iodine for several experiments collects in the funnel. Scrape the crystals into a dish.

II. *Properties.* Study the properties of the iodine as follows: (*a*) Observe and record the physical properties, especially the color of the solid and of the vapor, and the odor (cautiously). Determine the volatility by putting a crystal or small piece in a bottle and exposing to the sunlight.

(*b*) Heat a crystal in a dry test tube, and invert the test tube when it is half full of vapor. What does the result show about the density of iodine vapor?

(*c*) Touch a crystal with the finger. What color is the stain? Will water remove it? Will alcohol? Will a solution of potassium iodide? What do these results show about the solubility of iodine?

NOTE. — If crystals are left, use them in the next experiment. Preserve the iodine in a stoppered bottle, if not used at once.

Experiment 157 — Tests for Free Iodine

MATERIALS. — Iodine, potassium iodide, carbon disulphide, starch.

Precaution. *Carbon disulphide is inflammable. It should not be used near flames.*

(*a*) Add a few drops of carbon disulphide to a very dilute solution of iodine, which can be prepared by dissolving a crystal of iodine in potassium iodide solution. Shake well, and observe the color of the carbon disulphide.

(*b*) Grind a very small lump of starch in a mortar with a little water, pour the mixture slowly into about 15 cubic centimeters of hot water, and stir the hot liquid. Allow it to cool, or cool it by holding the vessel in a stream of cold water. Add a few cubic centimeters of the cold starch solution to a test tube nearly full of water, and then add a few drops of dilute iodine solution. Observe the result. (The starch should be colored blue; if the color is black, pour out half of the liquid and add more water.)

State briefly the two tests for free iodine.

Experiment 158 — Tests for Iodine in Iodides

MATERIALS. — Potassium iodide, chlorine water, starch, carbon disulphide, silver nitrate solution.

(*a*) Add a few drops of carbon disulphide to a very dilute solution of potassium iodide. Now add several drops of chlorine water, and shake well. Observe and explain the result.

(*b*) Add a few cubic centimeters of cold starch solution to a very dilute solution of potassium iodide. Add a few drops of chlorine water, and shake well. Observe and explain the result.

(*c*) To a solution of an iodide, add a little silver nitrate solution, and shake. Observe the properties of the precipitate, especially the color and texture. Test the solubility of a little of the precipitate in ammonium hydroxide, and state the result. Compare the properties of silver iodide with those of silver chloride and silver bromide (see Exps. **36**, **155** (*b*)).

(*d*) Proceed as in Exp. **155** (*a*), using potassium iodide instead of potassium bromide.

PHOSPHORUS — ARSENIC — ANTIMONY — BISMUTH

Experiment 159 — Tests for Orthophosphoric Acid and Orthophosphates

MATERIALS. — Solutions of disodium phosphate, silver nitrate, ammonium molybdate, ammonium chloride, magnesium sulphate, and orthophosphoric acid, bone ash, fertilizer.

(*a*) Put a little disodium phosphate solution in a test tube and add a little silver nitrate solution. Observe and describe the result. What is the name of the visible product? What is its formula?

(*b*) Put 5 cubic centimeters of disodium phosphate solution in a test tube and add one or two cubic centimeters of dilute nitric acid; add an equal volume of ammonium molybdate solution. Observe and describe the result. (Warm, if no precipitate appears.) The precipitate is ammonium-phosphomolybdate ($(NH_4)_3PO_4.12MoO_3$, approximately). Apply this test to a dilute solution of orthophosphoric acid, and state the result.

(*c*) To magnesium sulphate solution add successively solutions of ammonium chloride, ammonium hydroxide, and disodium phosphate. Observe and describe the result. The precipitate is ammonium magnesium phosphate.

(*d*) Dissolve a little bone ash in warm dilute nitric acid, filter, and apply the ammonium molybdate test.

(*e*) Proceed as in (*d*) with a sample of fertilizer.

Experiment 160 — Tests for Metaphosphoric Acid and Metaphosphates

MATERIALS. — Solutions of metaphosphoric acid, silver nitrate, and albumin; sodium ammonium phosphate.

(*a*) To a little metaphosphoric acid solution add silver nitrate solution until a definite change occurs. Describe the

result. What is the name of the visible product? What is its formula? Compare the color with that observed in Exp. **159**.

(*b*) Put a few crystals of sodium ammonium orthophosphate (microcosmic salt) in a clean porcelain dish, stand the dish on a gauze-covered ring, and heat gently. While heating, hold a moistened piece of red litmus paper over the dish; also smell cautiously of the escaping substance. What gas is liberated? Increase the heat slowly and continue to heat until no further change seems to take place. Let the dish cool, and dissolve the residue in cold water. Test the solution with silver nitrate, and state the result. Into what compounds has the sodium ammonium phosphate been changed?

(*c*) To a little albumin solution, add a little metaphosphoric acid, and shake well. Observe and describe the result. (This test is not applicable to metaphosphates.)

Experiment 161 — Preparation and Properties of Arsenic Trisulphide

MATERIALS. — Hydrogen sulphide water, solutions of arsenic trichloride, ammonium polysulphide, ammonium carbonate.

Add hydrogen sulphide water to a solution of an arsenic compound, such as arsenic trichloride. The precipitate is arsenic trisulphide. Describe it. Filter, or let the mixture stand until the precipitate settles, and then pour off the liquid. Divide the precipitate into two parts. Add considerable ammonium polysulphide solution to one part of the precipitate, and shake well. Observe and describe the result. Now add dilute hydrochloric acid carefully to acid reaction. Observe and describe the final result. To the other part of the original precipitate add considerable ammonium carbonate solution, and shake well. Observe and describe the result. Now add dilute hydrochloric acid solution slowly (to avoid loss by effervescence) to acid reaction. Observe and describe the final result. Summarize the properties of arsenic trisulphide.

Experiment 162 — Properties of Antimony Trichloride

Pour a little antimony trichloride solution (prepared as in Exp. **166 B** or a similar one obtained from the Teacher) into a large volume of water. Observe the result. What compound of antimony is formed? Add concentrated hydrochloric acid drop by drop, shaking constantly. Observe and describe the result. What compound of antimony is finally formed?

Experiment 163 — Preparation of Antimony Trisulphide

Add hydrogen sulphide water to the solution from Exp. **166 B** (or to a similar solution obtained from the Teacher). Observe the result. Compare the color of the precipitate with the corresponding arsenic compound.

SUPPLEMENTARY EXPERIMENTS

Experiment 164 — Properties of Phosphorus (Optional)

Precaution. Phosphorus is a dangerous substance. The yellow variety is kept beneath water, and should be cut under water and handled only when wet. Dry yellow phosphorus ignites readily, and a burn caused by it heals very slowly. It is advisable to touch yellow phosphorus only with wet fingers; a safer plan is to grasp it firmly with wet forceps while it is being cut or transferred. Unusual care should be taken not to leave pieces of yellow phosphorus in dishes or deflagrating spoons after the experiments have been performed. Ask the Teacher for directions about the disposal of unused phosphorus.

A. *Yellow Phosphorus.* Fill a porcelain mortar half full of water, and ask the Teacher to put three small pieces of yellow phosphorus beneath the water. Stand the mortar where it will not be upset.

(*a*) Smell cautiously of the water in which the phosphorus has been placed. If no characteristic odor is detected, proceed with the other experiments, and observe the odor later. Describe it.

(*b*) Wet the forceps, transfer a piece of the phosphorus to an evaporating dish which has been slightly warmed by the hand or a low flame. Observe the result. Stand back as soon as the phosphorus begins to burn. Add a little cold water to the residue in the dish, test the solution with litmus paper (both colors), and state the result. What substance is in the solution?

(*c*) Fill a test tube half full of water, transfer a piece of the yellow phosphorus with wet forceps from the mortar to the test tube. Warm the test tube very gently and observe the ease with which phosphorus melts. As soon as the phosphorus melts, stand the test tube carefully in the test-tube rack and ascertain the temperature of the water by a thermometer. Record the temperature.

(NOTE. — Read the **Precaution** above.)

(*d*) Have ready a few crystals of iodine upon a piece of paper. Transfer the remaining piece of phosphorus from the mortar to an evaporating dish, dry it quickly by touching it with the end of a piece of tightly rolled filter paper, and then slip the iodine upon the dried phosphorus. Stand back and observe the result.

(*e*) Smell of the head of a phosphorus tipped match. Compare the odor with that observed in (*a*). Rub the head of a phosphorus tipped match in a dark place, and observe and describe the result.

B. *Red Phosphorus.* Obtain a little red phosphorus from the Teacher. (*a*) Examine the red phosphorus and observe its characteristic properties.

(*b*) Put a *very little* in a *clean* deflagrating spoon, and heat it cautiously in a Bunsen flame in the hood. Observe the result. Compare with the result observed in **A** (*b*). Proceed with the product as in **A** (*b*), and state the result.

Experiment 165 — Properties of Antimony

MATERIALS. — Antimony, graduate, blowpipe, charcoal.

(*a*) Examine a specimen of antimony and state its characteristic properties, such as the color, luster, crystalline appearance, hardness, brittleness.

(*b*) Determine the specific gravity of antimony by the method described in Exp. **88** (*b*); use a 25 cubic centimeter graduate and small pieces of antimony. State the result.

(*c*) Heat a small piece of antimony on charcoal with the oxidizing blowpipe flame. Describe the result. What is the white product?

Experiment 166 — Interaction of Antimony and Acids

A. *Nitric Acid.* Boil a little powdered antimony with concentrated nitric acid in the hood. Observe the effect on the antimony What compound of antimony is formed?

B. *Aqua Regia.* Boil a little powdered antimony with *aqua regia* for several minutes in the hood. Observe the result. What compound of antimony is formed? Pour off the solution from any unchanged antimony. (The solution may be used in Exps. **162**, **163**.)

Experiment 167 — Properties of Bismuth

Proceed as in Exp. **165**, using bismuth instead of antimony.

Experiment 168 — Preparation and Properties of Bismuth Trichloride

A. Proceed as in Exp. **166 B**, using bismuth instead of antimony and taking care to boil off most of the acid.

B. Proceed with the solution from **A** as in Exp. **162**.

Experiment 169 — Fusible Alloys

MATERIALS. — Fusible alloys, thermometer.

A. Examine specimens of fusible alloys and state their characteristic properties.

B. Slip a thin piece of fusible alloy into a test tube half full of water, heat the water gradually, hold a thermometer in the water, and note the temperature at which the alloy melts. State the result.

SODIUM — POTASSIUM — AMMONIUM COMPOUNDS

Experiment 170 — Tests for Sodium

MATERIALS. — Sodium compounds, solutions of potassium hydroxide and tartar emetic.

(*a*) Recall the flame test, or apply it to several sodium compounds, using a clean test wire in each case.

(*b*) Make a solution of a sodium compound slightly alkaline with potassium hydroxide solution, and add a little freshly prepared tartar emetic solution. The white precipitate is acid sodium pyroantimonate ($H_2Na_2Sb_2O_7$).

Experiment 171 — Properties of Sodium Chloride

MATERIALS. — Sodium chloride (several varieties) and the solution needed for (*e*).

(*a*) Examine several varieties of sodium chloride and state the characteristic properties of each.

(*b*) Prepare about 100 cubic centimeters of a nearly saturated sodium chloride solution. Filter, if it is not clear, and then proceed with the crystallization as in Exp. **20**. Examine and describe the best crystals.

(*c*) Heat a few crystals of sodium chloride in a test tube. State and explain the result.

(*d*) Put a little sodium chloride (e.g. table salt) in a test tube, and cork the test tube tightly. Put some of the original salt in an open dish. Place both vessels where they will not be disturbed for a day or two, and then compare the two specimens. State and explain the result.

(*e*) Apply the test for a chloride and a sulphate to separate portions of a solution of rock salt and of table salt. State and explain the results. (1) Test a specimen of reddish rock salt for iron as follows: Dissolve the salt in water, add a little dilute hydrochloric acid and boil, cool, and then

add ammonium hydroxide solution to alkaline reaction; the red-brown gelatinous precipitate is ferric hydroxide. (2) Test a specimen of salt for calcium by dissolving the solid in water and adding a little ammonium hydroxide and ammonium oxalate solution; the white precipitate is calcium oxalate. (3) Test a specimen of salt for magnesium as follows: Dissolve the solid in water, and add in succession ammonium chloride solution, ammonium hydroxide, and disodium phosphate solution; the white precipitate is ammonium magnesium phosphate.

Experiment 172 — Properties of Sodium Hydroxide

(*a*) Perform, recall, or repeat (if necessary) experiments with sodium hydroxide which show the effect of (1) exposing it to the air, (2) adding acid to it, (3) dissolving it in water, (4) heating its solution with aluminium and with silicon.

(*b*) Heat a small piece of sodium hydroxide upon a piece of porcelain, and describe the result.

(*c*) Put a little pulverized sodium hydroxide in a dish and let it stand exposed to the air for a day or more. Describe the final product. Test it for a carbonate, and state the result.

(*d*) Fuse a small quantity of sodium hydroxide on a piece of porcelain, add a part of a match stick or a small piece of paper, and continue the fusion. State the effect on the wood and paper.

Experiment 173 — Properties of Potassium

MATERIALS. — Potassium, litmus paper.

Precaution. Observe the same precaution as in using sodium. (See Exp. **12 D**.)

(*a*) Examine a very small piece of freshly cut potassium, and observe its most obvious physical properties.

(*b*) Drop a small piece of potassium on the water in an evaporating dish. Stand just near enough to see the action. Describe the action. Compare it with the action of sodium. Test the water with litmus paper, and state the result. What compound of potassium is in solution?

Experiment 174 — Tests for Potassium

MATERIALS. — Potassium compounds, sodium cobaltinitrite solution.

(*a*) Apply the flame test to several potassium compounds, using a clean test wire in each test. State the result.

(*b*) Add several drops of sodium cobaltinitrite solution to a moderately concentrated solution of a potassium compound, and shake well. The yellow precipitate is potassium cobaltinitrite ($K_3Co(NO_2)_6$).

Experiment 175 — Properties of Ammonium Chloride

MATERIAL. — Ammonium chloride.

(*a*) Examine a specimen of ammonium chloride and state its characteristic properties.

(*b*) Add a few grams of ammonium chloride to a test tube half full of water, shake well, and observe the result. Does ammonium chloride dissolve easily in water? How does the dissolving affect the temperature of the solvent? Save the solution for (*c*).

(*c*) Add a small piece of sodium hydroxide to the solution from (*b*), warm gently, and very cautiously observe the odor of the gaseous product. What is the gas? Explain its formation.

(*d*) Put a little ammonium chloride in a clean, dry test tube, heat the closed end gently, and observe the result. What is the white deposit? What general name is given to this process? To the product?

SUPPLEMENTARY EXPERIMENTS

Experiment 176 — Properties of Sodium

MATERIALS. — Sodium, litmus paper, tea lead.

Precaution. See Exp. **12 D.**

(*a*) Examine a small piece of sodium, and observe its most obvious physical properties, e.g. color, luster, whether hard or soft.

(*b*) Perform, recall, or repeat (if necessary) Exp. **12 D.** (Preparation of Hydrogen by the Interaction of Sodium and Water.)

(*c*) Perform, recall, or repeat (if necessary) that part of Exp. **16 A** in which sodium is used. (Chemical Properties of Water.)

(*d*) Fill an evaporating dish nearly full of water. Put a piece of sodium on a piece of filter paper (about the diameter of the dish), lay the paper upon the water, and stand back and observe the result. Wait for the slight explosion that usually occurs soon after the action stops. Describe all you have seen. What burned? To what is the vivid color of the flame probably due?

Experiment 177 — Preparation and Properties of Sodium Bicarbonate

MATERIALS. — Ammonium carbonate, ammonium hydroxide, sodium chloride, carbon dioxide generator.

A. *Preparation.* Put 8 grams of powdered ammonium carbonate and 75 cubic centimeters of ammonium hydroxide into a bottle; add about 35 grams of fine sodium chloride, cork the bottle, and shake the mixture vigorously until most of the solid has dissolved. Filter the liquid, if it is not clear, into a large test tube. Construct a carbon dioxide generator as directed in Exp. **83 A.** Fill the generator bottle half full of marble, introduce dilute hydrochloric acid as usual, and pass carbon dioxide through the solution from thirty to forty-five minutes (or less, if a precipitate begins to form). Then remove the generator, cork the test tube, and let it stand an hour or more to allow the sodium bicarbonate to settle out of the solution. Filter, and wash quickly with a very little cold water. Dry the precipitate between filter paper. (Note. If only a little of the precipitate is formed, use sodium bicarbonate from the laboratory bottle for **B**.)

B. *Properties.* (*a*) Subject small portions of the precipitate to the flame test for sodium and the usual test for a carbonate. State the result.

(*b*) Put a little on moist litmus paper (both colors). Observe and explain the result.

(*c*) Heat a little in a test tube inclined so that the open end is the lower. Observe the result. What is the visible product? Apply the usual test for carbon dioxide to the gas in the test tube; state the result. Continue to heat until there is no further evidence of change. Determine what the final residue is by applying to it tests for sodium, a bicarbonate as in (*a*) and (*b*), and sodium carbonate. State the result.

Experiment 178 — Testing for Sodium and Potassium Carbonates

MATERIALS. — Washing soda, washing compounds, potash, lye.

Apply the test for a carbonate, potassium, and sodium to the substances enumerated above, and state the result in each case.

Experiment 179 — Preparation and Properties of Potassium Nitrate

MATERIALS. — Sodium nitrate, potassium chloride, charcoal.

I. *Preparation.* Dissolve about 15 grams of potassium chloride in about 40 cubic centimeters of water, warming if necessary. Add about 17 grams of sodium nitrate, and stir well. Boil several minutes, or until a white solid separates. Let it stand until the solid settles somewhat, then pour the liquid (down a glass rod — see Int. **6** (1) (*a*)) into an evaporating dish and let it cool. Pour off the liquid from the crystals. Dissolve the crystals in a small volume of hot water and let the solid crystallize again. Drain off the water and dry the crystals between filter paper.

II. *Properties.* (*a*) Prepare a solution of the final crystals and test portions for (1) potassium and (2) a nitrate. State the result.

(*b*) Test the solution also for (1) sodium and (2) a chloride. State the result. Explain it.

(*c*) Lay a piece of charcoal upon a block of wood or a brick and heat it by directing the flame upon it. Drop potassium nitrate cautiously upon the hot charcoal. State and explain the result.

Experiment 180 — Properties of Ammonium Compounds

MATERIALS. — Ammonium compounds.

(*a*) Recall, perform, or repeat (if necessary) the experiment showing the effect of heating ammonium nitrate (see Exp. **56**).

(*b*) Test several ammonium salts as in Exp. **175** (*b*) and (*c*). State each result.

(*c*) Test baking powder for ammonium salts (see Exp. **113 F**).

(*d*) Expose a piece of ammonium carbonate to the air. Smell of it occasionally and state the result.

(*e*) Suggest an experimental method of preparing ammonium chloride or ammonium sulphate (see Exp. **53**). Before proceeding, submit the details to the Teacher.

COPPER — SILVER — GOLD

Experiment 181 — Properties of Copper

MATERIALS. — Copper, electric bell and battery.

A. *Physical.* (*a*) Examine several forms of copper — wire, sheet, filings, borings, etc. — and state the characteristic properties.

(*b*) Hold a piece of copper in the flame. Does it melt readily? Is copper a good conductor of heat? Insert a piece of copper wire in the circuit with an electric bell. Is copper a good conductor of electricity?

(*c*) Determine the specific gravity of copper (e.g. a compact roll of wire) by the method given in Exp. **88** (*b*). State the result.

B. *Chemical.* (*a*) Perform, recall, or repeat (if necessary) the experiments which show the effect of heating copper in air (see Exp. **4**).

(*b*) Perform, recall, or repeat (if necessary) experiments which show the action of copper with (1) dilute nitric acid and (2) concentrated sulphuric acid (see Exps. **54**, **135**).

Experiment 182 — Tests for Copper

MATERIALS. — Copper wire, copper sulphate solution, ammonium hydroxide, acetic acid, potassium ferrocyanide solution.

(*a*) Heat a copper wire in the Bunsen flame, and observe the color imparted to the flame. Heat a minute quantity of one or more copper compounds on a test wire in the flame, and observe the color. This color is characteristic of copper and its compounds.

(*b*) Add considerable ammonium hydroxide to copper sulphate solution, shake well, and observe the result. The formation of the blue solution is a characteristic and decisive test for copper.

(*c*) Add to a test tube one fourth full of water an equal volume of copper sulphate solution, and shake; then add a few drops of acetic acid and of potassium ferrocyanide solution. The brown precipitate is cupric ferrocyanide ($Cu_2Fe(CN)_6$).

(*d*) Add hydrogen sulphide water to copper sulphate solution. The black precipitate is cupric sulphide (CuS).

(*e*) Perform, recall, or repeat (if necessary) the borax bead test for copper.

Experiment 183 — Properties of Copper Sulphate

MATERIALS. — Copper sulphate, alcohol.

(*a*) Examine a typical specimen of crystallized copper sulphate, and state its characteristic properties.

(*b*) Prepare anhydrous copper sulphate by heating a little of the pulverized salt in an evaporating dish. (1) Allow a little to remain exposed to the air for an hour or more. Describe and explain the change in the solid. (2) Add the rest of the anhydrous copper sulphate to a test tube half full of alcohol, and shake well. Describe and explain the change in the solid.

(*c*) Allow a piece of red and of blue litmus paper to remain in a solution of copper sulphate for fifteen minutes or more. State the result; explain it in terms of the theory of ionization. What term is applied to this kind of a chemical change?

(*d*) See Exps. **20, 22.**

Experiment 184 — Displacement of Metals — Copper

MATERIALS. — Copper wire, iron nail, zinc, copper sulphate solution, mercuric chloride solution (POISON).

(*a*) Put a clean copper wire in a test tube half full of mercuric chloride solution (POISON). After a short time remove the wire and wipe it with a soft cloth or paper. Observe and explain the change.

(*b*) Put a clean iron nail in a test tube half full of copper

sulphate solution. After a short time remove the nail and examine it. What is the deposit? Explain its formation.

(*c*) Repeat (*b*), using a strip of zinc instead of an iron nail. Observe and explain the result.

Required Exercise. — Arrange the metals (used in this experiment) in the order of their displacing power with reference to copper.

Experiment 185 — Tests for Silver

MATERIALS. — Silver coin, hydrogen sulphide, silver nitrate solution.

(*a*) Recall and state the effect of exposing silver to hydrogen sulphide gas or to a sulphide solution.

(*b*) Add dilute hydrochloric acid to silver nitrate solution, add considerable ammonium hydroxide and shake, and then add dilute nitric acid to acid reaction. The precipitation of silver chloride, its solubility in ammonium hydroxide, and its reprecipitation by dilute nitric acid constitute the usual test for silver.

Experiment 186 — Properties of Gold

MATERIALS. — Gold, chlorine water, potassium cyanide solution (POISON), electric bell and battery.

A. *Physical.* (*a*) Examine a specimen of gold (e.g. gold leaf), and state its characteristic properties.

(*b*) Heat a bit of gold on charcoal with a blowpipe flame. Does the gold melt? Lay a piece of gold leaf upon a glass plate and touch the gold with the two wires that are in the circuit with an electric bell. Is gold a conductor of electricity?

(*c*) Determine the specific gravity of a gold ring by the method already used. State the result.

B. *Chemical.* (*a*) Prepare or obtain about 15 cubic centimeters of strong chlorine water. Touch a leaf of gold with the moistened end of a glass rod, roll the rod gently over the gold to make some of the metal adhere, and lower the gold-coated rod carefully into the chlorine water. Warm gently, and as soon as the gold falls away from the rod, remove the latter and continue to warm the chlorine water. State the

final result. What gold compound is formed? Save the contents of the test tube for Exp. **187**.

(*b*) Proceed as in **B** (*a*), using a mixture of a few cubic centimeters of concentrated nitric and hydrochloric acids instead of chlorine water. State the final result. What gold compound is formed? Save the contents of the test tube for Exp. **187**.

(*c*) *Perform this experiment cautiously.* Proceed as in **B** (*a*), using potassium cyanide solution (POISON) instead of chlorine water. Heat the mixture slightly. State the result. What gold compound is formed? Pour the solution into the waste jar *in the hood.*

Experiment 187 — Test for Gold

MATERIALS. — Solutions from Exp. **186**, stannous chloride solution.

Heat (in the hood) one or both of the solutions from Exp. **186** until most of the chlorine has been driven off, dilute the final solution with water, and then slowly add dilute stannous chloride solution. A precipitate is produced, varying in color from faint purple to black according to the conditions. This precipitate is finely divided gold; its formation is a test for gold.

SUPPLEMENTARY EXPERIMENTS

Experiment 188 — Tests for Copper in Alloys

MATERIALS. — Brass, aluminium bronze, German silver, American cent, nickel, and dime.

(*a*) Prepare a solution of one of the alloys enumerated above by boiling a small piece in dilute nitric acid; it may be necessary to treat the alloy with several portions of acid in some cases. Filter the final liquid, if it is not clear. Apply the test for copper to the clear solution (see Exp. **182**). State the result in each case.

(*b*) Proceed as in (*a*) with one or more alloys obtained from the Teacher. State the result.

(*c*) Proceed as in (*a*) with metallic substances suspected to contain copper, e.g. pins and inexpensive jewelry.

Experiment 189 — Preparation and Properties of Cuprous Oxide

Proceed as in Exp. **106**. Observe and state the properties of the precipitated cuprous oxide.

Experiment 190 — Deposition of a Silver Film

Proceed as in Exp. **105**.

Experiment 191 — Displacement of Metals — Silver

Proceed as in Exp. **184**, using silver nitrate solution and several metals. State the result in each case.

Experiment 192 — Tarnishing and Cleaning Silver

MATERIALS. — Silver coin, sulphur, rubber band, mustard.

A. Perform one or more of the following: (*a*) Recall and state the effect of exposing silver to hydrogen sulphide gas.

(*b*) Place a small lump of sulphur upon a clean silver coin, wrap the whole tightly in several pieces of paper, and let the package stand undisturbed for several days. Examine the surface of the coin upon which the sulphur was placed. Describe and explain the result.

(*c*) Proceed as in (*b*), using a rubber band instead of sulphur. Describe and explain the result.

(*d*) Cover one side of a clean silver coin with a paste made of mustard and water. Let the covered coin stand undisturbed for an hour or more. Wash off the paste, and examine the coin. Describe and explain the result.

B. Dissolve a little sodium chloride and sodium bicarbonate in about 75 cubic centimeters of water and heat to boiling. Put a small piece of aluminium and a tarnished silver coin into the solution, taking care to have the metals in contact. Remove and examine the coin after a few minutes. State the result.

Experiment 193 — Preparation and Properties of Silver Halides

MATERIALS. — Solutions of silver nitrate, potassium chloride, potassium bromide, potassium iodide, sodium thiosulphate.

To separate portions of silver nitrate solution add the chloride bromide, and iodide solution. Observe and state the color of each precipitate. Filter each separately.

Test precipitate separately by (*a*) exposing a little to the light, (*b*) shaking some with ammonium hydroxide, and (*c*) shaking some with sodium thiosulphate solution. State each result.

Experiment 194 — Testing for Copper, Silver, and Gold

(*a*) Test samples of inexpensive jewelry for these metals. Cut or file the sample into small pieces and heat with dilute nitric acid until the solid is dissolved or there is no further evidence of solution. Filter if not clear, and save the undissolved portion, if any, for (*c*).

(*b*) Evaporate the filtrate to a small volume, and dilute with water. Test this solution for silver by adding enough dilute hydrochloric acid for complete precipitation. Filter, and test the filtrate for copper by adding ammonium hydroxide to alkaline reaction. State the result of each test.

(*c*) Heat the undissolved residue from (*a*) with *aqua regia* and apply the test for gold to the properly prepared solution. State the result.

CALCIUM — STRONTIUM — BARIUM

Experiment 195 — Properties of Calcium

MATERIALS. — Calcium, electric bell and battery.

A. *Physical.* (*a*) Examine a piece of clean calcium, and state its characteristic properties, e.g. luster, hardness.

(*b*) Insert a piece of calcium in the circuit with an electric bell. Is calcium a conductor of electricity?

B. *Chemical.* (*a*) Let a piece of clean calcium remain exposed to the air for several days. Describe the final result.

(*b*) Heat a test tube half full of water, nearly to boiling, and drop in several small pieces of calcium. Observe and describe the action. Test the gas with a blazing joss stick. What is the gas? Describe the contents of the test tube. What is the suspended solid? Write the equation for the interaction of calcium and water.

(*c*) Heat a small piece of calcium several minutes on charcoal in the oxidizing flame of a blowpipe. State the result. What is the product?

(*d*) Drop a small piece of calcium into a test tube one fourth full of dilute hydrochloric acid, and warm gently if the action is not marked. State the result. If a gas is liberated, test it with a lighted joss stick; state the result. Write the equation for the interaction of calcium and hydrochloric acid.

(*e*) Proceed as in (*d*), using dilute nitric acid instead of hydrochloric acid.

(*f*) Proceed as in (*d*), using dilute sulphuric acid instead of hydrochloric acid.

Experiment 196 — Tests for Calcium

MATERIALS. — Calcium compounds, ammonium oxalate and ammonium carbonate solutions.

(*a*) Subject several calcium compounds to the flame test, using a clean test wire in each case. What color is imparted to the flame?

(*b*) Add an excess of ammonium oxalate solution to calcium chloride solution, and state the result. The precipitate is calcium oxalate. Divide into two parts. To (1) add an excess of dilute hydrochloric acid, warm gently, and state the final result. To (2) add considerable acetic acid and warm gently; observe and state the final result.

(*c*) Add an excess of ammonium carbonate solution to calcium chloride solution, and state the result. The precipitate is calcium carbonate. Divide it into two parts, and treat with the acids as in (*b*). State the results and compare with the results obtained in (*b*).

(*d*) Suggest a test for calcium in calcium carbonate and calcium sulphate.

Experiment 197 — Testing for Calcium

MATERIALS. — Mortar, plaster, bone ash, plaster of Paris, tooth powder, whiting, cement, bleaching powder.

(*a*) Prepare a solution of the substances enumerated above by boiling a little of each with dilute hydrochloric acid (or dilute nitric acid) and filtering. Test the filtrate for calcium. State the result in each case.

(*b*) Obtain "unknowns" from the Teacher and test them for calcium.

Experiment 198 — Plaster of Paris

MATERIALS. — Plaster of Paris, block of wood, coin, vaseline.

Mix a little plaster of Paris with enough water on a block of wood to form a thick paste. Rub a very little vaseline upon one side of a coin, and press the coin, coated side down, into the paste. Let it stand undisturbed for fifteen or more minutes.

Then remove the coin carefully, and examine and describe the effect upon the hardened plaster.

Experiment 199 — Calcium Compounds and Hardness of Water

(*a*) Proceed as in Exp. **116** (*d*), using only the calcium compounds.

(*b*) Prepare some permanently hard water and devise an experiment to soften it. Submit the details to the Teacher before proceeding.

Experiment 200 — Tests for Strontium

MATERIALS. — Strontium compounds, test wire, calcium sulphate solution.

(*a*) Apply the flame test to strontium nitrate and other available strontium compounds, using a clean test wire in each case. What color is imparted to the flame? Compare this color with that produced by calcium compounds.

(*b*) To the solution of a strontium compound add calcium sulphate solution. The precipitate is strontium sulphate.

Experiment 201 — Tests for Barium

MATERIALS. — Barium compounds, test wire, potassium dichromate solution.

(*a*) Apply the flame test to barium nitrate and other available barium compounds, using a clean test wire in each case. What color is imparted to the flame? Compare this color with that produced by calcium and by strontium compounds.

(*b*) Add dilute sulphuric acid to barium chloride solution (or the solution of any barium compound). The precipitate is barium sulphate. Describe it. Test its solubility by heating a little of the precipitate in (1) concentrated hydrochloric acid, (2) concentrated nitric acid, (3) concentrated sulphuric acid; perform the experiment in the hood and heat the acids cautiously, especially the sulphuric acid. State the results.

(*c*) Add potassium dichromate solution to barium nitrate

solution. The precipitate is barium chromate. Describe it. Test its solubility by heating some of the precipitate in (1) acetic acid and (2) concentrated hydrochloric acid. State the results.

Supplementary Experiments

Experiment 202 — Calcium Carbonate and Acid Calcium Carbonate

Perform, recall, or repeat (if necessary) the experiment in which gentle heat was applied to the product of the interaction of an excess of carbon dioxide and calcium hydroxide. (See Exp. **85**.) Express the essential chemical changes by reactions.

Experiment 203 — Preparation and Properties of Calcium Oxide and Calcium Hydroxide

Materials. — Calcium carbonate, calcium oxide.

A. *Preparation.* (*a*) Wind a test wire around a small lump of calcium carbonate, and heat the solid for several minutes in the hottest part of the Bunsen flame; or heat the calcium carbonate on charcoal with the oxidizing flame of the blowpipe. Then let the residue cool somewhat, put it in an evaporating dish, and add a little water. Observe the result. Test the liquid with red litmus paper; test it also for calcium. State the results. What calcium compound was formed by heating the calcium carbonate? By treating the product of the heating with water?

(*b*) Prepare a small quantity of solid calcium hydroxide by adding a little water to a lump of lime, and save it for **C**.

B. *Properties of Calcium Oxide.* (*a*) Examine a lump of calcium oxide and state its characteristic properties.

(*b*) Put a lump of calcium oxide on a glass plate or block of wood and let it remain exposed to the air for a few days. Examine it at intervals and describe it. Describe the final product. What is it?

(*c*) Recall, perform, or repeat (if necessary) the experiment that shows the effect of mixing calcium oxide and water. Express the chemical reaction by an equation.

C. *Properties of Calcium Hydroxide.* (*a*) Examine the calcium hydroxide prepared in **A** (*b*) and state its characteristic properties.

(*b*) Add a little calcium hydroxide to a test tube half full of water and shake vigorously. Let the suspended solid settle somewhat, and filter. Pour half of the filtrate into an evaporating dish and evaporate it to dryness. (Meanwhile (*c*) may be performed.) Compare the amount of residue in the dish with the amount originally shaken with water. Draw a conclusion regarding the solubility of calcium hydroxide in water.

(*c*) Taste of the solution saved from (*b*), and describe the taste. Determine the reaction toward litmus; is the solution acid, alkaline, or neutral? Heat the solution slowly to boiling, and describe the result. What is the effect of increased heat on the solubility of calcium hydroxide in water?

(*d*) State the result of (1) exposing calcium hydroxide solution to the air and (2) exhaling the breath through calcium hydroxide solution. Express each reaction by an equation.

Experiment 204 — Preparation of Red Fire and Green Fire

MATERIALS. — Strontium nitrate, powdered potassium chlorate, powdered shellac, iron pan or brick, barium nitrate.

A. Mix carefully small and equal (in bulk) quantities of the three substances on a sheet of paper. Place the mixture in an iron pan or on a brick in the hood, and light it with a Bunsen burner. Describe the result.

B. Proceed as in **A**, using barium nitrate instead of strontium nitrate.

ALUMINIUM

Experiment 205 — Properties of Aluminium

A. *Physical.* Proceed as in Exp. **181 A** (*a*), (*b*), (*c*), using aluminium instead of copper.

B. *Chemical.* (*a*) Warm a piece of aluminium with concentrated hydrochloric acid. Test the escaping gas with a blazing joss stick; what is the gas? What compound of aluminium is formed?

(*b*) Boil a piece of aluminium with concentrated sodium hydroxide solution. Test as in **B** (*a*). What is the gas? What compound of aluminium is formed?

Experiment 206 — Preparation and Properties of Aluminium Hydroxide

MATERIALS. — Solutions of aluminium sulphate, sodium hydroxide, potassium hydroxide, ammonium sulphide, and sodium carbonate.

A. *Preparation.* (*a*) Add ammonium hydroxide to a solution of aluminium sulphate, and shake well. The precipitate is aluminium hydroxide; save it for further use in this experiment.

(*b*) Proceed as in (*a*), using aluminium sulphate solution and a very little sodium hydroxide solution. Compare with the result in (*a*). Save this precipitate. Predict the result of using potassium hydroxide (instead of sodium hydroxide). Verify the prediction.

B. *Properties.* (*a*) Examine the precipitate from **A** (*a*) and note its properties, e.g. color, texture, etc. Remove a little and rub it between the fingers; describe the result.

(*b*) To the precipitate from **A** (*b*) add sodium hydroxide slowly and shake constantly until a conspicuous change occurs. State the result. What compound of aluminium is formed?

(*c*) To a portion of the precipitate from **A** (*a*) add considerable ammonium hydroxide, and shake well. Compare with the result in **B** (*b*).

(*d*) Add dilute hydrochloric acid to a portion of the precipitate from **A** (*a*), and shake well. State the result. Proceed similarly with other acids, e.g. sulphuric and acetic. State the results.

Experiment 207 — Clarification of Water by Aluminium Hydroxide

MATERIALS. — Clay, aluminium sulphate solution.

Shake a little fine clay (or clay soil) in about 50 cubic centimeters of water. Divide the turbid water into two equal portions. Save one for comparison. To the other add a little aluminium sulphate solution and ammonium hydroxide, and mix well. Compare the two portions in a few minutes. State the final result. Explain it.

Experiment 208 — Thermit

MATERIALS. — Thermit, sand (or clay) crucible about 10 centimeters (4 inches) deep, brick, sand, iron pan, granulated aluminium, barium peroxide, magnesium ribbon.

Fill an iron pan with sand and stand it on a brick. Put about 30 grams of thermit in the crucible, and bury the crucible about halfway in the sand; as a precaution, a box of sand should be near by to throw upon the molten iron in case the crucible should break. Prepare a fuse mixture by mixing thoroughly about 10 grams of barium peroxide and 1 gram of granulated aluminium. Make a hole in the top of the thermit and pour in the fuse mixture; insert a piece of magnesium ribbon into the heap of fuse mixture. Light the magnesium with the Bunsen flame, and stand away. The reaction is vigorous. Describe it. When the crucible is cool, break it open and examine the contents. Describe the two parts. What is the name of each?

Experiment 209 — Tests for Aluminium

MATERIALS. — Aluminium sulphate, cobaltous nitrate solution, blowpipe, charcoal.

(*a*) Proceed as in Exp. **206 A** (*a*).

(*b*) To a portion of the solution of the aluminium compound add a little sodium hydroxide solution and then an excess. To another portion add an excess of ammonium hydroxide. The precipitation and properties of aluminium hydroxide serve as the test.

(*c*) Heat a little aluminium sulphate (or any other aluminium compound) on charcoal in the blowpipe flame. Cool, and moisten with a drop or two of cobaltous nitrate solution. Heat again, and observe the color of the residue.

SUPPLEMENTARY EXPERIMENTS

Experiment 210 — Aluminium Salts as Mordants

MATERIALS. — Solutions of alum and cochineal.

Add a little alum solution to a dilute solution of cochineal, then add ammonium hydroxide and shake well. Filter, and compare the colors of the filtrate and precipitate.

Experiment 211 — Preparation and Properties of Potassium Alum

MATERIALS. — Aluminium sulphate, potassium sulphate, evaporating dish.

A. *Preparation.* Add 8 grams of aluminium sulphate and 4 grams of potassium sulphate to about 40 cubic centimeters of water and heat the mixture in a porcelain dish until the salt is dissolved. Set it aside to crystallize; well-formed crystals may be obtained upon a thread suspended in the solution. (Meanwhile proceed with **B** (*a*)). Crystals of potassium alum will be deposited. Remove the best ones; dry and examine. Describe them, giving color, luster, size, and crystal form.

B. *Properties.* (*a*) Test a solution of alum (from the laboratory bottle) for aluminium ions and sulphate ions, and state the result. Cautiously taste the solution, and describe the result. Test solid alum for water of crystallization, and state the result.

(*b*) Select several good crystals from those prepared in **A** and examine them carefully. Describe them. Test as in **B** (*a*), and state the results. Allow some crystals to remain exposed to the air for several hours. Compare finally with the original crystals. Explain the difference.

Experiment 212 — Displacement of Metals by Aluminium

Devise experiments similar to Exp. **184** to illustrate the displacement of metals by aluminium.

Experiment 213 — Equivalent of Aluminium

Proceed as in Exp. **64**.

Experiment 214 — Hydrolysis of Aluminium Salts

(*a*) Prepare a solution of aluminium sulphate and test it with litmus paper. State and explain the result.

(*b*) Proceed as in (*a*) with an alum solution. State and explain the result.

Experiment 215 — Alum Baking Powder

Proceed as in Exp. **113 G.**

IRON

Experiment 216 — Properties of Iron

MATERIALS. — Cast and wrought iron, steel, magnet, iron thread, iron powder.

A. *Physical.* (*a*) Examine typical specimens of cast iron, wrought iron, and steel, and state their characteristic physical properties.

(*b*) Determine the heat and the electrical conductivity of iron wire by proceeding as in Exp. **181** (*b*). Compare the result with that of similar experiments.

(*c*) Determine the specific gravity of iron by the method given in Exp. **88** (*b*). Compare as in (*b*).

(*d*) Try the action of a magnet on each kind of iron. State the result.

(*e*) Drop a pinch of iron powder into a Bunsen flame. Hold a piece of iron thread in the flame. Describe the results, and draw a conclusion.

B. *Chemical.* (*a*) Perform, recall, or repeat (if necessary) experiments which show the effect of heating iron in oxygen, chlorine, nitrogen, nitrous oxide, and sulphur. State each result.

(*b*) As in (*a*), experiments showing the action of acids with iron. State the results.

(*c*) As in (*a*) experiments illustrating the displacement of metals by iron. If necessary, try additional experiments with iron and solutions of metals. State the results. (Compare Exps. **184, 191, 212.**)

Experiment 217 — Properties of Ferrous Compounds

MATERIALS. — Iron powder (or filings), hydrochloric acid, solutions of sodium hydroxide and potassium ferricyanide.

Put a few grams of iron powder in a test tube, add about 10 cubic centimeters of dilute hydrochloric acid, and warm

gently; ferrous chloride is formed (in solution). Proceed as follows: (1) Pour a little into a test tube one third full of sodium hydroxide solution. The precipitate is ferrous hydroxide. Describe it. Watch and describe the changes in color. To what are the changes due? (2) Add a second portion to potassium ferricyanide solution. The precipitate is ferrous ferricyanide. Describe it.

Experiment 218 — Properties of Ferric Compounds

MATERIALS. — Solutions of ferric chloride, sodium hydroxide, potassium sulphocyanate, and potassium ferrocyanide.

To a little ferric chloride solution add (1) sodium hydroxide solution. The precipitate is ferric hydroxide. Describe it. Add to ferric chloride solution (2) a little potassium sulphocyanate solution. The rich wine-red color is caused by soluble ferric sulphocyanate. This test readily distinguishes ferric from ferrous compounds. Add as above (3) a little potassium ferrocyanide solution. The precipitate is ferric ferrocyanide. Describe it.

Tabulate the results of Exps. **217** and **218**, showing the behavior of ferrous and ferric compounds under the same conditions.

Experiment 219 — Interrelation of Iron Compounds

MATERIALS. — Ferric chloride solution, zinc, ferrous sulphate, potassium chlorate.

A. Put a piece of zinc in ferric chloride solution made slightly acid by hydrochloric acid. After the operation has proceeded for about fifteen minutes, test a portion of the liquid for a ferrous and a ferric compound by Exps. **217** and **218**. State and explain the result.

B. (*a*) To a solution prepared from fresh or freshly washed ferrous sulphate add a little hydrochloric acid, warm gently, and then add a few crystals of potassium chlorate. After heating a short time, test portions of the solution for a ferric and a ferrous compound (as in **A**). State and explain the result.

(*b*) Add 10 cubic centimeters of concentrated nitric acid, drop by drop, to a hot solution of ferrous sulphate to which a little sulphuric acid has been added, and boil. Test and explain as in (*a*).

Supplementary Experiments

Experiment 220 — Testing Substances for Iron

Materials. — Clay, brick, flower pot, bauxite, rusty rock, sheet tin, iron rust, bluing, solutions of potassium ferricyanide and potassium sulphocyanate.

(*a*) Prepare a solution of each of the substances to be tested by boiling a little of the powdered material with concentrated hydrochloric acid. Test the clear solution for iron, both ferric and ferrous, and state the result in each case.

(*b*) Obtain other substances (from the Teacher) and test them for iron as in (*a*).

(*c*) Add considerable sodium hydroxide solution to a dilute solution of bluing. Describe and explain the result. (Suggestion. — See Exp. **218** (1).)

Experiment 221 — Blue Print Paper

Materials. — Ferric ammonium citrate solution (2.2 gm. to 10 cc. of water), potassium ferricyanide solution (same concentration), cotton or sponge, smooth, hard paper.

Prepare, or obtain from the Teacher, the two solutions. Mix equal volumes of each. Dip a piece of absorbent cotton or a sponge into the mixture, squeeze out the excess, and apply a thin coat to one side of a piece of paper. Let the paper dry in a dark place.

Lay a key or a coin on the coated paper and expose to the sunlight for a few minutes. Wash the paper thoroughly with water. Compare it with (1) the original uncoated paper, (2) the coated unexposed paper, and (3) a piece of exposed and washed paper. State the result.

Nickel and Cobalt

Experiment 222 — Test for Nickel

To a solution of nickel chloride add sodium hydroxide to alkaline reaction. The precipitate is nickelous hydroxide. Describe it.

Experiment 223 — Test for Cobalt

To a solution of cobaltous nitrate add acetic acid and considerable solid potassium nitrite, warm and shake well. A yellow precipitate of potassium cobaltinitrite ($K_3Co(NO_2)_6$) is formed.

MAGNESIUM — ZINC — MERCURY — CADMIUM

Experiment 224 — Tests for Magnesium

MATERIALS. — Solutions of magnesium sulphate (or chloride), ammonium chloride, ammonium hydroxide, disodium phosphate.

(*a*) To a solution of magnesium sulphate (or chloride) add successively solutions of ammonium chloride, ammonium hydroxide, and disodium phosphate. A precipitate of ammonium magnesium phosphate (NH_4MgPO_4) is formed. Describe it.

(*b*) Put a little powdered magnesium oxide in a cavity at the end of a piece of charcoal, moisten with water, and heat intensely in a blowpipe flame. Cool, and moisten with a drop of cobaltous nitrate solution. Heat again, and when cool observe the color. If the experiment has been conducted properly, a pink or pale flesh colored residue coats the charcoal.

Experiment 225 — Tests for Zinc

MATERIALS. — Zinc, zinc sulphate and cobalt nitrate solutions, zinc oxide, blowpipe, charcoal.

(*a*) Apply tests for metallic zinc (see Exp. **181**, **A**).

(*b*) Add a very little sodium hydroxide solution to zinc sulphate solution, and shake well. Describe the precipitate. What is it? Divide the mixture into three parts. To one add considerable sodium hydroxide, to another add ammonium hydroxide, and to the third add dilute hydrochloric acid. Shake each well, and observe the result. What compound of zinc is formed in each case?

(*c*) Fill a small cavity at one end of a piece of charcoal with zinc oxide (or any other zinc compound), and heat intensely in the blowpipe flame. Moisten with a drop of cobaltous nitrate solution, then heat again. Cool and examine. State the color of the incrustation on the charcoal in or near the cavity. (Compare Exp. **209** (*c*).)

Experiment 226 — Properties of Mercurous and Mercuric Compounds and Tests for Combined Mercury

MATERIALS. — Solutions of mercurous nitrate, mercuric chloride, and potassium iodide.

A. *Mercurous.* (*a*) Add a few drops of hydrochloric acid to a little mercurous nitrate solution. The precipitate is mercurous chloride. Describe it. Note its insolubility in water and in dilute hydrochloric acid. Add an excess of ammonium hydroxide. The black precipitate is a test for mercury in mercurous compounds.

(*b*) Add potassium iodide solution to mercurous nitrate solution. Describe the result. What compound of mercury is formed?

B. *Mercuric.* (*a*) Add a few drops of hydrochloric acid to a little mercuric nitrate solution. Compare with the result in **A** (*a*). Add a few drops of ammonium hydroxide, or enough to produce a decided change. Compare with **A** (*a*). The precipitate is mercuric ammonium chloride.

(*b*) Proceed as in **A** (*b*), using mercuric chloride solution.

C. See experiments showing displacement of metals in which mercury and its compounds are involved.

SUPPLEMENTARY EXPERIMENTS

Experiment 227 — Properties of Magnesium and Zinc

MATERIALS. — Magnesium, zinc.

A. *Physical.* Proceed as in Exp. **181 A**, using magnesium and zinc instead of copper.

B. *Chemical.* (*a*) Perform, recall, or repeat (if necessary) experiments showing the results of heating magnesium and zinc (1) in a limited supply of air and (2) in an abundance of air; and also treating magnesium and zinc with acids. State the results.

(*b*) Proceed as in Exp. **205 B**, using zinc instead of aluminium. What zinc compound is formed?

Experiment 228 — Equivalent of Zinc and Magnesium

Proceed as in Exps. **61** and **62**.

Experiment 229 — Physical Properties of Mercury

(*a*) Pour a drop or two of mercury into an evaporating dish. Examine the mercury, and state its characteristic properties. Agitate the dish, and describe the result.

(*b*) Stand a funnel in a test tube and carefully pour the mercury from the dish into the test tube. Remove the funnel. Heat the bottom of the test tube gently and observe the result, especially the deposit, if any, upon the upper part of the tube. Scrape a little of it out of the tube with a glass rod. What is the deposit? What property of mercury is shown by this experiment?

(*c*) Suggest a method of determining the specific gravity of mercury. If approved by the Teacher, try it.

Experiment 230 — Displacement of Metals — Magnesium, Zinc, and Mercury

Proceed as in former experiments (e.g. Exp. **184**), using these metals and solutions of several metallic compounds. Tabulate the results.

Experiment 231 — Test for Cadmium

MATERIALS. — Solutions of cadmium chloride and hydrogen sulphide.

Add hydrogen sulphide water to a test tube half full of cadmium chloride solution. The precipitate is cadmium sulphide. Describe it.

TIN AND LEAD

Experiment 232 — Test for Tin

MATERIALS. — Solutions of stannous chloride and mercuric chloride (POISON).

Add a few drops of stannous chloride solution to mercuric chloride solution. The white precipitate is mercurous chloride. Add considerable stannous chloride and warm gently. The gray-black precipitate is finely divided mercury. Explain the chemical change and express it by equations.

Experiment 233 — Tests for Lead

MATERIALS. — Lead nitrate and potassium dichromate solutions, sulphuric acid, hydrochloric acid.

(*a*) Recall the result of reducing lead oxide in the blowpipe flame.

(*b*) Recall the action of hydrogen sulphide with the solution of a lead compound.

(*c*) Add dilute hydrochloric acid to a little lead nitrate solution until precipitation ceases. The insoluble precipitate is lead chloride. Boil some of the precipitate with considerable water. Describe the action.

(*d*) Add dilute sulphuric acid to a little lead nitrate solution until precipitation ceases. The precipitate is lead sulphate. Observe its properties. Is it soluble in hot water? Try it.

(*e*) Repeat (*d*), using potassium dichromate solution instead of sulphuric acid. The precipitate is lead chromate. Describe it, especially the color.

SUPPLEMENTARY EXPERIMENTS

Experiment 234 — Physical Properties of Tin and Lead

MATERIALS. — Tin, lead.

(*a*) Proceed with tin and lead as in former experiments (e.g. Exp. **181**).

(*b*) Bend a piece of tin and note the crackling noise.

(*c*) Rub a piece of lead upon a hard surface, e.g. the (outside) bottom of a mortar. State the result. Rub lead with the fingers, and compare with the preceding result.

Experiment 235 — Displacement of Metals — Tin and Lead

Proceed as in former experiments (e.g. Exp. **184**), using tin and lead and solutions of metals. Tabulate the results and compare with similar experiments.

Experiment 236 — Testing for Lead and Tin

MATERIALS. — As below.

A. *Lead.* (*a*) Warm thin shavings of solder with dilute nitric acid, filter and test the filtrate for lead.

(*b*) Proceed as in (*a*) using one or more of the following: Tea lead, type metal, plumbago, shot, bullets, metallic cap of a bottle, "lead" of a lead pencil, and "unknowns" obtained from the Teacher.

(*c*) Apply the (reduction) blowpipe test for lead to white lead, red lead, litharge, dry paint, chrome yellow, and "unknowns."

B. *Tin.* (*a*) Boil a piece of tin foil with concentrated hydrochloric acid, filter, and test the filtrate for tin.

(*b*) Proceed as in **B** (*a*) with metals known or suspected to contain tin.

Experiment 237 — Analysis of Solder

MATERIALS. — Solder, ammonium polysulphide solution.

Dissolve a gram of solder filings in as small a quantity of hot *aqua regia* as possible, evaporate nearly to dryness (in the hood), dissolve the residue in water, add 10 to 15 cubic centimeters of dilute hydrochloric acid, and precipitate the metals as sulphides by bubbling hydrogen sulphide gas through the solution for 15 or 20 minutes. Filter, wash with hot water, pierce a hole in the filter paper, and wash the precipitate into a test tube with yellow ammonium sulphide. Add more ammonium sulphide, and shake. Filter.

The filtrate contains the tin as ammonium sulphostannate; add to it dilute hydrochloric acid, and yellow stannic sulphide is precipitated.

The precipitate is lead sulphide. Dissolve it in hot dilute nitric acid, filter, and test the filtrate for lead.

Experiment 238 — Qualitative Analysis of a Solution of Lead, Silver, and Mercury (ous)

MATERIALS. — Solution containing lead nitrate, silver nitrate, and mercurous nitrate.

Add dilute hydrochloric acid drop by drop to the solution until precipitation eases. Allow the mixture of precipitated chlorides to settle, pour off the liquid carefully (see Int. § **6** (1)(*a*)), add about 15 cubic centimeters of water, and boil. Filter, and test the filtrate for lead. Wash the precipitate with hot water until the wash water does not give a test for lead. Pierce a hole in the point of the filter paper with a glass rod, and wash the mixed precipitates of silver and mercurous chlorides into a test tube with dilute ammonium hydroxide. Warm gently and shake. Filter, and test the filtrate for silver. The black residue is a sufficient test for mercury. Its presence may be confirmed thus: Dissolve the black precipitate in a *very* little *aqua regia*, dilute with water, and add a clean copper wire; remove the wire in a few minutes, wipe gently, and mercury will be seen on the wire as a bright silvery coating.

CHROMIUM — MANGANESE

Experiment 239 — Tests for Chromium

MATERIALS. — Borax, chrome alum, potassium carbonate, potassium nitrate, acetic acid, nitric acid, sodium hydroxide solution, lead nitrate solution, potassium dichromate solution, test wire, piece of porcelain, forceps.

(*a*) Apply the borax bead test to chrome alum.

(*b*) Mix equal small quantities of potassium carbonate, potassium nitrate, and powdered chrome alum, place the mixture on a piece of porcelain, hold it with the test tube holder in the Bunsen flame, and heat it until the mixture fuses. A yellow mass, due to the presence of potassium chromate, results. If the color is not decided, dissolve the mass in water, add acetic acid, slowly at first, and boil until all the carbon dioxide is expelled. Add a few drops of lead nitrate solution to a portion, and yellow lead chromate is precipitated. (If the precipitate is white, it is lead carbonate, and shows that not all the potassium carbonate was decomposed, as intended.)

(*c*) Proceed as in Exp. **233** (*e*), using potassium chromate or dichromate solution. State the result.

Experiment 240 — Properties of Potassium Chromate and Dichromate

MATERIALS. — Potassium chromate and dichromate, concentrated hydrochloric acid, potassium hydroxide solution.

(*a*) Make a dilute solution of potassium chromate and dichromate, and compare the colors. Save for (*b*) and (*c*).

(*b*) Add a few drops of concentrated hydrochloric acid to the solution of potassium chromate prepared in (*a*), and observe the change in color. Describe it. Compare with the color of the potassium dichromate solution. Draw a conclusion.

(*c*) Add potassium hydroxide solution to the solution of potassium dichromate prepared in (*a*) until a change of color is produced. Describe the color. Compare with the potassium chromate solution. Draw a conclusion.

(*d*) Add a few drops of concentrated hydrochloric acid to powdered potassium chromate and dichromate in separate test tubes. What gas is evolved? By what chemical change was it produced?

Experiment 241 — Tests for Manganese

MATERIALS. — Manganese dioxide, potassium carbonate, potassium nitrate, ammonium sulphide, manganese sulphate solution, hydrochloric acid, acetic acid, ammonium hydroxide.

(*a*) Subject a minute quantity of manganese dioxide (or any other manganese compound) to the borax bead test, and note the color of the bead after heating in each flame.

(*b*) Fuse, on a piece of porcelain, a little manganese dioxide mixed with potassium carbonate and potassium nitrate. The green color of the mass is due to potassium manganate.

(*c*) Add ammonium sulphide to manganese sulphate solution. The flesh-colored precipitate is manganese sulphide. Compare with other sulphides as to color (see Exps. **161, 163**).

SUPPLEMENTARY EXPERIMENTS

Experiment 242 — Reduction of Chromates to Chromic Compounds

MATERIALS. — Potassium dichromate solution, concentrated hydrochloric acid, alcohol.

Add to a few cubic centimeters of potassium dichromate solution a little concentrated hydrochloric acid and a few drops of alcohol. Warm gently. Two important changes occur. The chromate is *reduced* to chromic chloride which colors the solution green; the alcohol is oxidized to aldehyde, which is detected by its peculiar odor.

Experiment 243 — Preparation and Properties of Chromic Hydroxide

MATERIALS. — Solutions of sodium hydroxide and chrome alum.

Add a little sodium hydroxide solution to a solution of chrome alum. The precipitate is chromic hydroxide. Describe it. Add an excess of sodium hydroxide solution, and shake. Describe the result. Boil, and state the result. (Compare with Exp. **206**.)

Experiment 244 — Oxidation with Potassium Permanganate

MATERIALS. — Potassium permanganate, sulphuric acid, ferrous sulphate, filter paper.

(*a*) Add a few drops of sulphuric acid to a weak solution of ferrous sulphate; then add, drop by drop, a dilute solution of potassium permanganate. The potassium permanganate oxidizes the ferrous to ferric sulphate; its color is changed, owing to the loss of oxygen and transformation into other compounds.

(*b*) Boil a piece of filter paper in a dilute solution of potassium permanganate. Describe and explain the result.

LABORATORY EQUIPMENT

The lists given below include the apparatus, chemicals, and supplies needed for the experiments in this book. Quantities and prices have been omitted in justice to teachers, dealers, and the author. The author, at his own suggestion, has lodged with the L. E. Knott Apparatus Co., 15 Harcourt Street, Boston, Mass., information regarding the quantities needed for classes of varying size. It is hoped that teachers who desire information will correspond with the dealer when preparing orders. The author takes this opportunity to say he has no financial connection with any dealer in scientific supplies.

List A — Individual Apparatus

This list includes the apparatus constantly used, and each student should be provided with a set.

1 Blowpipe.
1 Blowpipe tube.
5 Bottles, wide mouth, 250 cc.
1 Bottle, generator, 250 cc.
1 ft. Copper wire, No. 20.
1 Bunsen burner.
1 Deflagrating spoon.
1 Erlenmeyer flask, 250 cc.
1 Evaporating dish, $2\frac{3}{4}$ in.
100 Filter papers, 4 in.
1 Forceps, iron.
1 Funnel, $2\frac{1}{2}$ in.
4 Glass plates, 4 x 4 in.
6 in. Glass rod.
5 ft. Glass tubing.[1]
1 Graduated cylinder, 25 cc.
1 Iron stand, clamp (medium), ring (3 in.).
1 Mortar and pestle, 3 in.
1 Pinch clamp (Mohr's).[4]
1 Pneumatic trought complete.[2]
1 Rubber stopper, one-hole.[3]
1 Rubber stopper, two-hole.[3]
2 ft. Rubber burner tubing, $\frac{1}{4}$ in.
6 in. Rubber connecting tubing, $\frac{5}{16}$ in.
6 in. Rubber pressure tubing, $\frac{3}{16}$ in.[4]
6 Test tubes, 6 x $\frac{3}{4}$ in.
3 Test tubes, 8 x 1 in.
1 Test tube brush.
1 Test tube holder.
1 Test tube rack.
1 Thistle tube.[4]
1 Wire gauze, iron, 4 x 4 in.

[1] To fit the rubber stoppers.

[2] Indurated fiber keeler No. 4 and shallow flower pot, 4 in.

[3] To fit the 8 x 1 in. test tube. Such stoppers also fit the average 250 cc. Erlenmeyer flask and the 250 cc. generator bottle (if the neck is small); they also fit the 2500 cc. bottle (acid bottle) — see *List B*.

[4] See Exp. **10**. Straight stem of thistle tube must fit the rubber stopper.

List B — Special Apparatus

This list includes apparatus used infrequently or of such a nature that it may be used by a class or groups. Numbers in parentheses refer to experiments.

1 Battery, 4 or more cells (30, 70, 72, etc.).
1 Battery jar, 4½ in. diam. (70, 72).
2 Beakers, No. 3 (63, 78).
2 Bottles, 2500 cc. (13).
2 Burettes, 50 cc. (78).
1 Burner, acetylene (87).
1 Chlorine tube (29).
1 Clamp, medium (extra) (78).
1 Condenser, complete (26, 127).
1 Crucible and cover, porcelain, No. 0 (9, 32, 81).
1 Crucible, Hessian (sand), 4 in. deep (80, 208).
1 Crucible, iron, 60 cc. (55).
1 Crucible block, wood, 4 x 4 x 1 in. (9, 32).
1 Dish, lead (147, 150, 152).
1 Electric bell (70, 72).
2 Electrodes, carbon (70, 72).
1 Electrolysis apparatus (30, 75).
1 Flask, 500 cc. (26, 127).
1 Hydrometer (135).
1 Jar, 12 x 4 in. (62, 65).
1 Magnet (216).
6 in. Nichrome wire (Int. **5** (4)).
1 Pan, iron, 4 in. (204).
1 Sq. in. Platinum foil (30).
3 in. Platinum wire (Int. **5** (4)).
1 Retort, 250 cc. (47).
1 Screw, Hofmann (13).
1 Thermometer, −10 to 110° C. (frequently).
1 Triangle (9, 32).
1 Tripod (9, 32).
1 Tube graduated, 100 cc. (62, 65).
1 U-tube, 4 in. (71, 77).
1 Welsbach burner and mantle (102).
1 Wing-top burner (Int. **3** (*b*)).

List C — General Apparatus

Numbers in parentheses refer to experiments.

1 Balance (61–65).
1 Barometer (13, 61, 62, 64, 65).
1 set Cork borers (Int. **5** (3)).
1 File, round (Int. **5**, (3)).
1 File, triangular (Int. **3** (*a*)).
2 Cylinders, graduated, 250 cc. and 500 cc.
1 Microscope (108).
1 Scales.
1 set Weights for balance, 1 mg. to 50 gm.
1 set Weights for scales, 1 gm. to 500 (or 1000) gm.
Wooden blocks, 6 x 6 x 1 and 4 x 4 x ½ (with ½ in. hole in center) (33, 35).

List D — Chemicals

This list includes the chemicals (except those in *List E*) needed for the experiments in this book. Numbers in parentheses refer to experiments in which the chemicals are used infrequently or in small quantities.

Acid, acetic.
hydrochloric.
metaphosphoric (160).
nitric.
orthophosphoric (159).
oxalic (91).
pyrogallic (57).
sulphuric.
Alcohol, ethyl.
methyl (109, 128).
Alum, chrome (239, 243).
potassium.
Albumin.
Aluminium, bronze (188).
granulated (208).
lump (205).
sheet.
wire (13).
sulphate.
Ammoniacal liquor (53, 99).
Ammonium carbonate (161, 177, 180).
chloride.
dichromate (52, 76).
hydroxide.
molybdate (117, 119, 159).
nitrate (56).
oxalate.
polysulphide (161, 237).
sulphate (53).
sulphide (241).
Aniline (18).
Antimony (165, 166).
chloride (162).
See Tartar emetic.
Arsenic trioxide (139, 161).
Asbestos (13).
Baking powder (*List E*).
alum (113, 215).
Barium chloride.
dioxide (8, 31, 208).
hydroxide (60).
nitrate (52).
peroxide (*see* dioxide).
Bauxite, red (220).
Bismuth (167, 168).
Bleaching powder (34, 197).
Bone ash (159, 197).
Borax.
Brass (188).

Cadmium chloride (231).
Calcium (12, 16, 29, 65, 195).
carbide (87).
carbonate (marble).
chloride.
fluoride (150, 152).
oxide (lime).
sulphate.
Camphor (109).
Carbon disulphide.
tetrachloride (114).
Carborundum, lump (93).
powder (150).
Casein (103).
Celluloid (126).
Cement (197).
Chalk (86).
Charcoal, animal.
lump.
powder.
Chloroform (66).
Chrome alum. *See* Alum.
yellow (236).

Clay (207).
Cobalt chloride.
nitrate (76).
Cochineal (210).
Collodion (126).
Copper, borings.
wire (No. 20).
bromide (76).
nitrate (51, 76).
sulphate.
Cream of tartar (44).

Dextrin (125).

Ether (114, 129).

Fehling's solution (*see* Exp. **106**).
Ferric ammonium citrate (221).
Ferric and ferrous salts (*see* Iron).
Formalin (128).
Fusible metal (2, 169).

Gasoline (114).
Gelatin.
German silver (188).
Glass wool (13).
Glycerin (18).
Glucose. *See* Grape sugar.
Gold leaf.
Grape sugar.
Graphite, artificial (88).
native (88).
Guncotton (126).

Hydrogen dioxide (8).

Iodine.
Infusorial earth (150).
Iron filings (54).
powder.
thread (Steel wool).
chloride (ic).
sulphate (ous).
sulphide (ous).

Lead, sheet.
tea.
acetate.
dioxide (8, 41).
nitrate.
monoxide (litharge).
red (tetroxide), (41, 236).
white (carbonate), (86, 236).
Lignite (81).
Lime. *See* Calcium oxide.
Litmus paper.
solution (71).

Magnesium, powder (32).
ribbon.
carbonate (89).
chloride.
oxide (224).
sulphate.
Manganese dioxide.
sulphate (241).
Mercury (229).
chloride (ic).
nitrate (ic), (226).
nitrate (ous), (226, 238).
oxide (8).

Nickel chloride (76, 222).
sulphate (76).

Paraffin wax (152).
Phenol-phthalein solution (78, 87, 90).
Phosphorus, red (164).
yellow (164).
Plaster of Paris (97).
Potash (178).
Potassium (16, 173).
bromide.
carbonate.
chlorate (cryst.).
chlorate (powd.).
chloride.

List E — Miscellaneous Supplies

Numbers in parentheses refer to experiments.

Apple (14).
Baking powder (86, 113, 215).
Bluing (220).
Bread (14, 123, 124).
Brick.
Bullets (236).
Butter (114).
Calico (33).
Candle, paraffin (80).
Candy (107).
Celery (14).
Cloth, colored (34).
  unbleached (34).
Coal, hard (81).
  soft (81, 94).
Coke (99).
Corks, assorted (*see* Exp. **82**).
Cotton.
Cotton-seed oil (115).
Cracker (14, 124).
Cranberry (14).
Emery paper (Int. **3**).
Excelsior (25).
Fertilizer (159).
Flour (120).
Flower pot (220).
Gas carbon (99).
Gelatin (103).
Grape juice (44).
Hay (25).
Iron, cast (216).
  nails.
  rust (220).
  steel (216).
  wrought (216).
Jam (107).
Jelly (44, 107).
Joss sticks (frequently used).
Kerosene (18).
Lard (114, 115).
Leather (103).
Lemon juice (44).
Maple sugar (107).
Matches.
Meat (14, 103).
Milk (44).
Molasses (107).
Mortar, old (86, 197).
Mustard (103).
Pickles (44).
Plaster (197).
Potato (14, 108, 123).
Quill toothpick (48).
Raisins (25).
Rice (123).
Rock, rusty (220).
Sand.
Shot (236).
Sirup, table (107).
Soap.
Starch (108).
Sugar.
Tallow (114).
Tar (99).
Taper, wax (10).
Thread.
Tin, sheet (220).
Tooth powder.
Vinegar (112).
Wood ashes (44).
Yeast (127).

List F — Emergency Supplies (*See Int.* **6**)

Absorbent cotton, 1 oz.
Bandages (2 in.).
Blanket.
Boric acid solution, 1 oz.
Camphor solution, 1 oz.
Collodion, ½ oz.
Carron oil, 1 oz.
Court plaster, 1 book.
Fire extinguisher.
Medicine dropper.
Mustard, 1 oz.
Pins, 1 paper.
Sand and scoop.
Scissors.
Smelling salts, 1 bottle.
Sodium bicarbonate, 1 oz.
Thread, 1 spool.
Vaseline, 1 oz.

List G — Solutions

The solutions needed for most of the experiments in this book are approximately 10 per cent (unless otherwise specified) except the following:

Ammonium hydroxide, 1 vol. to 3 vols. water.

Ammonium molybdate. Dissolve 15 gm. of the salt in 100 cc. water and pour this solution into 100 cc. nitric acid (1 vol. acid to 1 vol. water).

Ammonium oxalate, 5 per cent.

Ammonium polysulphide. Add sulphur to ammonium sulphide solution.

Ammonium sulphide, 1 vol. to 1 vol. water.

Barium chloride, 5 per cent. Use distilled water.

Barium hydroxide, 1 per cent. Use clear solution.

Battery solution (Grenet). Dissolve 103 gm. powd. potassium dichromate in 1000 cc. water and slowly add 103 gm. conc. sulphuric acid with constant stirring.

Chlorine water. Saturate water with the gas.

Cobaltous nitrate, 5 per cent.

Cochineal. Grind a little cochineal with water, dilute as desired, and filter.

Ferric chloride, 5 per cent.

Ferrous sulphate, 5 per cent. Must be freshly prepared.

Hydrochloric acid, dilute, 1 vol. to 5 vols. water.

Lead salts. Use distilled water or filter.

Limewater. Slake lime, add considerable water, shake occasionally, siphon off clear liquid.

Litmus. As under Cochineal.

Mercuric chloride, 5 per cent. POISON.

Mercurous nitrate, 5 per cent. Add a little mercury.

Nitric acid, dilute, 1 vol. to 5 vols. water.

Phenol-phthalein. Dissolve 1 gm. in 100 cc. alcohol and dilute slightly with water.

Potassium permanganate, 5 per cent.

Potassium sulphocyanate, 5 per cent.

Silver nitrate, 5 per cent. Use distilled water.

Silver sulphate, .5 per cent. Use distilled water.

Sodium cobaltinitrite. Dissolve 10 gm. sodium nitrite in 20 cc. water; dissolve 6 cc. acetic acid and 1 gm. cobaltous nitrate in 15 cc. water. Mix these solutions and filter.

Stannous chloride. Reduce conc. hydrochloric acid with tin, dilute with water, and keep tin in this solution.

Sulphuric acid, dilute. Slowly pour 1 vol. acid into 5 vols. of water, stirring constantly.