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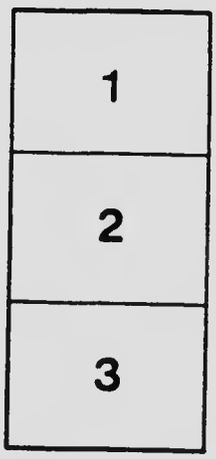

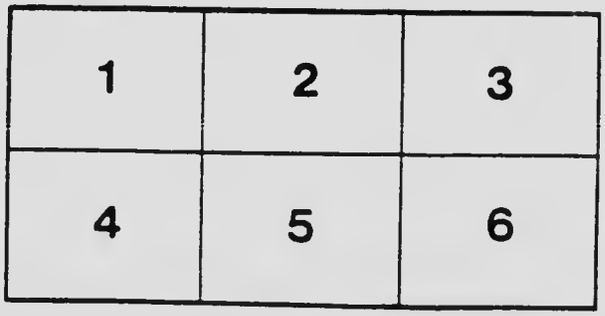

LABORATORY MANUAL

TO ACCOMPANY

ELEMENTARY CHEMISTRY FOR HIGH SCHOOLS

BY

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PREFACE

The experiments here described are intended to give pupils a more intimate knowledge of elementary chemistry than can be obtained by reading only, or even through lectures and demonstrations; it is not, however, neeessary that all of them should be carried out by each pupil. Although most of them require only the very simplest apparatus, a few call for certain things that may not be at hand in all school laboratories. The teacher must decide on the choice and order of experiments best suited to the time at his disposal and the equipment of his own school.

Here and there simple quantitative experiments are introduced. The "Chemical Revolution" of 1775 was brought about mainly by attention being directed to quantitative relations, and it is very necessary that pupils should be impressed with the importance of this side of the science. A few measuring vessels, a rough balance, and a balance carrying 100 grams in each pan, and sensitive to 0.01 gram, with weights, being the extra equipment that is necessary for a small class, and a great effort should be made to provide it.

Where laboratory equipment is very meagre, an ingenious instructor can do a great deal with ordinary utensils and a little skill: even a balance and counterpoises can be improvised. In many experiments where flasks with thistle and delivery tubes are used for generators, these can be replaced by test tubes fitted with delivery tubes only, the experiments then being carried out on a smaller

scale; test tubes may also frequently take the place of beakers; pickle bottles, or other wide-mouthed bottles, will serve for the collection of gases.

Where coal gas is not available, spirit lamps may be used for heating.

In many cases it is advisable that pupils work together in pairs; this saves apparatus, and the work is accomplished more expeditiously.

The experiments described have all been carried out by High School classes and have been found to be well within the capacity of these pupils. Each exercise as arranged can be completed in less than an hour (except No. XXXVIII), if it has been read up beforehand by the pupils and if the necessary supplies are at hand. An accurate balance should be provided for every four pupils, if possible, though it is required only in the case of about eight of the exercises.

The authors wish to record their indebtedness to Miss L. Isabel Howe, M.Sc., Assistant in Chemistry in the Montreal High Schools, who has rendered valuable assistance in the preparation of the manual.

CONTENTS

LABORATORY MANUAL

GENERAL DIRECTIONS

It is well that the pupils should have an experiment assigned to them for home study before taking it up in class; but, even if this is done or not, before beginning an experiment in the laboratory, the directions (including the questions) should be read through carefully by the pupil from beginning to end. Then, all the supplies necessary should be placed to hand, so as to save subsequent annoyance and loss of time in hunting them up; and any special observations, called for by the questions, will not be overlooked, necessitating possibly a repetition of the experiment or part of it.

Each pupil should supply himself with a towel and sponge.

The apparatus employed should always be clean and dry. During the work, the work-table and the outsides of beakers, etc., should be kept dry; and when the experiments are finished the apparatus should immediately be cleaned again and, with other supplies, returned to the proper places.

The glass tubing employed in most experiments should not be more than 6 mm. outside diameter.

CAUTIONS—ACCIDENTS

Great caution should be exercised in *smelling* substances, as the volatile matters given off are sometimes very strong. Some of the gas or vapor should be wafted towards the

nose with the hand, and only after its harmlessness has been ascertained in this way should the nose be brought near the tube or other receptacle.

Chemicals should never be *tasted* unless the pupil is specially told to do so. Then, only a very small quantity should be put into the mouth; and as soon as the taste is perceived, the mouth should be rinsed out, unless the substance is known to be quite harmless.

Certain of the substances employed in the experiments here described may be very dangerous if carelessly handled; hence, all warnings given in the descriptions should be very carefully attended to.

If strong acids, etc., come into contact with the skin, they should be washed off at once with plenty of water —strong reagents must never be applied to the flesh to counteract their effect.

Burns from acids or from hot objects, or scalds, may be treated with a paste of water and baking soda (not washing soda), or with carron-oil (equal parts of lime-water and olive or cotton-seed oil, well shaken up), then covered with a soft cloth soaked in the same and bandaged.

Cuts and scratches should be carefully washed out with water and then with hydrogen peroxide (see directions on bottle), and then bandaged if necessary.

In case of serious burns, cuts, etc., a doctor should be consulted at once.

Acid burns on clothing should be washed at once with plenty of water, then treated with plenty of ammonia, and washed again.

In case of fire, if the combustible be of an oily nature, smother with sand. Pails or boxes of sand for this purpose, and no other, should be always at hand in the laboratory. Water is used for ordinary fires.

LABORATORY REPORTS

Probably half the value of laboratory work consists in cultivating the ability of writing concise and exact reports on what has been done, the observations that have been made on the phenomena evoked, and the inferences that may be drawn from these.

Reports are written preferably in a stiff-covered exercise book, about 6½ x 8 inches, having a ruled margin. They should be written on the right-hand pages only, the left-hand pages being reserved for corrections, etc. Nothing should be written in the margin, except the numbers referring to sections, questions, etc: the instructor will use it for marks and other notes.

While it is difficult to have a set form suitable for all reports, the following outline, corresponding in the main to that used in the descriptions of most of the experiments, will be found satisfactory.

Date.

Subject of Exercise.

Sketch of Apparatus Used. In making the drawings, a lead pencil and stencil may be employed, and tubes may be represented by single lines, as shown in Fig. 1.

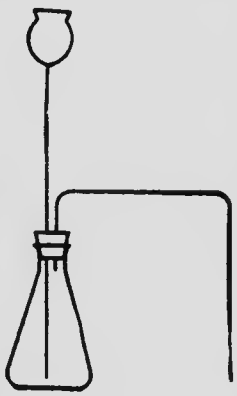

FIG 1.

Procedure followed in the experiments. Tell, in short paragraphs, numbered to correspond with the directions, what you did.

Observations. State concisely what you saw happen, and number these observations to correspond with the sections of the experiment.

Deductions. State what conclusions may be drawn from the observations made, numbering them correspondingly.

Questions. Answer the questions asked, numbering the answers to correspond with the questions; do not write out the questions themselves. No question should be answered with a simple yes or no; when this form of answer is possible, it should be amplified with reasons. In order to answer some of the questions, it may be necessary to consult the text-book, the dictionary, or some other book.

Laboratory books must be handed in on the day appointed each week, otherwise the pupil may not receive credit for the work done.

Spelling mistakes and incorrect formulas will be underlined by the instructor and must be written out correctly ten times each. Corrections to incorrect answers will be indicated, and no marks should be awarded unless these corrections are made by the pupil and shown to the instructor at the time set.

ON THE CARE AND USE OF APPARATUS

(1) **Work-table.** The work-table should be kept clean and dry; and all apparatus should be cleaned up as soon as an experiment is finished.

(2) **Sinks and Rubbish Receptacles.** Waste paper, matches and other solid rubbish must not be thrown into the sinks, or on the floor, but are to be put into the receptacles provided. Sinks must be flushed with plenty of water after corrosive liquids have been poured into them.

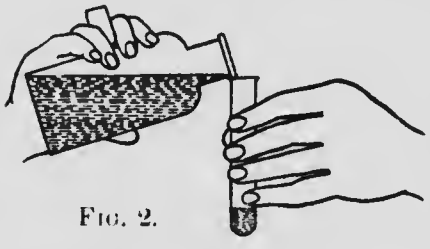

FIG. 2.

(3) **Reagent Bottles.** Reagents should be poured **label up,** and stoppers should be held between the fingers (Fig. 2), for if put down on the bench they are liable to

piek up material whieh will eontaminate the liquid in the bottle. A glass stopper must be returned to its proper bottle; the stopper will only fit the bottle it has been made for. Very small quantities of liquids may be removed from bottles by means of a glass tube open at both ends, as indieated in Fig. 3. Solids may be removed by means of a spatula, as indieated in Fig. 4. When chemicals are needed, take a clean beaker or a pieee of paper to the stoek bottle and obtain the **required quantity; do not take** the stoek bottles to **your desk.**

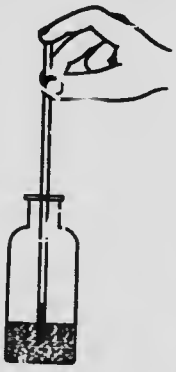

Fig. 3.

(4) **Pouring** from one vessel to another should be done with the help of a stirring rod; see Fig. 5. The rod prevents the liquid running down the outside of the vessel and also directs the stream of liquid to the place desired. When the rod is used for stirring liquids in beakers it is well to have a piece of rubber tubing on the end, otherwise the rod may break the beaker.

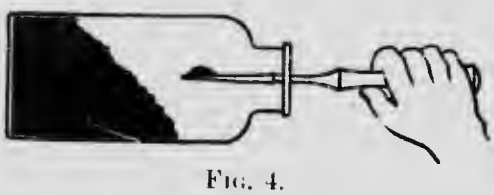

Fig. 4.

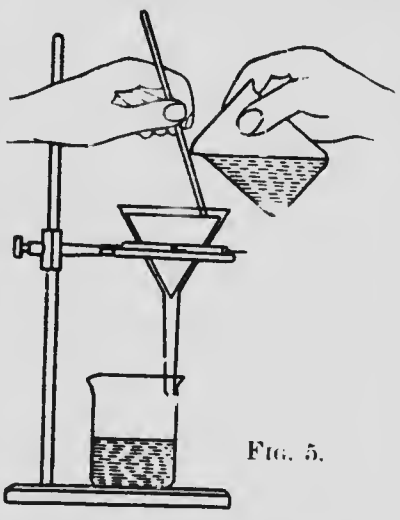

Fig. 5.

(5) **Filtering.** Fig. 5 shows how the operation may be carried on. The filter paper (A), Fig. 6, is folded in half to form a semicirele (B) and again to form a quadrant (C). It may then be opened to form a eone (D), which can be plaeed in the glass funnel, and moistened with water to

hold it in place. The paper should be properly fitted so that it filters quickly. It is always better to test it with water before using; if it filters slowly, much time will be lost. The funnel is supported by a pipe clay triangle resting on a ring held by the retortstand. The stem of the funnel **touches the side** of the lower beaker, as this prevents splashing. The stirring rod is used in pouring to prevent the liquid running down the outside of the beaker. Liquids should be filtered hot whenever possible, for they filter faster. The liquid in the funnel should **never** be above the filter paper. The filtrate is the liquid which runs through the filter paper.

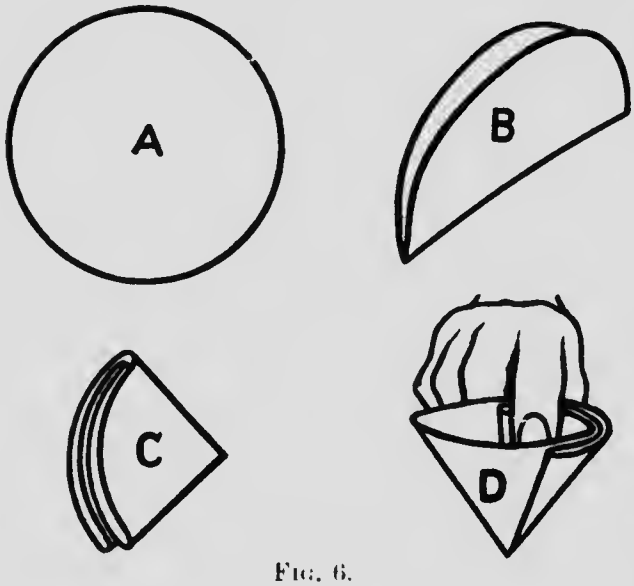

Fig. 6.

(6) **Heating Glassware: All glassware should be dry on the outside, otherwise it breaks on heating.**

(*a*) *Test Tubes.* Fig. 7 shows how a solid may be heated in a dry test tube, care being taken to warm the tube gently at first. By holding the tube horizontally, as shown, it is possible to notice anything that may condense in the cold part of the tube.

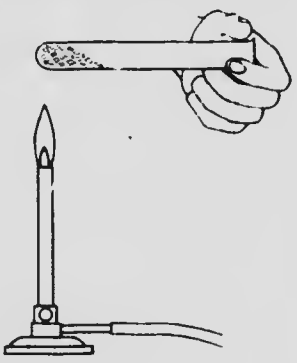
Fig. 7.

Fig. 8 shows how a liquid may be heated in a test tube. Hold the test tube in the test tube holder and boil the liquid by applying heat, being careful that the heat does not strike the tube at or above the surface of the liquid in the tube. The test tube should be continually shaken to give the vapors formed a chance to readily escape without throwing the liquid out of the tube.

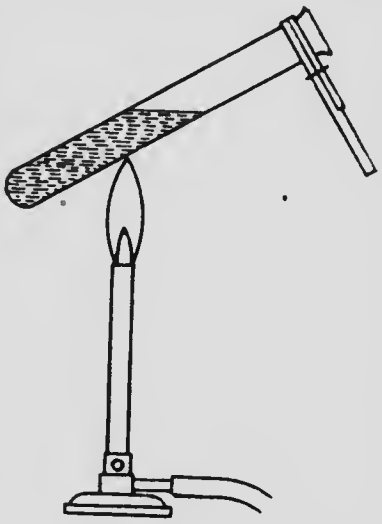

Fig. 8.

Never point a test tube towards anyone, in case the liquid should spurt out. Never place a test tube under anyone's nose.

Fig. 9 shows how a powder may be placed in a test tube. Cut a strip of paper a little wider than the diameter of the test tube, and a little longer than the latter; fold it lengthwise down the middle, so as to form a trough. Place the powder in this trough at one end, push it into the test tube held horizontally, and turn the tube up vertically.

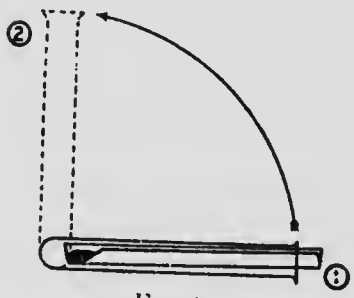

Fig. 9.

Test tubes should be kept in the test tube rack, and washed with a test tube brush before being put away.

(*b*) *Flasks and beakers* may be heated on a wire gauze as in Figs. 10 and 34. Care must be taken not to use too large a flame or to heat too rapidly. Hold the burner in the hand and warm the flask or beaker slowly by moving

the burner underneath the wire gauze for a little whi
at the commencement.

(7) **Heating Porcelain.** Porcelain should be dry on th
outside before heat is applied and, like glassware, should b
gently and slowly heated to the desired temperature.

(*a*) *Crucibles* may be heated by supporting them o
a pipe clay triangle (Fig. 11). The crucible tongs ar
used for moving the cover and also the crucible. Th

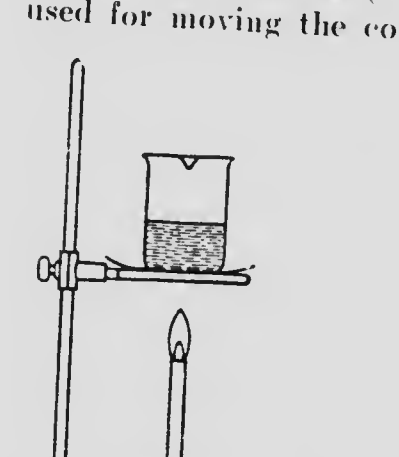

FIG. 10.

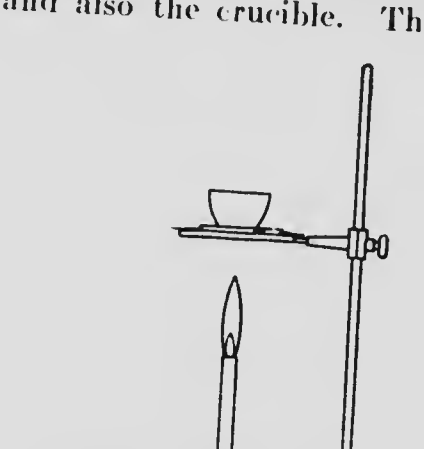

FIG. 11.

crucible should never be touched with the hands after weighing, but moved by means of the tongs. The tongs **should not be heated in the flame and should not be used for stirring.** They must be kept clean and dry.

(*b*) *Evaporating Dishes.* The evaporating dish may be heated on a wire gauze or over the naked flame (Fig. 12). Evaporation goes on most rapidly without the watch glass, but when solutions are evaporated to dryness it is necessary to cover when most of the liquid has evaporated, for otherwise when this stage is reached some of the solid is often thrown out of the dish and lost. The diagram shows the watch glass partly covering the dish.

(8) **Water Bath.** Concentrated liquids are frequently evaporated in a vessel placed over a water bath as shown in Fig. 13. The lower vessel contains water, so that the temperature of the evaporating dish never rises above 100° C.

(9) **Rubber Corks.** Rubber corks and tubing should be wetted before glass tubing is inserted into them. Push the tubing into the cork with a twisting motion. Care

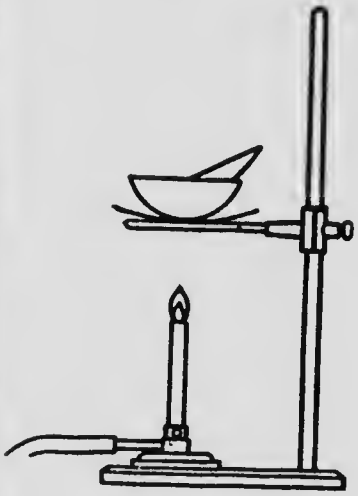

Fig. 12.

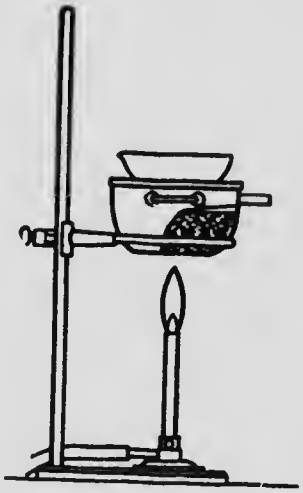

Fig. 13.

should be taken to see that glass tubing is rounded, otherwise it may stick in the cork and break into your hand. Glass tubes should be removed from corks and rubber tubing when experiment is finished.

(10) **Balances and Weights.**

Fig. 14 shows a common pattern of chemical balance:

A.—The pans;

B.—The beam;

C.—The support;

D.—The scale to determine the swing;

E.—The hook for suspending articles to be weighed;

F.—Plumb bob to level the balance;

H.—Pan hanger;
K.—The knife edges;
L.—The lever to raise and lower the beam from its rests;
L.S.—Levelling screws;
P.—Pointer to show when equilibrium is obtained;
R.—Rests for the beam when not in use, or when weights are being put on or taken off;
S.—Bows for holding the pans.

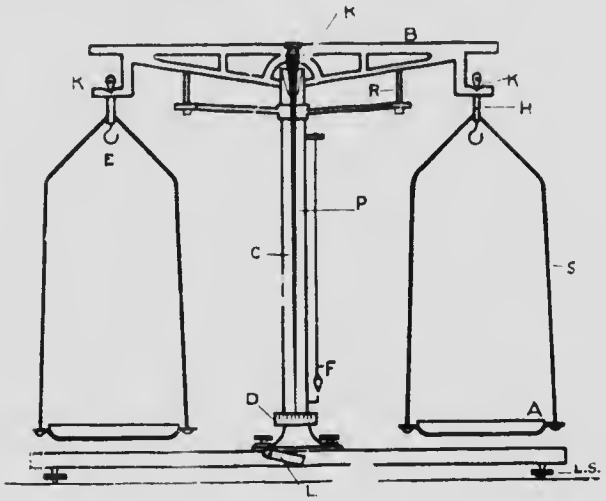

Fig. 14.

Fig. 15 shows a weight-box. There is a compartment for each weight, and the weight of each is marked in the diagram. A diagram placed inside the cover of the weight box shows not only the proper compartment for each piece, but also its weight.

Rules for Weighing. (*a*) Each pupil will use the balance and weights assigned and **no other.**

(*b*) The balances supplied are delicate instruments and **must be used very carefully;** any defect should be reported at once to those in charge, as should also the loss of, or injury to, any weight.

(*c*) The balances should be kept off their knife edges while the object or weights are being put on or taken off the pans. When weighing is finished, the beam should be removed from its bearings.

(*d*) The object should be placed on the **left-hand** pan and the weights on the right.

(*e*) The weights should be applied by means of the forceps only and in **systematic order**, as this saves time. **Start with a weight slightly heavier** than the object being weighed, and work right down the weights, trying each one. Do not skip about.

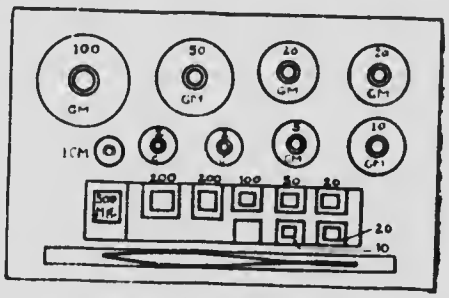

FIG. 15.

(*f*) When equilibrium has been obtained (i.e., when the pointer swings evenly on both sides of the zero mark), record the weight in the notebook at once, do not trust to the memory or loose pieces of paper. Write down the weight by noticing the holes which are vacant in the weight box, and then check the weights by noting them as you replace them in the box from the pan of the balance.

(*g*) **Replace all weights in the box when finished and put each weight in its proper compartment.**

(*h*) Chemicals must not be spilled on or near the balances. Chemicals must never be weighed directly on the balance pans; a watch glass may be used. Pieces of celluloid adjusted to fit the balance pans are more convenient than paper.

(*i*) Weighings are to be made on the rough balance unless otherwise stated.

(*j*) **Do not attempt to adjust balances yourself—report the matter.**

EXERCISE No. I

THE BUNSEN BURNER — WORKING GLASS TUBING — BORING CORKS

SUPPLIES.— *Three-feet glass tubing (6 mm. outside diameter), file, wing top, Bunsen burner, test tube, gummed label, graduate, foot-rule.*

1. **Bunsen Burner.**—(*a*) Take the Bunsen burner apart, examine its construction and put it together again.

(*b*) Light the burner by **first** turning on the gas full and **then** bringing a burning match about two inches above the burner.

(*c*) While the gas is burning, open and close the air holes several times. Observe what happens.

(*d*) Hold a glass rod in the non-luminous flame for a few moments. Observe what happens to the rod.

(*e*) Hold a glass rod in the luminous flame for a few moments. Observe what happens to the rod.

CAUTION.—Never allow the burner to strike back, i.e., to burn at the base inside the brass tube; it heats up the burner, spoils the rubber connections, makes a bad odor, and may burn the desk.

2. Glass Tubing.—It is important that the glass tubing be worked to the shape and dimensions given on Fig. 16, for the pieces are used in future experiments.

(*a*) *Cutting.*—Cut a piece of glass tubing by making a scratch on it with a triangular file; hold the tubing in both hands, scratch away from you, and having the

thumbs opposite the scratch; a slight outward bending or pulling as though to open the crack will cause the tubing to break (Fig. 17).

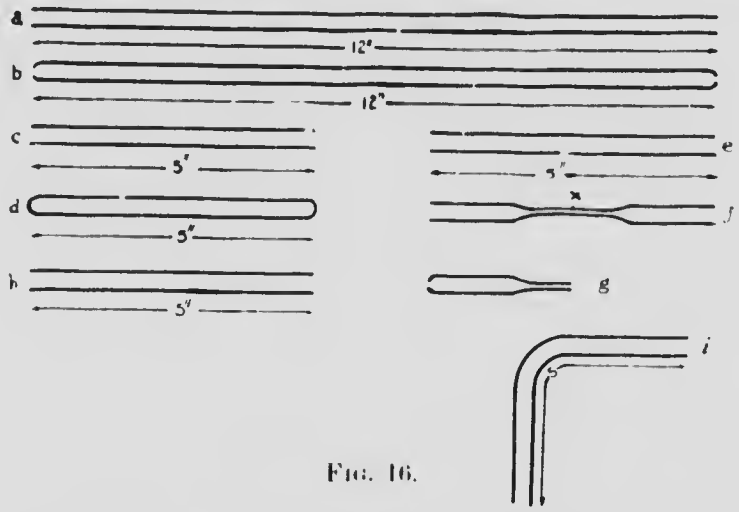

Fig. 16.

(b) Rounding.—Fire-polishing.—Round the sharp corners of a piece of glass tube 12" long (Fig. 16, a) by holding it in the Bunsen flame (Fig. 18), until the edges

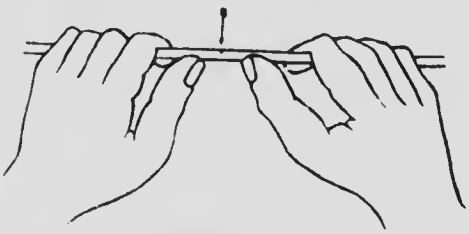

Fig. 17.

soften and just begin to round themselves off. **The tube must be revolved all the time it is being heated.** In this way Fig. 16, b is made. The ends of all glass tubing must be rounded before joining up to rubber tubing or being placed in rubber corks.

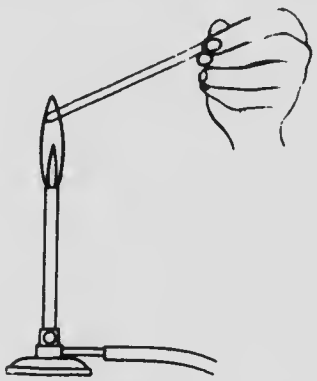

Fig. 18.

(*c*) *Stirring Rods.*—Cut a piece of glass tubing 5″ long (Fig. 16, c). Completely close each end by heating as in Fig. 18, revolving all the time. A stirring rod (Fig. 16, d) will result.

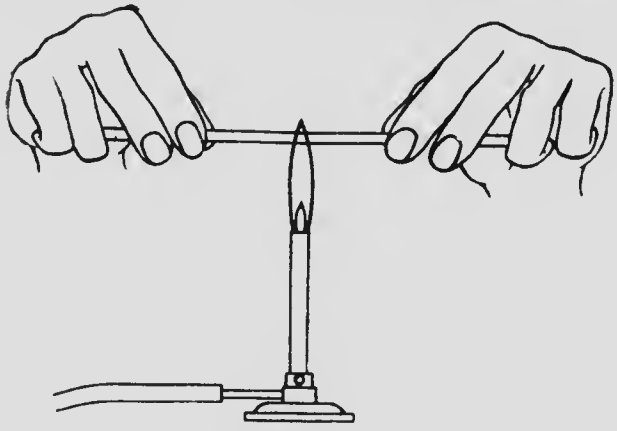

Fig. 19.

(*d*) *Drawing a Jet.* Heat a short piece of glass tubing 5″ long (Fig. 16, e) in the Bunsen flame, as shown in Fig. 19, until quite soft; revolve the tube while heating; remove from the flame and draw out as shown in Fig. 20. Cut at X (Fig. 16, f) and you have two jets (Fig. 16, g). Round (do not close) both ends of the jets. The small opening should be about 1 mm. in diameter.

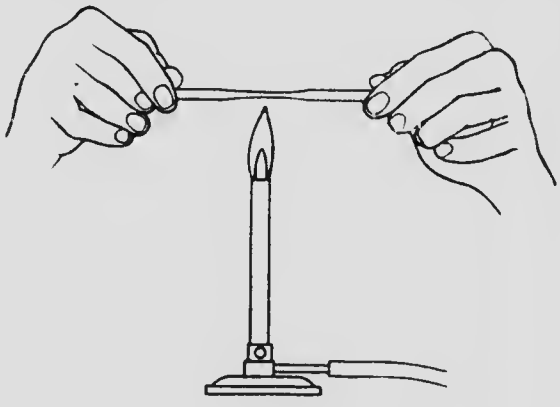

Fig. 20.

(*e*) *Bending.*—Place a wing top on the Bunsen burner and light the burner. Hold a piece of glass tubing 5″ long, (Fig. 16, h), parallel to the wing top and slowly rotate the tubing so that it will heat uniformly (Fig. 21). Heat until quite soft; withdraw from the flame and bend to the required angle (Figs. 22 and 23).

In this way Fig. 16, i is obtained, and it is called an elbow. Round the ends **slightly.**

Show the pieces of tubing you have made to the instructor.

3. Boring Corks. — The use of ordinary (bark) corks is deprecated; but, in case this is necessary, they must frequently be bored for glass tubing. This is effected by means of a cork-borer, or a rat-tail file. In the former case the cork is carefully rolled under foot till soft, a cork-borer is selected slightly smaller than the glass tube, and it is worked through the cork with little pressure and much revolving back and forth. As soon as the hole is finished, the borer is cleaned out. If a rat-tail file is used, the cork is first softened as described above, the tang of the file is thrust through, to give direction to the hole, and then the aperture is enlarged to the required extent by means of the file proper.

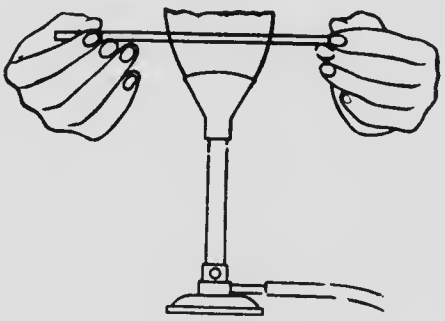

Fig. 21.

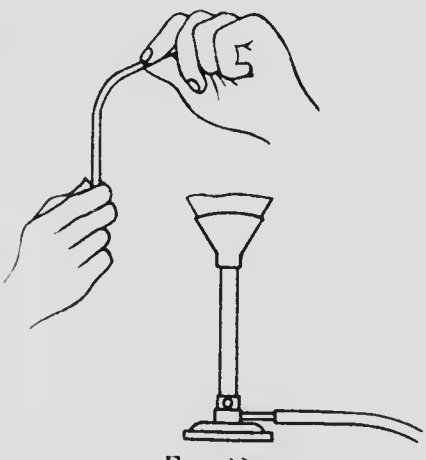

Fig. 22.

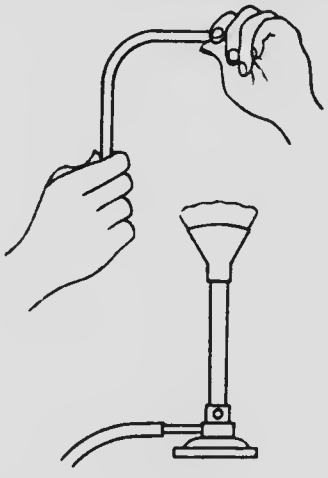

Fig. 23.

4. Construction of Wash-bottle.—The Exercises which follow can be performed without a wash-bottle, but if desired one may be constructed as follows: (Examine Fig. 24). Bend a short tube to the degree indicated, and fire-polish both ends. Draw out the jet on longer tube, about 1½″ from the end, cut it with a file and fire-polish the larger end. **Then** bend the tube at the proper place to the required degree.

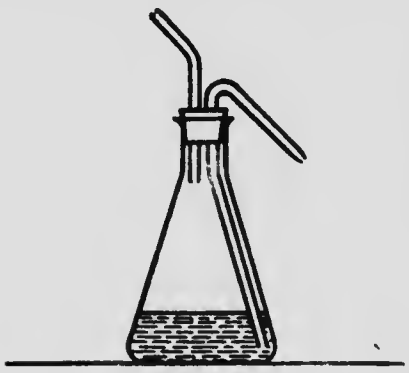

FIG. 24.

5. Making Measuring Tube.—Measure exactly 10 cc. of water into a test tube. Put a mark on a gummed label and fasten the label to the test tube so that the mark is level with the surface of the liquid. This tube will serve as a 10 cc. measure, and smaller quantities can be readily estimated.

It is not necessary to write a report on the above work.

EXERCISE No. II

LABORATORY PRACTICE IN THE USE OF APPARATUS

SUPPLIES.—*Balance and weights, beaker, clamp, watch glass, evaporating dish, elbow, flask, funnel, filter paper, gas bottles, graduate, rubber delivery tube, rubber cork, stirring rod, stand and ring, test tubes, test tube holder, thistle tube, wire gauze.*

Animal charcoal, matches, reagent bottle of liquid.

(Pupils should be familiar with pages on general directions and use of apparatus.)

Sketch.—None.

Experiments.—(1) Heat a piece of match (1″ long) in a test tube as shown in Fig. 7. Observe the cold part of the tube.

(2) Boil 10 cc. of water in a test tube. (Fig. 8.)

(3) Boil 25 cc. of water in a beaker or flask. (Fig. 10.)

(4) Practise pouring from one vessel to another, using a stirring rod. (Fig. 5.)

(5) Into a beaker put 1 grm. of animal charcoal and 15 cc. water. Heat to boiling and filter as in Fig. 5.

(6) Pour some liquid out of one of the reagent bottles into a test tube, holding the cork between the fingers. (Fig. 2.)

(7) Evaporate 25 cc. of water in an evaporating dish. (Fig. 2.)

(8) Set up the apparatus shown in Fig. 28, taking the proper precautions in working with the tubing and corks.

(9) Weigh your evaporating dish and watch glass together. Record result in your notebook.

It is not necessary to write up this exercise.

EXERCISE No. 111

CHANGES ON HEATING CERTAIN METALS IN AIR. OXIDES

SUPPLIES.—*Bunsen burner, fine balance and weights, crucible, pipe clay triangle, rough balance, stand and ring, tongs.*

Powdered magnesium or magnesium ribbon.

Sketch.—Fig. 11.

Experiment.—(1) Clean and thoroughly dry the crucible by heating for a few minutes over the Bunsen flame and allow to cool. (Fig. 11.)

(2) Place in the crucible 1 grm. of powdered magnesium weighed on the **rough balance.**

(3) Weigh the crucible and the magnesium accurately to 1 cg. on the **fine balance** and record result at once. Weight A. (See pages on balances and weighing.)

(4) Support the crucible as shown in Fig. 11.

(5) Heat the uncovered crucible gently at first and finally use the full Bunsen flame for ten minutes.

(6) Allow to cool and as soon as cold weigh. Record weight B.

Observations.—State everything that you observed happen in No. 5 above.

(B) Weight of crucible and white powder after heating ..... grms.

(A) Weight of crucible and magnesium before heating .....grms.

Change in weight caused by heating in air ....grms.

Deductions.—State what you conclude from the above experiment.

Questions.—(*a*) Is the change in weight a gain or a loss in weight?

(*b*) Where does the substance which causes the change come from?

(*c*) State the properties of the magnesium before it was heated.

(*d*) State the properties of the compound obtained by heating the magnesium in air.

(*e*) What is the general name given to the substances obtained by heating in air?

(*f*) What is combustion?

(*g*) Have you any reason to believe that fuels would behave the same as metals on burning? State your evidence.

(*h*) What is the Phlogiston Theory?

Instead of magnesium, zinc, tin, copper or lead may be used.

Clean and **return** any apparatus lent you for the above experiment.

EXERCISE No. IV

LAW OF CONSERVATION OF MATTER

SUPPLIES.—*Balance and weights, 2 glass plugs, two-hole rubber cork, short test tube, thread.*

Barium chloride, calcium chloride, ferric chloride, silver nitrate, sodium carbonate, sodium chloride, sodium hydroxide, sodium sulphate.

Pairs of solutions that may be used for this experiment are :

Barium chloride and sodium sulphate.
Calcium chloride and sodium carbonate.
Ferric chloride and sodium hydroxide.
Silver nitrate and sodium chloride.

Sketch.—Fig 25.

Experiment.—Arrange the apparatus as shown in Fig. 25, the holes in the cork being closed with glass plugs (tubing closed at one end) and the test tube held in place, if necessary, by a thread tied round it just under the flange and passing out through the neck of the flask beside the cork. Remove the test tube from the flask. Prepare a solution of barium chloride by dissolving 1 grm. in 10 cc. of water, and also a solution of sodium sulphate of the same strength. Put one solution into the test tube and the other into the flask. Place the test

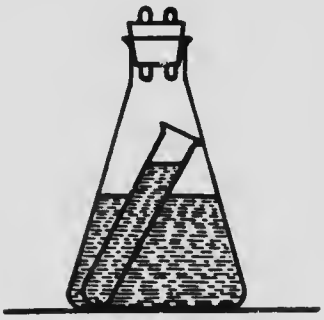

FIG. 25.

tube in the flask, without allowing the two solutions to mix, insert the cork and weigh the whole. Remove from the balance and tip up, so as to mix the two solutions. Weigh again.

Observations.—State your observations regarding weights and chemical reactions.

Deductions.—State your conclusions.

Questions.—(*a*) State the law of conservation of matter.

(*b*) Choose some chemical equation and show how it illustrates this law.

(*c*) What general name is given to the solids formed in the above experiments? (Text, p. 92.)

EXERCISE No. V

SEPARATION OF A MIXTURE OF SALT AND SAND BY SOLUTION

SUPPLIES. *Balance (rough) and weights, 2 beakers, evaporating dish, filter paper, pipe clay triangle, stand and ring, stirring rod, watch glass, wire gauze.*

Mixture of salt and sand, the proportions of its constituents being known to the teacher.

Sketches. Figs. 5 and 12.

Experiment. Weigh on the rough balance 5 grms. of the mixture and put it into a beaker. Treat with 10 cc. of boiling water, stirring with a glass stirring rod tipped with 1 inch of rubber tubing. Allow to settle. Filter through a filter as shown in Fig. 5. Again treat with 10 cc. of boiling water, stirring and filtering as before. Repeat the treatment with boiling water three or four times. It is found that successive small portions of water will more thoroughly remove the salt from the sand than the same quantity of water added in larger portions.

When all the salt is removed (this may be detected by the evaporation in a test tube of a drop of the filtrate obtained from the end of the funnel; if no residue is left, all the salt has been removed), evaporate the filtrate as shown in Fig. 12, using an evaporating dish. When the solid begins to spurt out of the dish, cover with a watch glass and heat very cautiously. When all the water is removed, taste the solid left.

Observations.—State your observations.

Deductions.—State your conclusions.

Questions. (*a*) What is a mixture?

(*b*) Give two other mixtures which could be separated by solution of one of the constituents. Tell how you would make this separation.

(*c*) Mention some mixtures made use of at home.

(*d*) State everything that this experiment has taught you.

Note. This experiment may be made quantitative, if desired, by exactly weighing the quantity of mixture used and by evaporating the filtrate obtained in a weighed evaporating dish with watch glass.

If desired, all the sand may be transferred to the filter paper, which may then be dried and burned in a weighed crucible. Thus the weight of sand may be determined, and so the proportions of the substances composing the mixture may be calculated directly.

EXERCISE No. VI

ELEMENTS, MIXTURES AND COMPOUNDS

SUPPLIES.—*Bunsen burner, magnet, magnifying glass, mortar and pestle, test tube, test tube holder.*

Powdered iron ("by-hydrogen") or filings, flowers of sulphur.

Sketch.—Fig. 8.

Experiments.—Weigh as accurately as possible on the rough balance 3 grms. of flowers of sulphur and 5 grms. of powdered iron. Place the iron and sulphur on separate pieces of paper.

(1) Examine the iron and sulphur. Note their physical properties, i.e., color, hardness, relative weight; (lift a bottle containing iron and one containing about the same volume of sulphur). Examine them with the magnifying glass and with the magnet.

(2) Mix the iron and sulphur carefully in the mortar, grinding them with a rotary motion; study the properties of the material in the mortar, using the magnet and the magnifying glass.

(3) Place half the material contained in the mortar in the test tube and heat (Fig. 8), note what happens. Allow to cool, break the test tube into a **clean mortar** and examine the contents with the magnet and magnifying glass. Compare with Experiment No. 2 above.

Observations.—State all your observations, numbering as above.

Deductions.—State your conclusions, numbering as above.

Questions.—(*a*) Are iron and sulphur on the list of elements?

(*b*) What name would you give to the material obtained in No. 2 above?

(*c*) What name would you give to the substance obtained by heating in Experiment No. 3?

(*d*) Define physical change, chemical change, mixture, compound, element. Give an example of each.

Return any apparatus lent you for the above experiments.

EXERCISE No. VII

OXYGEN

SUPPLIES.—*Bunsen burner, 3 cover glasses, glass elbow, 3 gas bottles, one-hole rubber stopper, hard glass test tube, pneumatic trough, rubber delivery tube, spoon, stand and clamp.*

Charcoal, manganese dioxide, mercuric oxide, potassium chlorate, splints, sulphur, iron tacks or filings, cotton.

Sketch.— Fig. 26.

Experiments. (1) Place 1 grm. mercuric oxide in a hard glass test tube. Heat, holding the tube by means of a test tube holder (Fig. 8). Test the gas which comes off with a glowing splint. Examine the sides of the tube. Allow tube to cool and return any undecomposed mercuric oxide to the stock bottle.

(2) Oxygen can be obtained from substances other than oxides. Fasten a test tube vertically in a clamp; put in 1 grm. of potassium chlorate and heat till it is very evident that a gas is being evolved. Test the gas by inserting a glowing splinter. Stop the heating, and, immediately effervescence ceases, drop in a very little manganese dioxide from the point of a knife-blade. **Be careful that your face is not directly over the tube.**

(3) Mix thoroughly on a piece of paper 6 grms. of potassium chlorate and 4 grms. of manganese dioxide. Place the mixture in a test tube fitted with the elbow, and one-hole cork and delivery tube, as shown in Fig. 26. The pneumatic trough should be filled until the water

starts to run out of the overflow. The overflow should be placed so that it empties into the sink. The gas bottle is made ready for the collection of the oxygen by filling it with water in the trough, turning it bottom up and placing it on the shelf in the trough, always keeping the mouth of the bottle below the surface of the liquid. Heat the test tube gently, holding the burner in your hand (do not heat strongly in one place). Collect 3 bottles of the gas

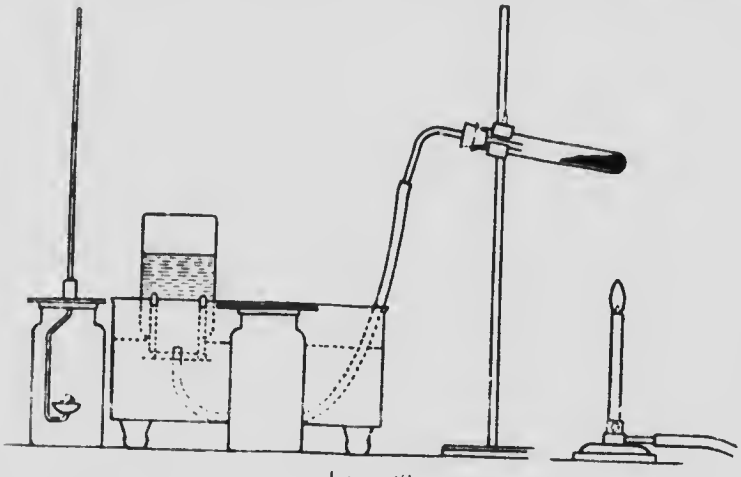

FIG. 26.

and **remove the end of the rubber delivery tube from the trough before you stop heating.** Keep the bottles mouth up, covered with cover glasses.

(*a*) Quickly drop a little piece of wood into a jar of the gas. Note if anything happens.

(*b*) Hold a glowing splint in the same jar as used in (*a*). Note result.

(*c*) Place a piece of charcoal the size of a bean on a deflagrating spoon (tin spoon may be used). Ignite it by means of the Bunsen burner and note how it burns in a bottle of air. Cover the bottle. After burning ceases, pour some lime-water into the bottle and shake.

(*d*) Place glowing charcoal (in a deflagrating spoon) in a jar of oxygen gas. Cover the bottle. Note the result. After the combustion ceases, pour a little lime-water into the jar and shake.

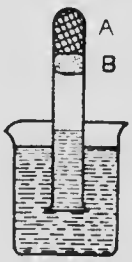

Fig. 27.

(*e*) Using a deflagrating spoon, burn a piece of sulphur the size of a pea in the air and then in the gas. Note result.

(*f*) Place some moistened iron filings in a test tube as shown in Fig. 27. (A, filings; B, cotton.) Note—Use just enough cotton to hold the filings in place and do not plug the tube too tightly. Allow to stand until next day, and examine carefully before removing the tube from the water.

Observations.—Record your observations, numbering as above.

Deductions.—State what you conclude from your experiments, numbering as above.

Questions. (*a*) State some other methods, not mentioned on this paper, for preparing oxygen.

(*b*) What general effect has it on substances which burn?

(*c*) Summarize the physical and chemical properties of the gas (see text-book).

(*d*) Of what importance is this gas?

(*e*) Define combustion, oxidation, oxide, kindling temperature, oxidizing agent. Give an example of each.

(*f*) Why are the bottles kept covered mouth up in the above experiment?

(*g*) Compare 3 (*c*) and 3 (*d*) above.

EXERCISE No. VIII

HYDROGEN

SUPPLIES.—*Bunsen, cover glasses, elbow, flask, 3 gas bottles, 1 ft. glass tubing (preferably hard glass, 6 mm. outside diameter), jet, pneumatic trough, rubber delivery tube, rubber cork (two-hole, to be returned to rack at end of period), thistle tube, wire gauze.*

Dilute sulphuric acid, granulated zinc, one-inch copper wire, splints.

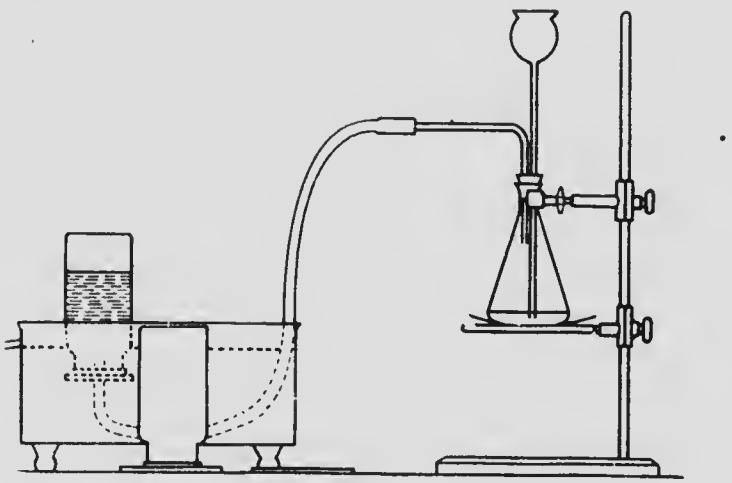

FIG. 28.

Sketches. Figs. 28, 30, 31.

Experiments. Weigh 15 grms. of zinc, hold the flask horizontally and carefully slide the zinc into the flask. **The flask will break if the zinc is dropped into it.** Set up the apparatus as shown in Fig. 28. By means of the graduate, measure 50 cc. of **dilute sulphuric acid** and

pour the acid into one of your beakers. **Place the graduate beside the acid bottle so that some one else will not lose time looking for it.** Pour a little of the acid down the thistle tube so that the bottom of the thistle tube is a little below the surface of the liquid. The gas will begin to come off, and whenever the action gets very slow add **a little more acid** from your beaker.

DANGER. Keep all flames away from the generator and delivery tube.

Collect test tubes of the gas, using the pneumatic trough and test by bringing the mouth of the tube into a flame and noting what happens. When a sample burns quietly it is safe to collect a cylinder of gas, but not before. Collect two bottles of gas.

Testing gas. Follow these directions carefully.

(1) Hold a bottle mouth downwards and thrust a **lighted** splint into the gas bottle and **slowly** withdraw it. Note everything that happens to the splint, the gas and the bottle.

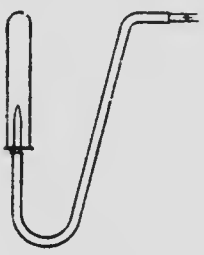

Fig. 29.

(2) Uncover a bottle of the gas, mouth up, for a full minute and then test with a burning splint.

(3) Collect a bottle half full of hydrogen and half full of air (or oxygen). Wrap a towel around it and bring the mouth of the bottle into a Bunsen flame. Note the inner sides of the bottle.

(4) Remove the rubber delivery tube from the generator and shake all the water out of it; replace and put the jet on the end, as shown in Fig. 29. Do not place the end of the jet or rubber delivery tube into the pneumatic trough again. **Wrap a towel around the generator** and

collect test tubes of the gas by upward displacement, as shown in Fig. 29, until you find the gas safe, i.e., till it burns quietly. Light the jet, note carefully the color of the flame; hold a clean, **cold, dry** beaker over the flame (Fig. 30) and note what happens.

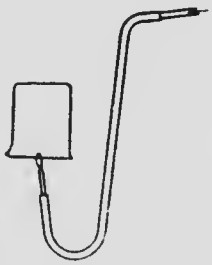

Fig. 30.

(5) Heat the short piece of copper wire by placing it on the corner of your gauze. Note the change in color. Place this wire in the straight hard glass tube and join up to the generator as shown in Fig. 31. Wrap a towel around the generator and, when it is found that the gas is safe, heat the copper compound carefully with the Bunsen flame. Note what happens to the copper compound when heated in a current of the gas. Note the cold part of the tube.

Keep the material in your generator for Exercise No. XIV.

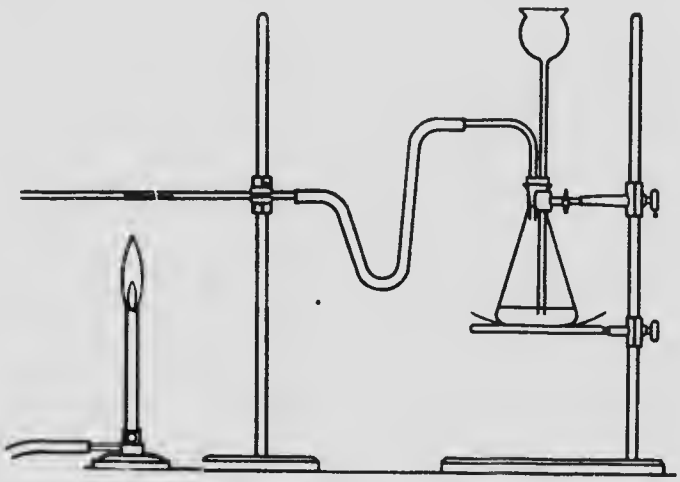

Fig. 31.

Observations.—State what you observed in each of the above experiments, numbering as above.

Deductions.—State what you conclude from each of the a' ve experiments, numbering as above.

Questions.—(*a*) What does the gas combine with when it explodes?

(*b*) Why do we use zinc which has been granulated?

(*c*) Why does the end of the thistle tube almost touch the bottom of the flask?

(*d*) Does the gas come from the acid or the zinc?

(*e*) Write the equation for the action of dilute sulphuric acid on zinc. (Text.)

(*f*) What do you call the copper compound obtained by heating copper in the air?

(*g*) What name is given to the reaction in (5) when the substance was heated in the current of hydrogen gas?

(*h*) Write the equations for the reactions in (5) above.

EXERCISE No. IX

GASES, No. 1

To Determine the Volume of Gas Liberated by the Action of an Acid on a Definite Weight of Metal

SUPPLIES.—*Barometer, battery jar or hydrometer jar, glass cup (piece of tubing 6 mm. outside diameter and 2 cms. long, sealed at one end), graduated gas-measuring tube, iron stand and clamp, mortar, thermometer.*

Magnesium ribbon, sulphuric acid (dilute 1:5).

The magnesium ribbon may be cleaned with fine sand-paper, and then pieces of exactly the same length cut from it—this facilitates weighing. If the same weight is used by all pupils, the volumes of gas obtained may be tabulated, and the mean of all the readings may be used for working out the final result.

Sketch.—Fig. 32, A.

Experiments.—Set up the apparatus as shown in Fig. 32.

(1) Fill the mortar three-fourths full of water.

(2) Half fill the gas-measuring tube with water and then completely fill to the top with dilute sulphuric acid (1:5).

(3) Place your first finger over the end of the tube and invert it in the mortar. When your finger is below the surface of the water in the mortar it may be removed. Rinse your finger.

(4) Clamp the tube in place, having the tube close to the side of the mortar as shown in Fig. 32, A.

(5) Place an accurately weighed piece of clean magnesium ribbon (about .04 grm. for a 50 cc. tube) in the glass cup, and fill the glass cup with water.

(6) Quickly place the mouth of the cup into the opening of the measuring tube and be sure not to lose any of the gas evolved.

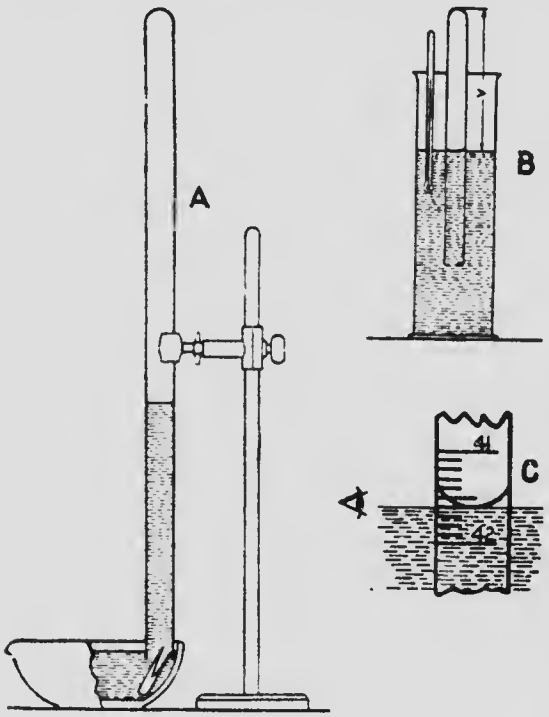

FIG. 32.

(7) When all the gas is evolved, place your finger over the mouth of the measuring tube and transfer it to the hydrometer jar, being careful not to allow any water to run out of the tube while transferring.

(8) Allow the gas to take on the temperature of the jar and then, having the level of the water inside and outside the tube the same, measure the volume of the gas as shown in Figs. 32, B, and C, noting the temperature of the water, i.e., the temperature of the gas.

(9) Note the barometric pressure.

(10) Subtract the pressure of the water vapor from the barometric pressure to get the true pressure under which the gas was measured. (**This may be omitted except in very exact work.**)

(11) Calculate the volume of gas obtained from the weight of magnesium used at S.T.P. (Standard Temperature and Pressure.)

(12) Calculate the volume of gas you would obtain at S.T.P. if you used 24 grms. of magnesium ribbon.

Observations.—State your observations obtained in Nos. 5, 8, 9, and 10.

Deductions.—State your deductions from Nos. 11 and 12.

Questions. (*a*) Write the equation for the reaction involved in this experiment.

(*b*) Why is the apparatus entirely filled with water?

(*c*) What is meant by G.M.V.?

(*d*) How does your calculated volume of gas liberated by 24 grms. of Mg. compare with the theoretical result?

(*e*) What is Avogadro's Hypothesis?

This experiment illustrates the law of definite proportions.

EXERCISE No. X

GASES, No. 2

Determination of the Weight of a Litre of Oxygen

SUPPLIES *Balance and weights, barometer, Bunsen burner, graduate, glass tubing especially bent, hard glass test tube, two-hole cork to fit bottle, pinch cock, 2 one-litre bottles, rubber tubing, thermometer.*

Potassium chlorate.

Sketch. Fig. 33.

Experiment. (1) Weigh the hard glass tube containing about 2.7 grammes of potassium chlorate. (Wt. X.)

(2) Fit up the apparatus as shown in Fig. 33.

Before starting the experiment, the following precautions must be taken:

(*a*) The apparatus must be tight. Before filling with water, any leak can be readily detected by placing a little water on the joints of the apparatus and blowing through the tube 'C.'

(*b*) The bottle 'A' should be filled with water to within one inch of the bottom of the cork.

(*c*) The tubing 'C' connecting Bottle 'A' to Bottle 'B' must be entirely filled with water; it may be kept filled by closing the pinch cock. A rubber tube may be used instead of glass tube 'C' if desired.

(*d*) The bottle 'B' should be empty at the beginning of the experiment.

(3) Open the pinch cock and **gently heat** the test tube so as to obtain a **slow** evolution of the oxygen gas. Finally, heat the test tube strongly all round.

(4) **Precautions to be taken before measuring the gas:**

(*a*) Allow the apparatus to cool; when this has taken place can readily be determined by carefully touching the test tube with the hand.

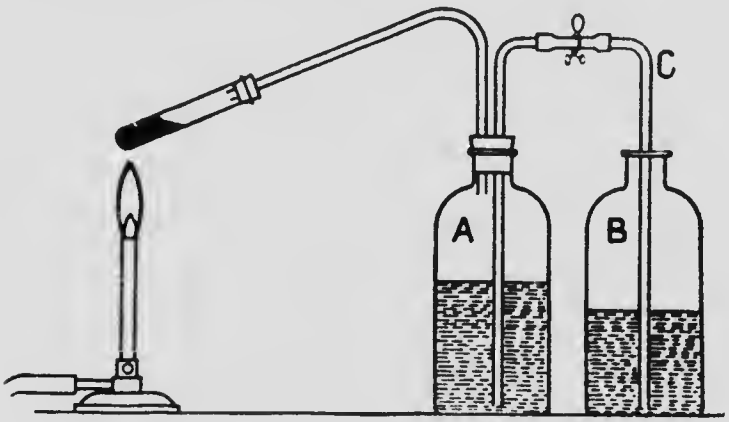

FIG. 33.

(*b*) The pinch cock should be open during cooling and the delivery tube 'C' below the water in Bottle 'B.'

(*c*) Bring the surface of the water in 'B' on a level with the surface of the water in 'A' by raising one or other of the bottles. Hold it there **for a minute** and **then** close the pinch cock.

(5) Weigh the test tube. (Wt. Y.)

(6) Place a thermometer in Bottle 'A' to get the temperature of the water, i.e., of the gas. (t.)

(7) Measure the volume of the water in 'B.' This gives the volume of gas liberated. (V.)

(8) Note the barometric pressure.

(9) (**This may be omitted except in very exact work.**) Consult the table for the vapor pressure of water. Subtract the vapor pressure of the water at the temperature at which the gas was measured from the barometric pressure. This gives the true pressure of the gas.

(10) Using the figures obtained in Nos. 6, 7 and 9, calculate the volume of gas at Standard Temperature and Pressure (S.T.P.).

(11) Calculate the weight of 1 litre of oxygen.

Observations.— (1) Weight of test tube and potassium chlorate before heating ..... grms. (X)

(5) Weight of test tube and potassium chloride after heating ..... grms. (Y)

Therefore, weight of oxygen measured, (X-Y) ...grms.

(6) Temperature at which gas was measured.....(t)

(7) Volume of gas obtained ..... cc.

(8) Barometric pressure ..... mm.

(9) Corrected pressure ..... mm.

Deductions.— (10)- Calculated volume at S.T.P.

(11) Calculated weight of 1 litre of oxygen.

Questions.—(*a*) How could you slightly modify the above experiment so as to determine the percentage of oxygen in the potassium chlorate?

(*b*) What would be the molecular weight of oxygen according to the figures obtained above?

(*c*) State Boyle's Law.

(*d*) State Charles' Law.

EXERCISE No. XI

WATER

SUPPLIES.— *Beakers, Bunsen burner, cork (two-hole, rubber), glass elbow, flask, cover glasses, long glass tube (three feet), pneumatic trough, short piece of rubber tubing, test tubes, test tube holder, thermometer.*

Calcium chloride (anhydrous), copper sulphate, distilled water, fruit, meat, potato, sodium sulphate crystals, tap water, wood.

Sketch.—Fig. 34.

Experiments.– (1) Heat gently a piece of match as shown in Fig. 7, holding the tube horizontally. Note what happens and observe the cold pa t of the tube. Repeat, using potato, fruit and meat. Use only very small pieces or you will lose a great deal of time.

(2) Place 50 cc. of distilled water in a **clean** beaker, Examine the color, odor, taste. Carefully evaporate 2 or 3 drops to dryness in a **clean** test tube. Note any residue.

(3) Repeat No. 2, using the same quantity of tap water.

(4) Set up the apparatus as shown in Fig. 34.

The thermometer bulb should be one inch above the liquid in the flask.

Fill the pneumatic trough with water and hold the test tube in the water by means of a test tube holder. Place 2 grms. of copper sulphate in the flask and 50 cc. of tap water, noting temperature at which the liquid boils. Distil 5 cc. of liquid into the test tube and compare it with the liquid in the flask.

CAUTION. When the test tube containing the distilled water is removed from the trough, do not allow the end of the long glass tube to get into the water in the trough. The water may be sucked back into the flask and the latter be shattered.

(5) Set out on a piece of cover glass (*a*) 2 or 3 crystals of sodium sulphate; (*b*) two or three pieces of calcium chloride. Place them in your locker and examine next laboratory period.

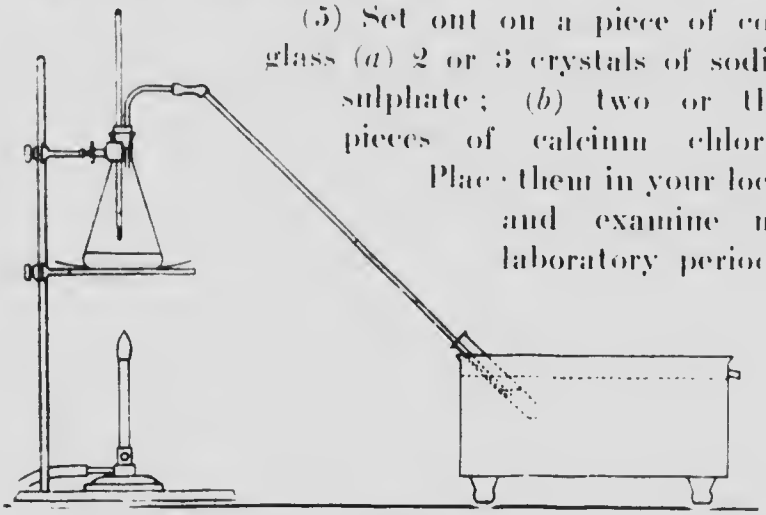

FIG. 34.

Observations. State what you observed, numbering as above.

Deductions.—State what you conclude from your observations, numbering as above.

Questions.—(*a*) Why does tap water differ from distilled?

(*b*) Which is purer, filtered or distilled water? Why?

(*c*) Give reasons for using metal instead of glass for larger scale distilling apparatus.

(*d*) Define Filtrate, Distillate, Fractional Distillation.

(*e*) How could a mixture of oils of different boiling points be separated?

(*f*) How could the distilled water be rendered more palatable?

EXERCISE No. XII

SOLUTION No. 1

(Half the class to do this while the other half does Solution No. 2. Consult Solubility Tables

SUPPLIES.—*Beakers, Bunsen burner, iron stand and ring, mortar and pestle, rough balance and weights, test tube, test tube holder, wire gauze.*

*Ammonium hydroxide, alcohol, crystals of ammonium carbonate, calcium oxide, *ether, kerosene, *olive oil, potassium chlorate, sugar, *soap solution, tartaric acid.*

Sketch.—None.

Experiments. (1) Examine the sodium sulphate and calcium chloride set out last laboratory period. Record your observations and conclusions.

(2) Place in the test tube rack separate test tubes containing 2 grms. of each of the following: **Finely powdered:** sugar, potassium chlorate, calcium oxide (lime). Add exactly 10 cc. of water to each, shake occasionally and examine at the end of the lesson. Note any differences in solubility.

(3) Mix 1 grm. of powdered tartaric acid with 1 grm. of powdered sodium carbonate in a **dry beaker.** Note what happens. Then add water. Observe what happens.

(4) Put 5 cc. of water in a test tube and add **a few drops** of ammonia, just sufficient to produce an appreciable odor in the tube. Boil for a few minutes and again smell.

(5) Place 25 cc. freshly drawn tap or spring water in a beaker; heat on a wire gauze. Note the bubbles that form long before the water boils.

(6) Pour 2 cc. of alcohol into a test tube and add the same quantity of water, shake and note what happens.

(7) Place 2 cc. of kerosene in a test tube and pour in the same quantity of water, shake and note what happens.

*(8) Put 2 or 3 drops of olive oil into a test tube and shake with water. Note result. Add some soap solution and shake vigorously; note result. This is called an emulsion—consult dictionary, or some other book of reference.

*(9) Put 2 or 3 drops of olive oil in a test tube and add a little ether. Shake and note what happens.

Observations.—State your observations, numbering as above.

Conclusions.—State your conclusions, numbering as above.

Questions.—(*a*) Is a solution a compound or a mixture?

(*b*) Why are so many substances used in solution in the chemical laboratory?

(*c*) What is (1) soda water? (2) ammonia water?

(*d*) State an experiment to show that all solids do not dissolve to the same extent in liquids.

*(*e*) What is an emulsion? What is a tincture?

(*f*) Are colorless liquids always safe to drink? Give reason for your answer.

*Parts starred on this paper may be omitted if desired.

EXERCISE No. XIII

SOLUTION No. 2

(To be used while half the class is doing Solution No. 1.)

To Determine the Solubility of Common Table Salt in Water

SUPPLIES. *Bunsen burner, beaker, evaporating dish, funnel, filter paper, fine balance and weights, stand and ring, stirring rod, thermometer, watch glass, wire gauze.*

Sodium chloride (ordinary table salt).

Sketch. -Fig. 12.

Experiment. While your partner is weighing the evaporating dish and watch glass together, prepare the salt solution as follows:

Place 10 grms. of salt, roughly weighed, in a beaker and add 20 cc. of water. Place the beaker on the wire gauze and boil one minute; remove from the gauze and stir thoroughly so as to get all the salt possible in solution. **Cool by holding the beaker under the tap until the temperature is 20°C.** Do not allow any tap water to get into the beaker. When cool, filter through a **dry** filter paper into a beaker. When your partner has weighed the dish and watch glass, add the filtered salt solution to the evaporating dish and weigh again (with watch glass, of course). Place the covered dish on the wire gauze and evaporate to dryness (Fig. 12). When all the moisture has been driven off the bottom of the watch glass you may stop heating. Cool and weigh. Keep the

watch glass on the dish all the time, never remove it, you may lose some material if you do.

Observations.—(A) Weight of dish and watch glass .....grms.

(B) Weight of dish, watch glass, water and salt..grms.

Subtract; B-A gives the weight of salt and water (X) .....grms.

(C) Weight of dish and watch glass and salt ....grms.

Subtract; C-A gives the weight of salt (Y) .....grms.

X-Y gives weight of water (Z) .....grms.

Calculate weight of salt in 100 grms. of water.

Deduction.- State what you conclude to be the solubility of salt in water at the room temperature.

Questions.- (*a*) Can you suggest any way of determining the quantity of solids in solution in mineral waters?

(*b*) What effect has temperature on the solubility of (1) a solid in a liquid? (2) a gas in a liquid?

(*c*) What effect has pressure on the solubility of a gas in a liquid?

EXERCISE No. XIV

CRYSTALLIZATION

SUPPLIES.—*Bunsen burner, beaker, evaporating dish, filter paper, funnel, magnifying glass, stand and ring, stirring rod, triangle.*

The material left in the hydrogen generator (Exercise IX), sodium chloride.

Sketches.— Figs. 5 and 12.

Experiments.— (1) Examine the liquid in the generator, and if you notice any crystals, remove them by means of a glass rod. . If you have any difficulty in doing this, empty the contents of the flask into your evaporating dish. Dry some of the crystals carefully, by placing between filter paper, and examine under the magnifying glass. If you have carried out the experiment on Hydrogen with the quantities indicated and allowed your generator to stand for some days, it should contain crystals. However, if your own generator does not contain any crystals, obtain some from another generator. Examine the color, hardness, shape, size of the crystals.

(2) Whether your generator contains crystals or not, warm the contents of your generator and filter (Fig. 5).

(3) Evaporate (Fig. 12) **until you notice that the solids begin to crystallize** at the edge of the evaporating dish, stop heating and allow to cool. Examine what

forms. Dry a few crystals between filter paper. Examine under the magnifying glass. Note color, hardness, shape, size.

(4) Allow the uncovered evaporating dish to stand in your locker until next day and examine again.

(5) Examine crystals of table salt. Compare with the crystals you prepared.

Observations.—State what you observed in the above experiments, numbering as above.

Deductions.—State what your observations lead you to conclude, numbering as above.

Questions.—(*a*) Define a crystal.

(*b*) What crystalline systems are there? (Consult text or encyclopædia.)

(*c*) Where does the substance obtained above come from? What is the name of the substance? Write its formula (see book).

EXERCISE No. XV

WATER OF CRYSTALLIZATION

Determination of the Percentage of Water of Crystallization in Barium Chloride

(This method is applicable to copper sulphate, but more careful heating is required.)

SUPPLIES.—*Beaker, Bunsen burner, balance and weights, crucible, crucible tongs, stand and ring, triangle.*
Barium chloride.

Sketch.—Fig. 11.

Note.—In order to finish in time, one member of a pair may weigh the barium chloride on the rough balance while the other member is getting the crucible weighed. It is not necessary to use the crucible lid in this experiment.

Experiments.—(1) Place the crucible on the pipe clay triangle and warm gently. Allow to cool and weigh as accurately as possible. (Note.—The crucible must not be touched with the hands, the crucible tongs should always be used to move the crucible.) Weigh roughly about 1.5 grms. of barium chloride crystals on the rough balance, and place the weighed crystals in the crucible. Weigh the crucible and crystals again as accurately as possible. Place the crucible on the pipe clay triangle (Fig. 11), and heat gently at first, gradually raising the temperature to a dull red heat, and keep at this temperature for fifteen minutes. Cool by placing the crucible on the wire gauze and weigh again as accurately as possible as soon as cold.

If time permits, heat again for five minutes and again weigh; these two weights shc ld agree; if not, heat again until you get two weighings which do. This will show when all the water has been driven off.

(2) After the above experiment is finished, examine the material in the crucible and compare it with the crystals weighed in the beginning. Note any difference.

(3) Put about 5 cc. of water into a beaker and dissolve the anhydrous barium chloride in the water; set the uncovered beaker in your cupboard until next day, when you can again examine the material and compare with the crystals weighed at first. What do you note?

Observations.—(A) Weight of crucible alone....grms.

(B) Weight of crucible and barium chloride crystals .....grms.

Subtract; then B-A gives weight of barium chloride (X). .....grms.

(C) Weight of crucible and barium chloride after heating..... grms.

Subtract; then C-A gives weight of barium chloride after heating (Y)..... .....grms.

Subtract; X-Y gives weight of water lost by crystals .....grms.

Deductions.—State what you conclude to be the percentage of water of crystallization in barium chloride. Tabulate your result with those of your classmates and state what you conclude.

Questions.—(*a*) How do your conclusions support the law of definite proportions?

(*b*) Define water of crystallization, anhydrous, deliquescent, effervescent, saturated solution. Consult other text-books or dictionary.

EXERCISE No. XVI

HYDROGEN PEROXIDE

SUPPLIES.—*Beakers, test tubes and rack.*

Hydrogen peroxide, hydrogen sulphide solution, lead acetate solution, manganese dioxide, splints, substances to bleach.

Sketch.—None.

Experiments.—(1) Place in a test tube 5 cc. of hydrogen peroxide and add 1 grm. of manganese dioxide. Note what happens. Test with a glowing splint.

(2) Write on a piece of paper with the pointed end of a match dipped in lead acetate solution. Hold the writing over hydrogen sulphide solution until it darkens. The hydrogen sulphide will be found in the draught cupboard. Brush over the darkened writing with hydrogen peroxide and observe what happens.

(3) Place 10 cc. of hydrogen peroxide in a beaker and add ammonium hydroxide until oxygen gas begins to come off. Then **partly immerse** a few pieces of hair in this solution, allow to remain several minutes, rinse and compare the immersed part with the part which has not been immersed.

(4) Try the bleaching action of peroxide on other substances, such as colored feathers, etc.

Observations.—State what you observed in above.

Deductions.—State what you conclude from your observations.

Questions.—(*a*) Write the equation for preparation of hydrogen peroxide.

(*b*) Write the equation, showing how the hydrogen peroxide decomposes.

(*c*) What action has the manganese dioxide in Experiment No. 1?

(*d*) Tabulate the physical and chemical properties of hydrogen peroxide; also state its uses.

EXERCISE No. XVII

LAW OF DEFINITE PROPORTIONS

To determine whether a certain weight of Sodium Bicarbonate always yields the same amount of Sodium Chloride.

SUPPLIES.—*Bunsen burner, balance and weights, evaporating dish, gauze, stand and ring, watch glass.*

One grm., accurately weighed, of sodium bicarbonate, concentrated hydrochloric acid.

Sketch.—Fig. 12.

Experiment.—(1) Weigh your watch glass and evaporating dish together.

(2) Place the weighed portion of sodium bicarbonate in the dish, add 2 cc. of water and carefully add 2 cc. of concentrated hydrochloric acid to the **covered dish,** pouring the acid down the lip of the evaporating dish so as not to lose any material. When a drop of acid causes no further effervescence, sufficient acid has been added. Place the covered dish on the wire gauze. Evaporate to dryness. (Fig. 12.) Weigh.

(3) Calculate the weight of salt obtained from 1 grm. of sodium bicarbonate. Tabulate your result with the results obtained by others.

(4) Taste the substance left in the dish.

Observations.—State what you observed happen in the above:

(1) Weight of dish and watch glass.....grms.

(2) Weight of dish, watch glass and salt.....grms.

Therefore weight of salt from 1 grm. of sodium bicarbonate is.....grms.

Deductions. State what your result leads you to conclude.

Questions. (*a*) Write the equation to show the reaction of hydrochloric acid on sodium bicarbonate.

(*b*) What is the name of the gas evolved?

(*c*) State the law of definite proportions. Have you any evidence to support this law?

EXERCISE No. XVIII

ATOMIC WEIGHT OF COPPER

To find the Weight of Copper which will combine with 16 parts of Oxygen. (An indirect method.)

SUPPLIES.—*Balances and weights, Bunsen burner, evaporating dish, stand and ring, watch glass, water bath, wire gauze.*

Copper foil, nitric acid.

Note.- It is recommended that *weighed* pieces of foil or of fine copper wire be given to the pupils so as to lessen time required for weighing.

The copper dissolves in nitric acid thus:

$$3Cu + 8HNO_3 = 3Cu(NO_3)_2 + 4H_2O + 2NO.$$

On heating, the copper nitrate gives black copper oxide:

$$Cu(NO_3)_2 = CuO + 2NO_2 + O.$$

So the copper has been converted into black copper oxide.

Sketch.—Fig. 13.

Experiment.—Place the weighed piece of copper, about ½ grm. (A), in the weighed evaporating dish (and watch glass) (B).

Keep the dish carefully covered and add some nitric acid (5:3), by means of the lip of the evaporating dish, just sufficient to dissolve the copper foil (about 5 cc.). Warm gently, and when the foil has dissolved place the

uncovered dish on a water bath and evaporate to dryness (Fig 13). (This may be more quickly done over a naked flame, but the dish must then be partly covered and great care is required to prevent loss.) Cover the dish, remove from water bath and heat the dried dish on the wire gauze until no more brown fumes come off. Cool and weigh (C).

Observations. State what you have observed above.

A. Weight of copper ..... grms.

B. Weight of watch glass and evaporating dish ..... grms.

C. Weight of dish, watch glass and copper oxide ..... grms.

Subtract, C-B and we get the weight of copper oxide Y) ..... grms.

Subtract, Y-A. This is the weight of oxygen which combines with A. grms. of copper.

Deductions. Calculate the weight of copper which combines with 16 parts of oxygen. Compare your result with the atomic weight of copper.

Question. Black copper oxide gives on analysis the following:

Copper, 79.99%; oxygen, 20.01%. Find the atomic ratio and write the formula — Cu. 63.6; O. 16.

EXERCISE No. XIX

CHLORINE

lasses, flask, ... *gauze, two-hole* ...

... *cotton, filter paper,* ... *dioxide,* ... *turpentine*

Sketch.—

Experiments. ... **experiments must be performed entirely in the draught cupboard.**

Arrange the apparatus as shown in Fig. 35, care being taken that ... is correctly placed and that ... down into the gas bottle. ... very ... joined to the elbow by a ... piece of rubber tubing.

... cc. of concentrated hydrochloric ... 15 grams of manganese dioxide (in small ... attempt to pour the manganese dioxide ... tube. Remove the cork and put the ... the flask. Apply a **gentle** heat.

1. Introduce a burning candle into a bottle of chlorine. Note what happens.

2. Place a few drops of hot turpentine on some filter paper and then introduce the filter paper into a bottle of chlorine. Note what happens.

(3) Place a piece of colored cloth, **half of which has been moistened,** in a jar of chlorine. Note what happens to the cloth. Compare the wet with the dry portion. Place a piece of filter paper moistened with ink in a jar of chlorine. Note result.

(4) **Sprinkle** a **little** powdered antimony into a jar of chlorine. Note result.

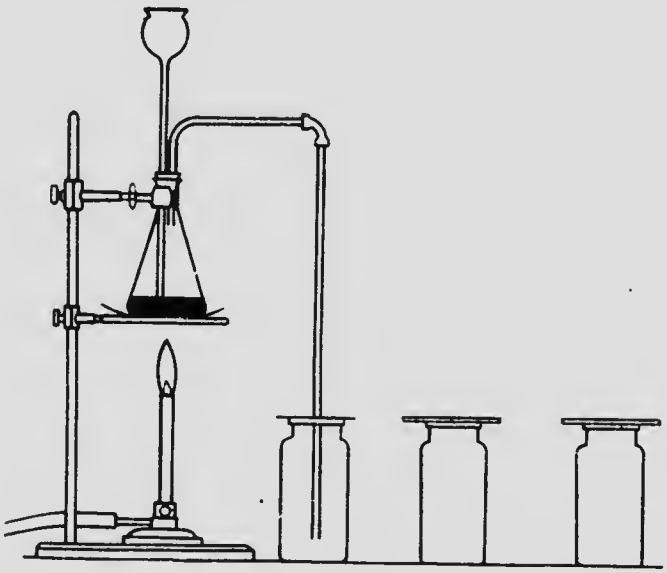

FIG. 35.

(5) Half fill a test tube with **cold** water. Bring the end of the delivery tube below the surface of the water and pass chlorine gas into the liquid for some time. Note the odor of the water. Cork and set the test tube away in the dark until next lesson.

Observations.— State your observations.

Deductions.— State your conclusions.

Questions.—(*a*) Write the equation representing the preparation of chlorine from common salt.

(*b*) What part does water take in the bleaching of the cotton? (Consult book.) Write an equation to make your answer clear.

(*c*) Can you find a reason from Experiment No. 5 for not collecting chlorine over a pneumatic trough?

(*d*) Why is **cold** water used in Experiment No. 5?

(*e*) Do you know of any gas other than oxygen which supports combustion?

(*f*) Why does the candle not burn brightly in Experiment No. 1?

(*g*) What compound of antimony is formed in Experiment No. 4?

(*h*) Is chlorine an active or an inactive element?

Clean out your flask in the draught cupboard. If any manganese dioxide sticks to the glass, it may be cleaned by rinsing with hot concentrated hydrochloric acid. Allow plenty of water to run so as to wash all the acid out of the plumbing.

EXERCISE No. XX

HYDROCHLORIC ACID

SUPPLIES.—*Bunsen burner, flask, thistle tube, glass elbow and glass delivery, short rubber connecter, gas bottles, stand, ring, clamp, wire gauze, two-hole cork.*

Ammonium hydroxide, sodium chloride, sulphuric acid (11:8), litmus, silver nitrate solution, bench reagent bottle of hydrochloric acid, candle on a wire.

Sketches.—Figs. 35 and 36.

All work must be carried out in the draught cupboard.

Experiments.—Set up the apparatus as shown in Fig 35. Place in the flask 15 grms. of sodium chloride and carefully pour down the thistle tube 25 cc. of sulphuric acid (11 : 8), to be found in a specially labelled bottle. Remove the flask from the stand and shake to make sure that the entire bottom of the flask is wet **on the inside with acid. Warm gently with a small flame.** Collect 3 bottles of the gas. You can detect when the bottle is full of gas by holding a rod moistened with ammonium hydroxide above the mouth of the bottle.

(1) Note color and, very carefully, the odor, etc.

(2) Place a burning candle in a bottle of the gas. Note what happens.

(3) Fill the sink on your work-beneh with water and hold the mouth of a bottle filled with the gas below the surface of the water. Note what happens.

(4) Place some litmus solution or a piece of moistened blue litmus paper in a bottle of the gas. Note the color change.

(5) Moisten a glass rod with ammonium hydroxide and hold the rod in the gas. Note what happens.

(6) Put 25 cc. water in a gas-bottle and place the glass delivery tube **not more than an eighth of an inch** below the surface of the water. Pass the gas into the water and note the currents set up (Fig. 36). Note the odor of the solution and compare with the odor of the hydrochloric acid in the reagent bottle.

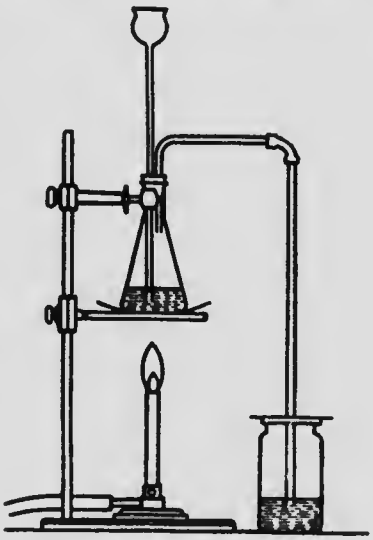

Fig. 36.

(7) Add a **few drops** of silver nitrate solution to 3 cc. of the solution of the gas in the test tube. Shake and heat. Note what happens.

(8) Add a **few drops** of silver nitrate solution to **a few drops** of dilute hydrochloric acid solution (bench). Shake and heat. Note what happens. This is the test for hydrochloric acid.

Empty and rinse your flask in the draught cupboard.

Wash chemicals out of the plumbing.

Observations.—Dictate what you observed.

Deductions.—Dictate your conclusions.

Questions.—(*a*) Does the method of collecting the gas lead you to believe that the gas is heavier or lighter than air?

(*b*) State the physical and chemical properties of the gas.

(*c*) Could hydrochloric acid be collected over a pneumatic trough?

(*d*) Could you live in an atmosphere of the gas? Give a reason for your answer.

(*e*) Define precipitate. Give an example.

(*f*) Write the equation for the reaction in Experiment No. 8.

(*g*) Write the equation for the interaction of common salt and sulphuric acid.

(*h*) Why is the delivery tube placed only one-eighth inch below the water in No. 6?

EXERCISE No. XXI

BROMINE

SUPPLIES.—*Beaker, Bunsen burner, clamp, pneumatic trough, retort, stand, test tubes, thistle tube.*

Carbon bisulphide, chlorine water, manganese dioxide, potassium or sodium bromide, sulphuric acid (dilute), cotton to bleach.

Sketch.- Fig. 37.

Experiments.- Weigh 1 grm. of potassium or sodium bromide, 2 grms. of manganese dioxide and place them in a **dry retort.** Add by means of a thistle tube 20 cc. of dilute sulphuric acid (11:8). Arrange the apparatus as shown in Fig. 37. Warm gently until no more bromine is given off. Cool the test tube in the pneumatic trough by pouring water over it.

1) Note the state, the color and (carefully) the odor.

2) Empty the bromine into a beaker containing a little water, test its bleaching properties, using a piece of colored cotton.

3) Add a little chlorine water to a solution of potassium or sodium bromide contained in a test tube. Note what happens. Add a little carbon bisulphide, shake well and note the result. **Keep all flames away from the carbon bisulphide.**

4) Keep the bromine water corked up and in the dark until next lesson.

Observations.—State your observations.

Deductions.—State your conclusions.

Questions.—(*a*) Write the equation for the preparation of bromine.

(*b*) Write the equation for the action of chlorine water on potassium or sodium bromide.

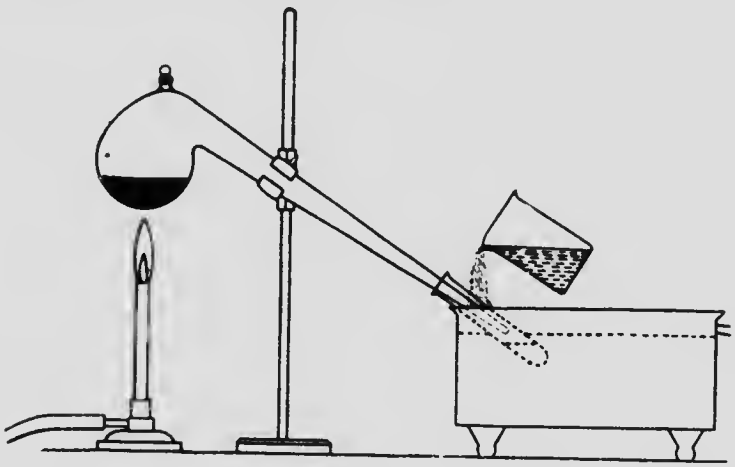

FIG. 37.

(*c*) What does the word "bromine" mean?

(*d*) Compare the solubility of bromine in water with its solubility in carbon disulphide.

(*e*) Compare the bleaching action of bromine with the bleaching action of chlorine.

Note. Do not get any acid or bromine into the trough. If you do, rinse immediately. Do not get any bromine on your hands.

EXERCISE No. XXII

IODINE

SUPPLIES.—*Bunsen burner, large test tube, beaker, mortar and pestle, test tube rack, test tubes, test tube holder, thistle tube.*

Alcohol, bromine water, carbon bisulphide, iodine, manganese dioxide, potassium or sodium iodide, sulphuric acid (dilute), starch.

Sketch.—Fig. 38.

Experiments.—(1) Prepare some iodine: place grm. of potassium or sodium iodide and 1 grm. of manganese dioxide in a dry test tube, and add by means of the thistle tube 10 cc. of sulphuric acid, being careful that the acid does not wet the top of the test tube. Clamp the test tube to the iron stand, place a clean dry beaker inverted over its mouth and heat gently **in the draught cupboard** (Fig. 38). Revolve the beaker while heating. Note the violet vapors produced. Examine the crystals obtained in the beaker.

(2) Remove, if possible, some of the iodine crystals found in the beaker and in the mouth of the test tube by means of a stirring rod. If you are unable to do this, procure some crystals from the instructor. Place the crystals in the bottom of a clean, dry test tube and heat gently as in Fig. 7. Note what forms in the cool part of the tube.

(3) Try the solubility of iodine in alcohol. Keep solution for Experiment No. 5.

(4) Try the solubility of a crystal of iodine in potassium iodide and water. Keep solution for Experiment No. 5.

(5) Try the action of starch solution on the iodine solutions prepared in Experiments Nos. 3 and 4. *This is the test for iodine.* Starch solution is prepared by grinding in cold water a piece of starch the size of **a bean,** diluting to 150 cc. with water and boiling until clear. If there is no starch solution on the bench, prepare some as above.

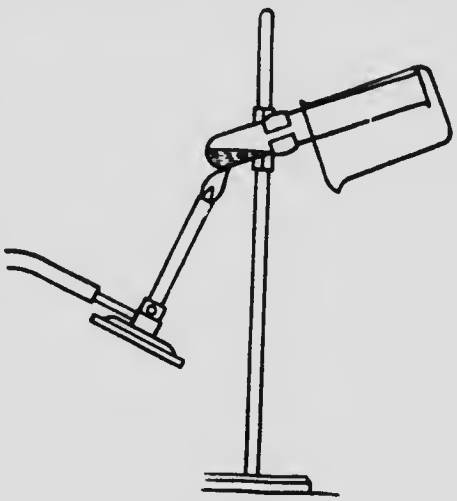

FIG. 38.

(6) Try the action of bromine water (prepared last lesson) on some sodium iodide solution. Note what happens. Add a little carbon bisulphide and shake. Note what happens.

Observations.—State your observations.

Deductions.—State your conclusions.

Questions.—(*a*) Write equations to show the preparation of iodine.

(*b*) What is the test for iodine?

(*c*) What is the test for starch?

(*d*) What is tincture of iodine?

(*e*) What is sublimation?

(*f*) Write under each other the equations for preparing chlorine, bromine and iodine, also for preparing hydrochloric, hydrobromic, hydriodic and hydrosulphuric acids. Do you notice any similarities?

EXERCISE No. XXIII

ACIDS, BASES, SALTS

SUPPLIES. —*Bunsen burner, evaporating dish, stand and ring, stirring rod, test tubes, test tube holder, test tube rack, wire gauze.*

Ammonium hydroxide, baking soda, cream of tartar, hydrochloric acid, lemon juice, lime-water, litmus paper (both colors), nitric acid, potassium hydroxide, sodium chloride, sodium hydroxide, sodium sulphate, sulphuric acid, vinegar, washing soda, zinc.

Sketch.—None.

Experiments.—(1) To 10 cc. of water in a test tube add **2 or 3 drops** of dilute sulphuric acid. To other test tubes containing water add a few drops of hydrochloric and nitric acids.

(*a*) Taste each of the above acid solutions by removing a drop on the end of a stirring rod and **carefully** putting the moistened rod on the tip of the tongue. Compare the taste of each of the acids.

(*b*) By means of a stirring rod, place a drop of each acid on the corner of a piece of red litmus paper. Repeat, using blue litmus paper.

(*c*) Add a piece of zinc **the size of a pin head** to each test tube containing the acid. If no reaction occurs, warm the test tube. Note any gas evolved and observe what happens to the zinc.

(2) To 10 cc. of water in a test tube add 2 or 3 drops of sodium hydroxide; to other test tubes containing water add potassium and ammonium hydroxides.

(*a*) Taste as directed in 1 (*a*).

(*b*) Try the action of the hydroxides on red and blue litmus paper.

(*c*) Rub a little of the solutions between the fingers.

(3) Put 10 cc. of sodium hydroxide solution into an evaporating dish and neutralize with hydrochloric acid. Test frequently with both red and blue litmus paper, and, when neutral, evaporate to dryness. Note the residue left and carefully taste it.

(4) Determine the reaction of the following substances, to both red and blue litmus: Vinegar, lemon juice, lime-water, washing soda, baking soda, cream of tartar, sodium chloride, sodium sulphate.

(If solutions of the solids are not available, prepare such by dissolving 1 grm. of the solid in 10 cc. of water.)

Observations.—State your observations.

Deductions.—State your conclusions.

Questions.– (*a*) Tabulate all the substances tested above, under the following headings:

Name	Formula	Color change with:		Reaction of Solution (Acid or Basic)
		Red Lit.	Blue Lit.	

(*b*) Define acid, base, salt, neutralization.

(*c*) Write equation representing reaction involved in No. 3 above.

EXERCISE No. XXIV

NEUTRALIZATION

It is desired to find if there is any definite relation between the quantities used when an acid is neutralized by a base.

SUPPLIES.—*2 beakers, 1 burette, 1 clamp, flask, pinch cock, pipette (10 cc.), stand.*

N/2 hydrochloric acid solution (See "Special Solutions"), litmus solution, N/2 sodium hydroxide solution.

Sketch.—Fig. 39.

Experiments.- Clamp the burette on the stand and place the pinch cock on the rubber tubing.

(1) Pour water into the burette from a beaker, place a flask below the burette, and quickly open and close the pinch cock until the glass tip is filled with water Fig. 39). Practise running the water out of the burette, also read the burette to the bottom of the menisens Fig. 40). Do this several times.

(2) Empty the water out of the burette and beaker. **Carefully dry the beakers.** Take the beakers to the draught cupboard and obtain 100 cc. of standard sodium hydroxide solution and 100 cc. of standard hydrochloric acid solution, **keeping the solutions separate.**

(3) Rinse the burette with about 5 cc. of the standard sodium hydroxide solution to remove any water there may be in the burette. Empty, and fill to the top with the standard solution.

(4) Pour water into a beaker; hold the 10 cc. pipette between the second and third fingers and the thumb of the right hand (Fig. 41), place the point in the water and carefully suck this up until it rises well above the mark (but do not suck into the mouth); remove the mouth and rapidly close the top of the pipette with the first finger. Holding the pipette vertically in front of the eye, slightly

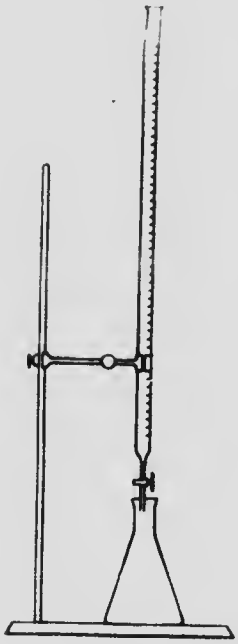

Fig. 39.

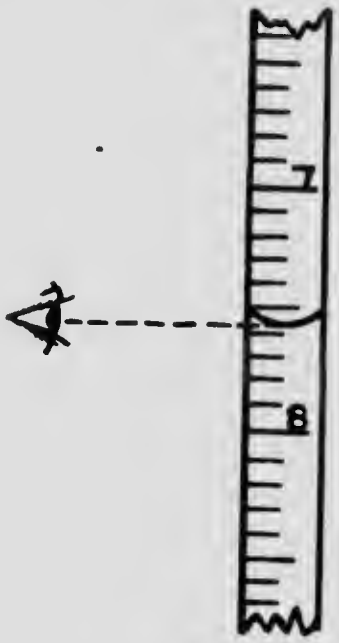

Fig. 40.

raise the first finger so as to allow the liquid to run down till the bottom of its curved surface (meniscus) is level with the mark, letting the excess of water run into the beaker. The pipette will now deliver the volume of liquid with which it is labelled; and this liquid may be allowed to run out into any vessel desired.

(5) Rinse the pipette with about 5 cc. of the standard hydrochloric acid solution. Measure 10 cc. of the acid solution into the flask. Add a few drops of litmus

solution. Place the flask on a filter paper below the burette containing the sodium hydroxide solution and titrate with the base, i.e., run the base in gradually, with constant stirring, until the solution reacts neutral. Note the number of cc. of the base needed to neutralize the acid.

6) Measure 10 cc. more acid into the flask, and again titrate, as in Experiment No. 5, repeating until your readings are constant. Allow your partner to check your work. State your result as a ratio.

FIG. 41.

(7) Write the equation for the reaction involved above, and if the sodium hydroxide contains 0.02 grm. per cc., calculate the strength of the acid solution in grms. per cc.

(8) The strength of the acid being known, it may be used to determine the strength of any base. If time permits, determine the strength of another base.

Observations.—State your observations in Experiments Nos. 5 and 6 above.

Deductions.—State what you conclude from Experiments Nos. 5, 6 and 7.

Questions.— (*a*) State the law of definite proportions.

(*b*) Show how your results illustrate the law of definite proportions.

(*c*) Give a general definition for an indicator.

EXERCISE No. XXV

SULPHUR

SUPPLIES.—*Balance and weights, Bunsen burner, beakers, crucible tongs, graduate, magnifying glass, mortar and pestle, test tubes, test tube rack, watch glass.*

Carbon bisulphide, copper foil or wire, flowers of sulphur, mercury, roll sulphur.

Sketch.- None.

Experiments.— (1) Examine roll sulphur and flowers of sulphur, note their physical properties.

(2) Try solubility of 1 grm. of roll sulphur in 3 cc. of water and also in 3 cc. of carbon bisulphide. (**Keep away from flame.**) Pour the latter solution on to a watch glass and allow it to evaporate in the draught cupboard. (Do not heat.) Examine the substance obtained with the magnifying glass.

(3) One quarter fill a test tube with roll sulphur; apply heat. (**Have sand ready in case of a break.**) Note the change in color and fluidity as the temperature rises. When the liquid gets thick, endeavor to pour the sulphur out of the tube. Continue heating until boiling results. Again note color and fluidity (read text, p. 112).

(4) Pour the almost boiling molten sulphur contained in the tube, Experiment 3, into a beaker of water. Note the properties of the sulphur after it is cold.

(5) Melt 10 grms. of sulphur in a test tube. Allow to cool. Watch mass carefully, and as soon as crystals start to form in the liquid, pour liquid part out of the tube. Examine the crystals left behind. Compare with Experiments 2 and 4.

(6) Burn a little sulphur in the air. Note what happens.

(7) (*a*) Heat some sulphur to boiling in a test tube and plunge into the vapor a piece of red hot copper wire or foil. Note what forms.

(*b*) Rub a drop of mercury with a little flowers of sulphur in a mortar.

(8) **Specific gravity of sulphur.**

Weigh as accurately as possible some small pieces of roll sulphur. The exact weight must be known and the quantity used should not be less than 10 grms. (W).

Pour into the 100 cc. graduate some water (about 50 cc.) and carefully note the volume of liquid contained (V_1).

Add the weighed roll sulphur to the water and note the new volume. (V_2). Calculate the Sp. g. of the sulphur.

$$\text{Specific gravity} = \frac{\text{weight of body}}{\text{weight of an equal volume of water}}.$$

Observations.— State your observations, numbering as above.

(8) Wt. of sulphur.....grms. (W)
Volume of water in graduate.....cc. (V_1)
Volume after adding sulphur.....cc. (V_2)
Change in volume ($V_2 - V_1$).....cc.

$$\text{Sp. g.} = \frac{W}{V_2 - V_1}.$$

Deductions.- State your conclusions, numbering as above.

Questions.--(*a*) Tabulate the properties of the different varieties of sulphur.

(*b*) What kind of sulphur crystals are obtained from the CS_2 solution?

(*c*) Write the equation for the reactions in Experiments 6, 7 (*a*) and 7 (*b*).

(*d*) Account for the formation of a black deposit on a silver spoon when used in eating eggs.

EXERCISE No. XXVI

HYDROGEN SULPHIDE

SUPPLIES.—*Elbow and delivery, flask, filter paper, gas bottles, two-hole cork, test tubes, test tube rack, thistle tube.*

Candle, iron sulphide, litmus paper, dilute sulphuric acid; solutions of ammonium hydroxide, cadmium sulphate; copper sulphate, lead nitrate, sodium chloride, zinc sulphate.

Sketch.—Fig. 42.

Experiments.—The following should be carried out entirely in the draught cupboard, observing the same precautions against explosion as in the case of the preparation of hydrogen.

(1) Holding the flask horizontally, carefully introduce 10 grms. of iron sulphide, and set up the apparatus as shown in Fig. 42. Cover the iron sulphide with 25 cc. dilute sulphuric acid. Collect 3 cylinders of the gas, keeping the bottle covered while collecting, by bringing the delivery tube through a piece of paper with a hole in it. Note the physical properties of the gas.

(2) Test the gas with a lighted candle (on a wire). Observe what happens to the gas and to the sides of the bottle, and to the candle. Also note the odor left in the bottle.

(3) Place a piece of filter paper moistened with lead acetate in a bottle of the gas and note what happens. What is the test used to detect the gas.

(4) Pass the gas for some time into a test tube half filled with water. Note the odor of the water. Test the solution with blue litmus paper. Keep this solution for the next experiment.

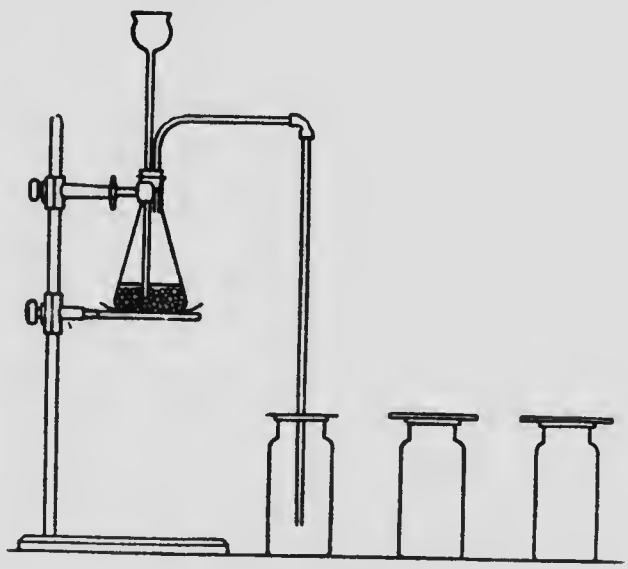

FIG. 42.

(5) Place 2 cc. of each of the following solutions in a separate test tube: Sodium chloride, lead nitrate, copper sulphate, zinc sulphate (to which has been added a few drops of ammonium hydroxide), cadmium sulphate. Add a few drops of the solution of gas prepared in No. 4. Note the colors. Tabulate results.

Observations.— State your observations, numbering as above.

Deductions.— State your conclusions, numbering as above.

Questions.—(*a*) Write the equation for the reaction between iron sulphide and sulphuric acid.

(*b*) Does the gas produced dissolve in water?

(*c*) Write equations for Experiments Nos. 2, 3, 5.

EXERCISE No. XXVII

SULPHUR DIOXIDE AND SULPHURIC ACID

SUPPLIES.—*Deflagrating spoon, cover glasses, gas bottles, test tubes.*

Barium chloride solution, candle, hydrochloric acid, litmus paper, material to bleach, solutions of various sulphates, sulphur, sulphuric acid (conc.), powdered iron pyrites, splints, sugar.

Sketch.— None.

Experiments.— 1. (*a*) Ignite ½ grm. of sulphur on a deflagrating spoon and hold it in a covered gas bottle until it ceases to burn. Note the odor. Test gas with a lighted splint.

(*b*) Place a moistened colored flower in a jar of the gas. Note what happens.

(*c*) Shake up some of the gas with water, and test with blue litmus.

(*d*) Boil in a test tube 2 cc. of concentrated sulphuric acid with a few pieces of copper turnings. Note gas evolved. Be careful not to get any of this hot acid on the skin. Compare with Experiment (*a*) above.

(*e*) Roast 2 grms. powdered iron pyrites by holding it on a spoon in a Bunsen flame. Note what happens.

2. (*a*) Examine a bottle of pure, concentrated sulphuric acid, and write down as many of the properties of the acid as you can observe without opening the bottle.

(*b*) Put 5 cc. of water into a test tube and hold the tube in the fingers by the closed end. Pour a little concentrated sulphuric acid into the test tube. Note what happens.

(*c*) Place a drop of concentrated sulphuric acid on a piece of wood and allow to stand for some time. Note result.

(*d*) Treat 1 grm. of sugar with a **few drops** of water and concentrated sulphuric acid. Note what happens.

(*e*) **Sulphuric acid test:**—

To a little water add a few drops of sulphuric acid and test with barium chloride solution. Note the substance that forms, also its color, and that it does not dissolve on addition of hydrochloric acid.

(*f*) Try the sulphuric acid test on solutions of various sulphates.

Observations. State your observations.

Deductions.— State your conclusions.

Questions. (*a*) Write the equations for reactions in 1 (*a*); 1 (*c*); 1 (*d*); 1 (*e*).

(*b*) What is the name of the gas formed in 1 (*a*) and 1 (*d*)?

(*c*) What part does the sulphuric acid take in 1 (*d*)?

(*d*) Account for what happens in 2 (*b*) and 2 (*c*).

(*e*) State physical and chemical properties of sulphur dioxide.

(*f*) State physical and chemical properties of sulphuric acid.

EXERCISE No. XXVIII

NITROGEN

SUPPLIES.—*Bunsen burner, copper or iron wire, 8" long, crucible, clamp, two-hole cork, elbow, filter paper, flask, gas bottles, pneumatic trough, ring, rubber delivery, stand, thistle tube, wire gauze.*

Ammonium chloride, phosphorus, splint, sodium nitrite.

Sketches.– Figs. 43 and 28.

Experiments.– 1. **Atmospheric Nitrogen.**

CAUTION.– The fingers should never be used in handling phosphorus, always use the crucible tongs. Phosphorus should be cut under water, otherwise it is liable to take fire.

(*a*) Set up the apparatus as shown in Fig. 43.

(*b*) Dry a piece of phosphorus the size of a pea between filter papers (**do not touch with the fingers**), and place it in the crucible.

(*c*) Float the crucible on the water in the trough.

(*d*) Light the phosphorus with a hot wire and quickly invert over the crucible a gas bottle, keeping the mouth of the bottle always below the surface of the water. Note everything that happens.

(*e*) When the smoke has all disappeared, carefully cover the mouth of the gas bottle (while still under the surface of the water) with a cover glass and, being careful not to allow any water to escape, turn the bottle mouth up.

(*f*) Test the gas with a lighted match.

(*g*) Note the proportion of the air used up by the phosphorus on burning.

Carefully get rid of any unburned phosphorus by burning it or putting it down the sink.

2. **Chemical Nitrogen.**

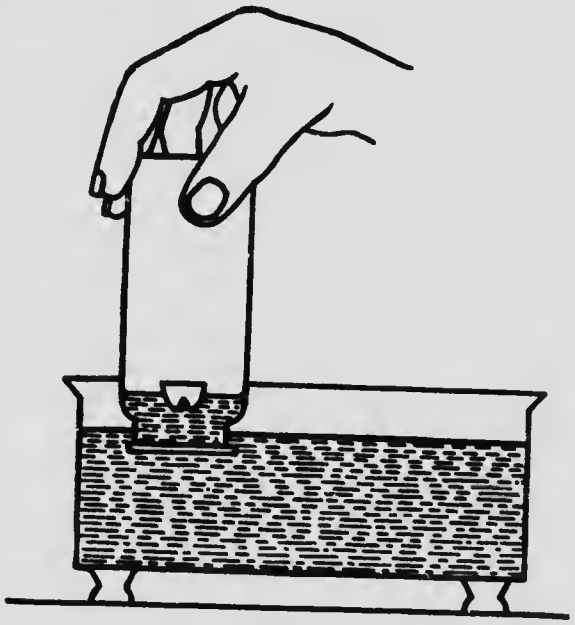

FIG. 43.

CAUTION.—Do not heat the flask highly in the following experiment.

Prepare some gas by **gently** heating a mixture of 3 g. of ammonium chloride, 4 g. of sodium nitrite and 26 cc. of water, as shown in Fig. 28.

Collect bottles of the gas until one is obtained which is pure. This may be determined with a lighted splint.

(*a*) Examine the physical properties of the gas.

(*b*) Compare with gas obtained in Experiment No. 1.

Observations.—State your observations.

Deductions.—State your conclusions.

Questions.—(*a*) Upon what properties of phosphorus does the preparation of nitrogen depend?

(*b*) Write the equation involved in Experiment No. 2.

(*c*) Summarize the physical and chemical properties of nitrogen.

(*d*) What is "atmospheric nitrogen"?

(*e*) What is "chemical nitrogen"?

(*f*) What is the function of nitrogen in the atmosphere?

EXERCISE No. XXIX

THE ATMOSPHERE

SUPPLIES.—*Battery jar, burette, cover glass, flask (with cork to fit), graduated gas-measuring tube, graduate, watch glass, 2 rubber bands.*

Calcium chloride, lime-water, potassium hydroxide solution (160 grms. to 130 cc. water), pyrogallic acid.

Sketch.—Fig. 44.

Experiments.—1. Set out on a cover glass a piece of calcium chloride the size of a pea, and examine it at the end of the lesson. (If nothing marked happens, set in locker until next day.) Record observations and conclusions.

2. (*a*) Put a little lime-water on a watch glass and allow to stand. Examine at the end of the lesson. Record observations and conclusions.

(*b*) **Quantitative test for carbon dioxide.** Measure the volume of your Erlenmeyer flask to the bottom of the cork by filling it with water. Empty the water out so as to obtain a sample of the air in the room. Pour into the flask one-twentieth of its volume of **clear** lime-water. Quickly cork and shake for two or three minutes. A milkiness indicates that the air is unfit for respiration. Test the atmosphere at home.

3. **Estimation of oxygen and nitrogen in air.** This experiment depends on the fact that oxygen is absorbed by an alkaline solution of pyrogallic acid.

(*a*) Place two elastic bands on a **dry** gas-measuring tube, Nessler tube, or test tube.

(*b*) Place in the tube 1 grm. of pyrogallic acid and 20 cc. of the strong potassium hydroxide solution. (Pyrogallic acid will stain the clothes and potassium hydroxide will act on varnish—do not spill these substances.)

(*c*) **Quickly cover the tube with the thumb and keep covered until the end of the experiment. Do not allow any air to enter the tube: if you do, the experiment is spoiled.**

FIG. 44.

(*d*) Move a rubber band to mark the depth of the solution in the bottom of the tube (A, Fig. 44). The volume from A to the open end of the tube is the volume of air worked on.

(*e*) Keep the thumb **tightly** on the opening and allow the solution to run from one end of the tube to the other for two or three minutes.

(*f*) Place the tube in a battery jar of water as shown in Fig. 32, B and remove the thumb (note what happens when the thumb is removed). Adjust so that the liquid inside the tube is at the same height as the liquid outside the tube. This means that the gas enclosed is at atmospheric pressure. Mark this position with a rubber band (B, Fig. 44).

The nitrogen in the volume of air worked on is shown by the volume from B to the closed end of the tube.

(*e*) Measure the volumes in (*d*) and (*f*) by means of a graduate or, preferably, a burette.

Observations.—(*e*) The volume from A to the mouth of the tube gives the amount of air worked with,

....cc. (X).

The volume from B to the closed end of the tube gives the amount of nitrogen left,.....cc. (Y).

Subtract and you get the volume of oxygen absorbed,
.....cc. (Z).

Deductions– Percentage of oxygen in air is.....%

Percentage of nitrogen in air is.....%

Questions.– 1. What constituents have you found in the air?

2. State the importance of each constituent of the atmosphere.

3. What are the sources of carbon dioxide?

4. Why does the atmosphere remain fairly constant in composition?

EXERCISE No. XXX

WEIGHT OF A LITRE OF AIR

SUPPLIES.—*Bunsen burner, stand, ring, clamp, gauze, graduate, round bottom flask, two-hole cork, glass plug, short piece of glass tubing, short rubber tubing, screw pinch cock, balance and weights.*

Air, water.

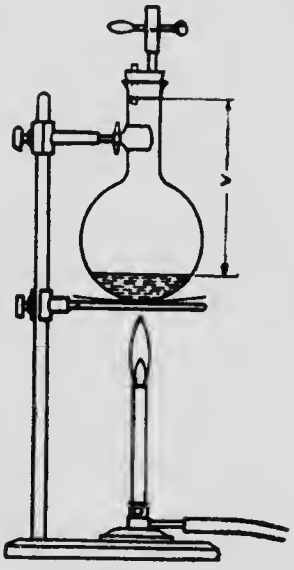

FIG. 45.

Sketch.—Fig. 45.

Experiments.—Place in the flask 25 cc. of water and set up the apparatus as shown in Fig. 45. Remove the pinch cock and boil the water briskly for a few minutes so that the steam may drive all the air out of the flask. **Stop heating. Quickly put on the pinch cock.** Allow to cool, and weigh when cold (*a*). Open the pinch cock and weigh again (*b*). (**Do not empty out the water**). The difference gives you the weight of the volume of air admitted to the flask (*c*). The volume (v) of air admitted is got by measuring with a graduate the amount of water needed to fill the flask to the bottom of the cork.

Observations.—(*a*) Weight of flask and water . . grms.

(*b*) Weight of flask and water and air . . . . . grms.

(*c*) Weight of air (*b*-*a*) . . . . . grms.

(v) Volume of flask from top of water to bottom of cork..... cc.

Deductions.- Therefore, weight of 1 litre of air is .....grms.

Questions.—(*a*) Will your answer be greater or less than the value stated in your book?

(*b*) Give a reason for your answer.

(*c*) Obtain the room temperature and barometric reading at the time the experiment was carried out, and determine the weight of one litre of air under standard conditions.

EXERCISE No. XXXI

AMMONIA

SUPPLIES.—*Bunsen burner, clamp, cover glasses, elbow, flask, gas bottles, two-hole cork, stand, straight glass tube, test tubes, test tube holder, wire gauze.*

Ammonium chloride, other ammonium salts, lime, litmus, sodium hydroxide.

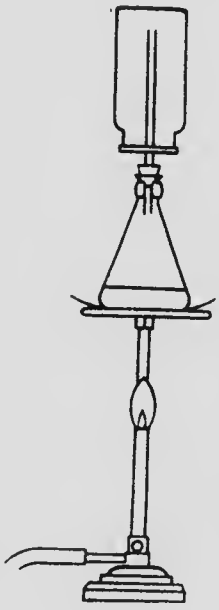

FIG. 46.

Sketch.— Fig. 46.

Experiment.— 1. (*a*) Boil in a test tube a solution of ammonium sulphate. Note if there is any odor.

(*b*) Add a few drops of sodium hydroxide solution and boil again. Note odor.

2. Repeat 1 (*a*) and 1 (*b*), using other ammonium compounds.

3. Place 10 g. of ammonium chloride and 20 g. of lime in a flask and just cover the mixture with water. **Shake to thoroughly wet the inside of the flask.** Set up the apparatus as shown in Fig. 46. Heat and collect 3 bottles of the gas by upward displacement.

(*a*) Note the physical properties of the gas.

(*b*) Does the gas burn or support combustion?

(*c*) Fill your sink with water and try the solubility of the gas by uncovering a bottle mouth down under water.

(*d*) Pass the gas into a gas bottle containing 25 cc. water. Have the delivery tube one-eighth inch **above** the surface of the liquid in the gas bottle (Fig. 36). Note if the water takes on any odor.

(*e*) Test the gas with dry and moistened red litmus paper.

Observations.—State your observations, numbering as above.

Deductions. State your conclusions, numbering as above.

Questions.—(*a*) Write equations for preparing ammonia, using (1) NaOH; (2) Lime.

(*b*) Write equations for preparing ammonium hydroxide.

(*c*) What is a compound metallic radical?

(*d*) Why will ammonia not act on dry litmus while it will on moist?

(*e*) Why is the inside of the flask wetted in No. 3 above?

EXERCISE No. XXXII

NITRIC ACID

SUPPLIES.—*Beaker, Bunsen burner, iron stand and clamp, pneumatic trough, retort, test tubes, test tube holder, thistle tube.*

Ammonium hydroxide, copper, ferrous sulphate, litmus, sodium nitrate, other nitrates, silk, sulphuric acid (concentrated), tin, wool.

Sketch.—Fig. 37.

Experiments. Place 10 grms. of sodium nitrate crystals in a retort and pour in by means of a thistle tube 25 cc. of concentrated sulphuric acid. Arrange the apparatus as shown in Fig. 37, and keep the test tube cool by pouring water over it. Heat carefully with a **small** flame directed against the **lowest** portion of the bulb of the retort. Collect a few cc. of liquid which distils over and use it to make the following tests. (If sufficient nitric acid is not obtained, the concentrated acid on the benches may be used.)

1. Note the physical properties of the acid you have prepared. Compare it with the nitric acid on the benches.

2. Try the action of the liquid on litmus paper.

3. Try the action on copper and on tin.

4. Try the action on a piece of silk or wool. Add a drop of ammonium hydroxide to where the acid has acted on the silk or wool.

5. **Test for nitric acid and its salts.** Add to 2 or 3 cc. of nitric acid an equal volume of concentrated sulphuric acid. Mix and thoroughly cool. Carefully float on top of the mixture some freshly prepared ferrous sulphate solution. A brown ring at the junction of the two solutions indicates nitric acid. Try this test on solutions of different nitrates.

Observations.—State your observations, numbering as above.

Deductions.—State your deductions, numbering as above.

Questions.— (*a*) Summarize the properties of nitric acid.

(*b*) Write equations for the preparation of nitric acid.

(*c*) Write equation for Experiment No. 3 (copper).

(*d*) Why does nitric acid turn yellow on standing?

(*e*) Write an equation to show that nitric acid is an oxidizing agent.

(*f*) What is aqua regia? Write an equation to show how it acts. What part of it acts on gold?

(*g*) What is an acid salt? Give an example.

(*h*) State general method for preparing an acid.

EXERCISE No. XXXIII

PREPARATION OF A FUSIBLE ALLOY—DETERMINATION OF ITS MELTING POINT

SUPPLIES.—*Beaker, brick, Bunsen burner, crucible tongs, one-hole rubber cork, iron stand and ring, iron or porcelain crucible, iron wire (8 inches long), pipe clay triangle, rubber band, stirring rod tipped with rubber, thermometer, wire gauze.*

Bismuth, cadmium, lead (sheet), tin (mossy).

Sketch.—Fig. 47.

Note.—To successfully perform this experiment, care must be taken to use as little heat as possible and not to prolong the heating or stirring.

Rose's Metal	**Wood's Metal**
[illegible]in.	1 part cadmium.
[illegible]lead.	2 parts tin.
8 parts bismuth.	4 parts lead.
Melting point, 95° C.	7 parts bismuth.
	Melting point, 70° C.

Parts are by weight.

Part of the class may prepare Rose's Metal while the others make Wood's Metal.

Experiments.—

1. **Preparation of the Alloy.**

(*a*) Weigh the portions of metals mentioned as accurately as possible in grams.

(*b*) **Consult the table of melting points and note the melting points of the metals being used.**

(*c*) **Place the crucible on a pipe clay triangle, as shown in Fig. 11, and proceed to melt the metals. Start with the metal whose fusion temperature is highest and, by applying a gentle heat, melt that metal. As soon as fusion is complete, add the metal of next highest melting point and proceed in this manner until all the metals are in the molten condition in the crucible, then quickly stir with the iron wire and pour at once on to a piece of iron or brick.**

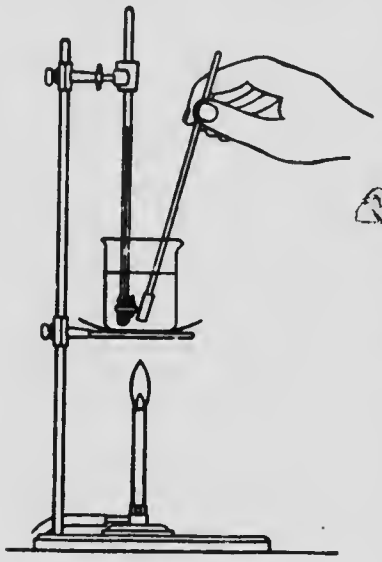

Fig. 47.

2. Determination of the Melting Point of the Alloy.

Set up the apparatus as shown in Fig. 47.

Place in the beaker 100 cc. of water and fasten to the thermometer bulb by means of a rubber band a small piece of the prepared alloy (preferably a chip with a sharp edge) and raise the temperature of the water **rapidly** until it is 10 degrees below the proper melting point of the alloy prepared. Then, with constant stirring, **slowly** raise the temperature until you notice that the sharp edge of the metal starts to fuse. Immediately read the temperature — this is the melting point of the alloy.

Observations.—State what you observed happen in the above experiment.

Deductions.—What do you conclude? Write down the melting points of the metals used in the above experiments. Compare the result obtained in Experiment 2 with these melting points. What do you conclude?

Questions.—(*a*) What is an alloy?

(*b*) Why may there be a slight amount of dross formed in the above experiment?

(*c*) How could the formation of dross be entirely prevented?

(*d*) Why may your alloy not melt exactly at the temperature mentioned above?

(*e*) What effect has antimony on alloys?

(*f*) What effect has bismuth on alloys?

(*g*) What is plumber's solder?

Melting points

Bismuth	260°
Cadmium	320 C.
Lead	322°
Tin	232°

EXERCISE No. XXXIV

CARBON

SUPPLIES. *Bunsen burner, clay pipe, clamp, crucible, delivery tube, evaporating dish, filter paper, funnel, glass elbow, hard glass test tube, iron stand and ring, one-hole cork, test tubes, tongs, test tube holder, wire gauze.*

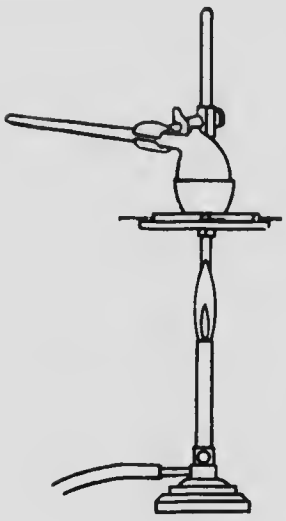

FIG. 48.

Bone charcoal, coal, copper oxide, china or fire clay, dilute hydrogen sulphide solution, dilute litmus solution, lime-water, wood, wood charcoal (lumps and powdered), some organic compound (sugar, starch, etc.).

Sketches.—Figs. 48 and 49.

Experiments.—1. Mix 10 grammes of china or fire clay with a **little** water to a **thick** paste in your evaporating dish. Place a few hardwood chips in the bowl of a clay pipe and insert the bowl into a porcelain crucible. Lute it in by means of the china clay (Fig. 48). The wood must be loosely put into the pipe so that it will drop into the bottom of the crucible when inverted.

Apply heat to the crucible; and, if the clay cracks, cover the openings with more clay.

Note the gases evolved, and see if they will burn. Leave the Bunsen burner under the crucible (while you

proceed to the next experiment), until no more gases are evolved; allow to cool, note the residue left in the crucible. Place it on a wire gauze and see if it will burn.

This experiment could be repeated, using soft coal.

2. Strongly heat ½ grm. of some organic substance in an old test tube (Fig. 7). Note residue.

3. To 20 cc. of water in your flask add **just sufficient** litmus solution to color the water. Add 1 grm. of animal charcoal, boil for a few minutes and filter (Fig. 5). Compare the color of the filtrate with the liquid before filtering.

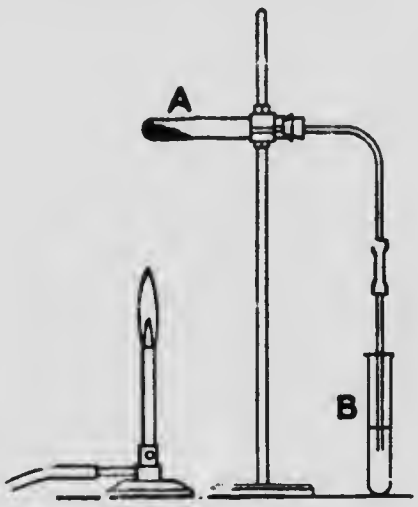

Fig. 49.

4. Try the action of acids and bases on charcoal.

5. To 10 cc. of water in each of two test tubes add two or three drops of hydrogen sulphide solution (just sufficient to give the water a slight odor). Drop into one of the tubes 2 grms. of wood charcoal (preferably freshly heated). Place the thumb over the mouth of the tube and shake vigorously. Compare the odor of the solutions in the two tubes.

6. Place 2 grms. of a mixture of copper oxide and powdered charcoal already prepared (75 grms. CuO and 25 grms. C.) in a hard glass test tube, A, Fig. 49, fitted with a one-hole cork and delivery tube. Heat and pass the evolved gas into lime-water contained in test tube B. Note the effect of the gas on the lime-water, and when **the tube is cold** examine the residue left in the hard glass tube.

Observations.—State your observations, numbering as above.

Deductions.—State your conclusions, numbering as above.

Questions.—(*a*) How does carbon occur in nature?

(*b*) Mention the artificially prepared varieties of carbon.

(*c*) Mention the allotropic varieties of carbon.

(*d*) Why is it that a newspaper may change color and yet the printing may be easily read?

(*e*) What would happen if a fuel (soft coal) were heated above its ignition temperature?

(1) In an excess of air?

(2) In a deficiency of air?

(3) In the absence of air?

(*f*) Write equations for reactions involved in Experiment No. 6.

(*g*) Why must the test tube be cold before the examination of the residue in Experiment No. 6?

(*h*) State the use, indicated by Experiment No. 6, to which carbon is put in metallurgy.

(*i*) What name is given to the process carried on in the crucible and clay pipe?

EXERCISE No. XXXV.

CARBON DIOXIDE

SUPPLIES.—*Candle on wire, 3 cover glasses, 2-hole cork, deflagrating spoon, glass elbow, glass tubing 6″ long to blow through, flask, 3 gas bottles, rubber delivery tube, test tube, test tube holder, thistle tube.*

Hydrochloric acid, magnesium, marble chips, sodium carbonate.

Sketch.—Fig. 42.

Experiments.—1. (*a*) To 1 grm. of sodium carbonate in a test tube add a few cubic centimetres of dilute hydrochloric acid. Note what happens.

(*b*) Place a burning match in the mouth of the tube. Observe what happens to the flame.

2. Arrange the apparatus as shown in Fig. 42, and put into the flask 15 grms. of marble chips and just sufficient water to cover the bottom of the thistle tube. **Measure into a beaker** 30 cc. of concentrated hydrochloric acid and add a **little of the acid from time to time** by means of the thistle tube. The bottle in which the gas is to be collected should be covered with a piece of paper, and a small hole made in the paper for the delivery tube to pass through. Collect 3 bottles of the gas.

(*a*) Test a bottle of gas with a burning candle.

(*b*) Pour the gas from one bottle to another; test both bottles with the burning candle.

(*c*) Light a short piece of candle and set it on a piece of glass placed on the table. Pour a bottle of gas over the burning candle. Observe what happens.

(*d*) By means of a deflagrating spoon, introduce some burning powdered magnesium into the gas. (If magnesium ribbon is used, it can be held with the crucible tongs.) Note the product left on the spoon. Shake the substance off the spoon into the gas bottle and treat it with dilute hydrochloric acid and note the residue left.

(*e*) Pass some of the gas into a test tube containing 10 cc. of lime-water. Note what happens.

(*f*) Blow into a test tube containing 10 cc. of lime-water, by means of a glass tube. Compare result with (*e*) above.

Observations. State your observations, numbering as above.

Deductions. State your conclusions, numbering as above.

Questions. (*a*) Summarize the physical and chemical properties of carbon dioxide.

(*b*) Write a note on the manufacture of soda water.

(*c*) Write equations—

(1) for the preparation of carbon dioxide from marble.

(2) for carbon dioxide turning lime-water milky.

(3) for the chemical reaction which takes place in a fire extinguisher.

(4) representing what occurs when carbon dioxide is passed over highly heated carbon.

(5) for the preparation of water gas.

(6) for the reactions in Experiment 2 (*d*) above.

EXERCISE No. XXXVI

LEAVENING VALUE OF BAKING POWDER

SUPPLIES.- *Flask, gas bottle, graduate, pinch cock, pneumatic trough, rubber delivery tube, thistle tube cut to act as a dropping funnel.*

Various baking powders emptied from their packages and labelled Nos. 1, 2, 3, 4, etc., with the price per pound on the label.

Sketch. -Fig. 50.

It is advisable to fill all the pneumatic troughs with water some hours before use, in order that the water in all may be at room temperature before the gas is collected.

If members of the class work on different powders, using exactly the same weight of powder, and tabulate the results, a comparison may be thus obtained.

Experiments. 1. Place exactly 3 grms. of the sample of baking powder in a **dry flask,** arranged as indicated in Fig. 50. Boil 100 cc. of water in a beaker, and pour a test **tube full of boiling water** down the thistle tube, **quickly** closing the pinch cock as soon as all the water runs out of the bottom of the thistle tube. Shake the flask occasionally. When all the gas is collected in the bottle, remove the rubber delivery tube from the trough, place the bottle in the trough so that the surfaces of the water in the bottle and in the trough are at the same level, then put a cover glass over the mouth of the bottle. Remove the bottle quickly from the trough and place it mouth up on the bench (Fig. 50, A). (**Care must be taken that no**

water runs out of the bottle while it is being removed from the trough.) The volume of gas in the bottle is too great by the volume of water added by means of the test tube (V_2 in Fig. 50, A); so to the gas bottle add a test tube full of water—**using the same test tube that the hot water was measured in.**

Carefully measure the volume of water required to completely fill the gas bottle (V_2). This is the measure of the gas liberated from the baking powder.

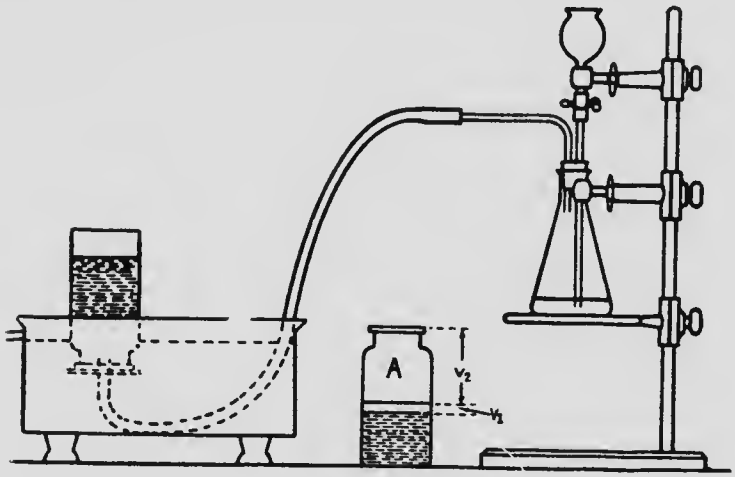

FIG. 50.

2. Repeat, using another sample of baking powder, and by comparison you obtain the leavening value of the two powders.

3. Divide the number of cc. of gas liberated by the price of the powder per lb. and you will be able to determine which is the best powder, so far as price is concerned.

Observations.—Record your observations, and those of your classmates, as below.

Sample No.	Vol. of gas obtained	Price per lb.	$\frac{\text{cc. of gas}}{\text{Price per lb.}}$	Samples in order of leavening value

Deductions.—Record your conclusions, numbering as above.

Questions.—(*a*) What is baking soda?

(*b*) What is baking powder?

(*c*) The reaction that takes place when water is put on baking powder is represented by the following equation:

$$KHC_4H_4O_6 + NaHCO_3 = KNaC_4H_4O_6 + H_2O + CO_2$$

From this equation, calculate the proportions of reagents necessary for a good baking powder.

(*d*) What effect would it have on the experiments if the water in each trough were at a different temperature?

Note.—In addition to leavening value, adulterants must be taken into consideration (some of which may be injurious), in estimating the real value of baking powder.

EXERCISE No. XXXVII

ACETYLENE

SUPPLIES. *Cut thistle tube, or funnel joined to straight glass tube, cover glass, elbow, flask, gas bottle, glass jet, two-hole cork, pinch cock, rubber delivery tube, rubber tube and clamp, splints, stand and ring, test tubes, test tube holder, test tube rack, towel, wire gauze.*

Acetone, calcium carbide, lime-water, litmus solution or paper (red), oxygen.

Sketch. Fig. 50 -omitting bottle on table.

CAUTION.- This experiment should be performed in the draught cupboard, all flames should be kept away from the generator and delivery tube, and the gas should be free from air when worked with.

Experiment.—Place in the dry flask (Fig. 50) 10 grms. of calcium carbide; fill the thistle tube with water, and allow a few drops at a time to act on the carbide, keeping up a gentle evolution of the gas. The surface of the water in the funnel should never be allowed to get below the pinch cock. Reject the first three bottles of gas collected. Collect a bottle of the gas; one test tube full; and one test tube quarter full. Keep the collected gas in the pneumatic trough till required.

1. Put a jet on the end of the delivery tube and test some of the gas to see if it is safe (as done in the preparation of hydrogen (Fig. 29). Wrap a towel round the

generator and light the jet. Note the characteristics of the flame. Collect some of the products of combustion in a gas bottle and shake up with lime-water.

2. Wrap a towel round the bottom of a bottle of gas, holding it mouth down; quickly plunge a lighted splint up into the bottle, and gradually withdraw it. Note everything that happens.

3. Fill the test tube which is quarter full of the gas with oxygen, or air, and wrap a towel round it. Bring a lighted splint to the mouth of the tube.

4. Into the full test tube of gas pour 2 cc. of acetone. Tightly cover with the thumb and shake vigorously. Note the suction when the thumb is removed. Account for this.

5. Test the liquid left in the generator with litmus solution.

6. Examine a dry piece of calcium carbide. Note the odor. Break it and note any difference between the inner and outer portions.

Observations.—State your observations, numbering as above.

Deductions.—State your conclusions, numbering as above.

Questions.—(*a*) Write the equation for the preparation of acetylene.

(*b*) What is the substance left in the generator called?

(*c*) What quantity of oxygen is necessary to completely burn 26 grms. of acetylene?

(*d*) Describe the working of an acetylene burner.

(*e*) Account for the odor of ordinary acetylene.

(*f*) Could acetylene be used to run gas engines?

EXERCISE No. XXXVIII

FLAME

SUPPLIES.—*Bunsen burner, beaker, candle on a wire, cover glass, copper wire, gas bottle, glass tube, joss sticks (or stick of punk), platinum wire (wire sealed in glass tube), sheet of paper, splint, tin spoon, wire gauze (copper, about 40 mesh).*

Chalk (powdered, from blackboard), finely divided iron (by hydrogen), lamp-black.

Solutions of barium, calcium, copper, lithium, sodium and strontium salts (preferably chlorides).

Sketches.—Figs. 51, 52 and 53.

Experiment.—1. (*a*) Light a joss stick and carefully note how it burns.

(*b*) Light a wooden splint and carefully note how it burns.

Compare (*a*) and (*b*) and account for the difference in burning.

2. (*a*) Bring a smoking joss stick near the open holes at the bottom of a lighted Bunsen burner. Note what happens.

(*b*) Turn off the gas. Note what happens to the smoke from the joss stick.

3. Open and close the holes of the lighted Bunsen burner several times. Note carefully what happens.

(*a*) Hold a glass rod in the non-luminous flame. Note what happens.

(*b*) Hold a glass rod in the luminous flame. Note what happens.

4. (*a*) Take some lamp-black on the tip of a tin spoon and introduce it by gently tapping the spoon while held at the openings in the base of the Bunsen burner. Note what happens. Repeat, using powdered blackboard chalk—and iron powder.

(*b*) Dip a clean platinum wire (Fig. 56) into a solution of calcium chloride and introduce it into the Bunsen flame. Note what happens. When the calcium salt ceases to color the flame, repeat, using some of the following solutions, copper, barium, strontium, lithium. Tabulate your results.

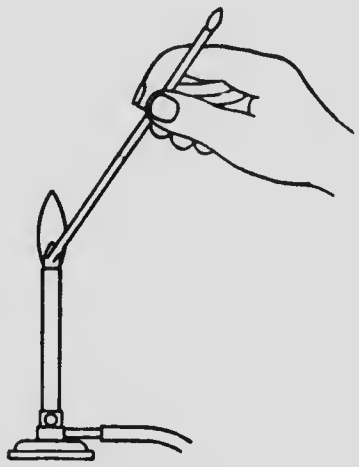

Fig. 51.

5. Determine the temperature of different parts of the Bunsen flame by exploring it with a piece of copper or platinum wire.

6. Pipe off some of the gases from the middle of the flame and light them as shown in Fig. 51.

7. Hold a piece of paper horizontally over the Bunsen flame and quickly bring it down into the flame, near the bottom, holding it there for a few seconds. Remove as soon as it chars. Note what has happened.

8. Thrust a pin through a match, ¼ inch below the head; hang in burner as indicated in Fig. 52; turn the gas on full and light it. Note what happens to the match.

9. Hold a fine brass or copper wire gauze 3 inches above the burner. Turn on the gas.

(*a*) Bring a lighted match **above** the gauze (Fig. 53). Note what happens.

(*b*) Bring a lighted match **below** the gauze. Note what happens.

(*c*) Light the burner and bring a wire gauze down into the flame. Note what happens.

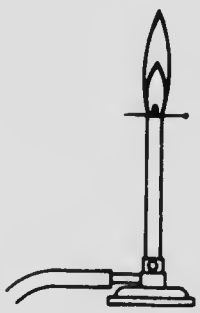

Fig. 52.

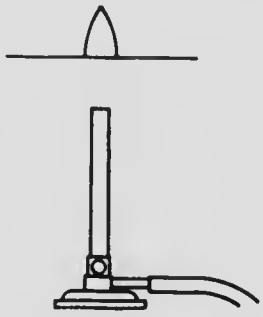

Fig. 53.

10. Turn the Bunsen non-luminous flame as low as possible.

(*a*) Hold a **clean cold dry** beaker in the flame. Note what happens.

(*b*) Let the flame burn for a few seconds in the middle of an inverted gas bottle. Pour in a little lime-water and shake. Note what happens.

11. (*a*) Light a candle; place it on a cover glass, have a dark background behind it, keep all draughts away. Draw a diagram of the different areas.

(*b*) Hold a cold dish in the candle flame. Note what happens.

(*c*) Hold a clean cold dry beaker over the candle flame. Note what happens.

(*d*) Lower a lighted candle on a wire into a gas bottle, cover the bottle, and when the candle goes out remove it.

pour in some lime-water, cover with the hand and shake. Note what happens.

(*e*) Blow out a lighted candle and quickly bring a lighted match into the smoke one-third inch above the wick. Note what happens.

(*f*) Make a spiral of heavy copper wire by winding it on a lead pencil, and bring it into the candle flame. Note what happens.

Observations.—State your observations, numbering as above.

Tabulate as follows: 4 (*b*).

Salt	Formula of Salt	Flame Color

Deductions.—State your conclusions, numbering as above.

Questions.—(*a*) Define luminosity, flame, combustible, kindling temperature, supporter of combustion, incandescent.

(*b*) Suggest some practical use to which the results in Experiment No. 4 (*b*) might be put.

(*c*) What are the requirements for combustion?

(*d*) Explain carefully how a lighted splint may burn from one end to the other.

(*e*) Draw a diagram of a Bunsen flame, marking the different areas, also the place of highest temperature.

EXERCISE No. XXXIX

FERMENTATION OF GLUCOSE—ITS PRODUCTS

SUPPLIES.—*Flask, glass elbow, glass plug, glass tubing, two-hole cork, rubber connecter.*

***Glucose, kerosene, splints, lime-water, yeast (one-quarter cake).*

Sketch.—Fig. 54.

Experiment.—Arrange the apparatus as shown in Fig. 54. In the flask put 150 cc. water, 25 grms. of glucose, and one-quarter cake of compressed yeast, ground up in a little water. Pour into the beaker 50 cc. **clear** lime-water, A in diagram, and cover the lime-water with 15 cc. kerosene, B in diagram, to prevent the carbon dioxide of the air acting on the lime-water.

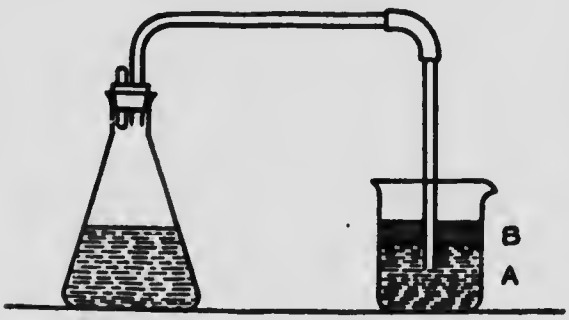

FIG. 54.

Place the apparatus thus charged in your locker for several days. The best conditions for fermentation are a moderately dark place and a temperature of 30°C.

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*Owing to the trouble in handling glucose, the teacher may find it advisable to prepare beforehand sufficient glucose solution for the pupils to work with.

If the tin and contents are placed in a dish of boiling water for a time, the glucose can be more readily removed.

1. Examine the apparatus from time to time and note what happens.

2. Remove the cork and test the gas in the flask with a burning splint.

3. Distil the liquid as described in Exercise No. XL.

Observations. State your observations.

Deductions. State your conclusions.

Questions.- (*a*) How may alcohol be obtained from starch?

(*b*) What is yeast?

(*c*) What are the products of fermentation?

(*d*) Write equation for the preparation of alcohol from glucose.

EXERCISE No. XL

ALCOHOL

SUPPLIES.—*Bunsen burner, burette clamp, evaporating dish, flask, glass elbow, glass tube (three-ft.), litmus paper, pneumatic trough, rubber cork (two-hole), rubber connecter (two-inch rubber tubing to fit tube and elbow), stirring rod, stand and ring, test tubes, test tube holder, test tube rack, thermometer, wire gauze.*

Absolute alcohol, camphor, iodine, gum-shellac, wood alcohol, a solution of glucose which has been prepared according to Exercise No. 39, and allowed to ferment for several days by means of yeast.

Sketch.—Fig. 34.

Experiments.—1. Place **two or three drops** of ethyl alcohol on the hand, note everything that happens, also the odor, and account for the sensation produced.

2. Try the action of ethyl alcohol on both red and blue litmus paper, placing the drop on the paper by means of the stirring rod.

3. (*a*) Place 5 cc. of either methyl or ethyl alcohol in your evaporating dish and **set the dish on your wire gauze. (Be sure that the stock bottle of alcohol is out of the way.)** Bring a lighted match in contact with the alcohol in the dish. Note what happens.

(*b*) Hold a test tube containing 2 cc. of water in the flame. Note what happens to the water and see if any soot is deposited on the tube itself.

4. Add 1 cc. of ethyl alcohol to a crystal of

(*a*) Iodine.

(*b*) Camphor.

Shake and examine at the end of the lesson.

5. Set up the apparatus as shown in Fig. 34. The thermometer bulb should be one inch above the liquid in the flask. Fill the pneumatic trough with water and hold the test tube by means of a test tube holder. Put 30 cc. of water and 10 cc. of alcohol into the flask. Distil the mixture. Note the temperatures at which the successive portions distil. When 5 cc. have been obtained in the test tube, remove the delivery tube, and pour the liquid into an evaporating dish and test with a flame. Distil 5 cc. more and again test with the flame; repeat several times, note the volume of liquid left in the evaporating dish each time.

When the test tube is removed, do not allow the end of the delivery tube to get below the surface of the water in the pneumatic trough. If it does, the water may be suddenly sucked back into the flask and the latter shattered.

6. **Distillation of fermented glucose.**

Pour 100 cc. of the fermented glucose solution obtained in Exercise 39 from one beaker to another several times so as to free it as much as possible from dissolved CO_2 (and prevent frothing on subsequent heating). Place it in the flask of the apparatus, arranged as in Fig. 34 and distil about 3 cc. into the test tube, noting the temperature at which the liquid distils over. Remove the test tube from the end of the delivery tube, bring the liquid in the test tube to the boiling point and test the evolved vapors with a lighted match. Note what happens. Compare with Experiment No. 5 above.

Observations.—State your observations, numbering as above.

Deductions.—State your conclusions, numbering as above.

Questions.—(*a*) Compare methyl and ethyl alcohols.

(*b*) What is methylated spirits?

(*c*) What are tinctures?

(*d*) What is the process carried on in Experiments Nos. 5 and 6 called?

EXERCISE No. XLI

ETHER

CAUTION.—All flames must be kept away from ether vapor; re-cork the bottle as soon as you pour any liquid out.

SUPPLIES.—*Bunsen burner, beaker, elbow tube, filter paper, two-hole cork, iron stand and ring, large test tube, stirring rod, tack, thermometer, test tubes, test tube rack, wire gauze.*

Ether, lard, litmus paper (red and blue).

Sketch.—None.

Experiments.—1. Carefully watching the mouth of the ether bottle, pour 5 cc. of ether into a large test tube, drop in a carpet tack and fit the two-holed cork with a thermometer and elbow tube. Put the cork into the mouth of the test tube (Fig. 55).

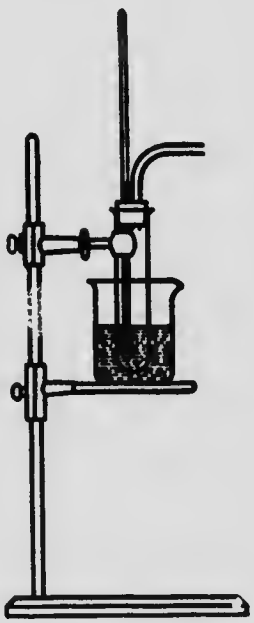

FIG. 55.

Lower the test tube into a beaker of water (which is near the boiling point). The test tube should be lowered until the liquid in the tube is on a level with the water in the beaker. Note the temperature at which the ether boils.

As soon as the boiling point has been determined, remove the tube from the water. Cool under the cold water tap and use the ether for the following experiments.

2. Pour into a test tube 10 cc. of water, and add a few drops of ether, shake and note if the ether is soluble in water.

3. Place a drop of ether on the back of the hand and note what happens.

4. Try the action of both red and blue litmus paper on ether (use stirring rod).

5. Shake up a small piece of lard (about the size of a pea) with 5 cc. of ether. Pour the ether on to a filter paper and allow to evaporate. Note residue. This is a test for a fat.

6. Pour **1 drop** of ether into a test tube or gas bottle. Cover the vessel and allow to stand for a few seconds. Bring a lighted match to the mouth of the vessel.

Observations.—State your observations, numbering as above.

Deductions.—State your conclusions, numbering as above.

Questions.—(*a*) Write the equation for the preparation of ether.

(*b*) Compare the boiling point of ether with that of ethyl alcohol and state which is the more volatile.

(*c*) Account for the sensation produced in Experiment No. 3 above.

(*d*) Does No. 3 suggest any use to which ether might be put? If so, explain.

(*e*) An American company had two men burned to death and another blown out of the window of the room where ether was being employed. Can you explain this?

(*f*) Could you suggest some safe method of distilling ether?

(*g*) What did you notice happen at the mouth of the bottle when pouring in Experiment No. 1?

EXERCISE No. XLII

ACETIC ACID

SUPPLIES.—*Bunsen burner, evaporating dish, stand and ring, stirring rod, test tube, test tube holder, test tube rack, wire gauze.*

Acetic acid (glacial), blue litmus paper, sodium bicarbonate, vinegar (malt).

Sketch.—None.

Experiments.—1. Pour into a test tube 2 cc. of vinegar, and into another tube the same quantity of glacial acetic acid. Examine the physical properties of both (**do not taste**).

2. Add 10 cc. of water to the glacial acetic acid and shake. Note what happens. Taste a drop of this and also a drop of vinegar, using a clean stirring rod to put the liquid on the end of your tongue.

3. Test both the vinegar and the dilute acetic acid with blue litmus.

4. Add a pinch of sodium bicarbonate to each. Note what happens. As soon as the reaction ceases, cover the test tube with the thumb and test the gas enclosed with a burning match.

5. Evaporate the liquid left in the tube and note the residue.

Observations.—State your observations, numbering as above.

Deductions.—State your conclusions, numbering as above

(**Questions.**—(*a*) How is vinegar prepared? Equation.

(*b*) What is meant by glacial acetic acid? (Dictionary.)

(*c*) Write the equation for the reaction in Experiment No. 4 above.

(*d*) What name is given to the residue obtained in Experiment No. 5 above?

EXERCISE No. XLIII

SOAP

SUPPLIES.—*Bunsen burner, balance and weights, evaporating dish, graduate, iron stand and ring, stirring rod, test tubes, test tube rack, wire gauze.*

Alcohol, distilled (or rain) water, lard, sodium hydroxide solution (2 grms. to 5 cc. of water). Solutions of calcium chloride, magnesium sulphate, sulphuric acid conc.

Sketch.—None.

Experiments.—*Weigh 5 grms. of lard, place the lard in an evaporating dish, add 10 cc. of absolute alcohol and stir well. Add 5 cc. of the sodium hydroxide solution. Stir thoroughly, and heat until the odor of alcohol has all disappeared. The alcohol is not absolutely necessary to bring about the reaction, but is added because it dissolves the fat, and so in this way hastens the reaction.

Observe the residue left in the dish. Add a little cold water, stir and filter.

1. Wash your hands with a little distilled water and a few drops of soap solution.

2. Wash your hands with a little dilute calcium chloride solution and a few drops of soap solution.

---

*Note.—As it takes some time to prepare the soap, the teacher may, if desired, have the tests mentioned performed on some laundry soap, while the evaporating is going on, and later on the pupil may work on the substance prepared by himself.

3. Place in separate test tubes a few drops of solution of calcium chloride and of magnesium sulphate. Add to each a few drops of soap solution. Note what happens. Compare with (1) and (2) above.

4. To a little strong soap solution add a few drops of conc. sulphuric acid, shake and warm. Note the formation of the oily ring on the surface of the liquid. This is the fatty acid.

Observations.— State your observations, numbering as above.

Deductions.— State your conclusions, numbering as above.

Questions.— (*a*) Write the equation for the preparation of soap, if lard is composed of glyceryl palmitate.

(*b*) What is meant by hard water?

(*c*) Why is hard water not desirable for washing purposes?

(*d*) What important substance is obtained as a by-product in the manufacture of soap?

(*e*) Write the equation for the reaction in Experiment No. 4. (Metathetical reaction.)

EXERCISE No. XLIV

BENZOL AND GLYCERINE

SUPPLIES.—*Cover glass, evaporating dish, test tubes, test tube rack.*

Benzol, glycerine, litmus paper (red and blue), roll sulphur.

Sketch.—None.

Experiments.

(A) **Benzol.**

1. Note the physical properties of benzol.

2. Place a piece of roll sulphur (size of a pea) in a test tube and cover with benzol. Shake and note what happens.

3. Place a drop of benzol in an evaporating dish and bring a lighted match in contact with it.

(B) **Glycerine.**

1. Note the physical properties of glycerine. Taste a little.

2. Try its solubility in water by pouring a drop into 10 cc. of water in a test tube.

3. Try its action on red and blue litmus paper.

4. Try if it will burn.

5. Place one drop of glycerine on a cover glass. Allow to stand until next lesson and note result.

Observations.—State your observations.

Deductions.—State your conclusions.

Questions.—(*a*) What is the source of benzol?

(*b*) Write formula of benzol.

(*c*) State uses of benzol.

(*d*) Write equation for the preparation of glycerine.

(*e*) Write equation for the preparation of nitro-glycerine.

(*f*) Write a note on dynamite.

EXERCISE No. XLV

CARBOHYDRATES

SUPPLIES.—*Bunsen burner, cover glass, filter paper, stand and rings, test tubes, test tube holder, test tube rack, wire gauze.*

Absolute alcohol, absorbent cotton, cane sugar, ether, Fehling's solution A and B, glucose, icing sugar, iodine solution, milk sugar, starch solution, conc. sulphuric and nitric acids.

Sketch.—None.

Experiments.—(If the tin of glucose is placed in a can of boiling water, the glucose may be removed more easily.)

1. Place on a **clean** cover glass a small quantity (1 grm.) of each of the following:—milk sugar, cane sugar, glucose. Note their physical properties. Compare the taste of each.

2. Into a test tube put 3 grms. of cane sugar and into another tube a like quantity of milk sugar. Add to each test tube 10 cc. of cold water and shake vigorously. Note what happens.

Keep the solution of cane sugar for Experiment No. 5.

3. (*a*) Try the solubility of a little glucose (size of a pea) in 10 cc. water.

(*b*) Test part of the solution made in (*a*) with iodine solution for starch. *Keep the rest of the solution for Experiment No. 5.

*These parts may be omitted.

4. (*a*) **Take 1 grm. of icing sugar, dissolve in water, bring to a boil and cool. Add a little iodine solution. Note what happens. (Icing sugar often contains starch.)**

(*b*) **Try a sample of baking powder as above.**

***5. Fehling's test for glucose.**

Mix equal parts (2 cc. of each) of Fehling's solution (A) and (B), and bring to a boil. Note what happens. If nothing happens you know that the Fehling's solution is suitable for the test.

Add to the mixed Fehling's solution a few drops of cane sugar solution. Boil. Repeat with glucose solution. Boil. Tabulate results.

6. (*a*) Try the action of cold water on 1 grm. of powdered starch. Heat to boiling and note what happens. *Divide into two portions, and treat as below.

*(*b*) Try the action of Fehling's solution on starch solution.

*(*c*) Boil a little starch solution with a few drops of sulphuric acid. **Neutralize** the acid with sodium carbonate and test with Fehling's solution. Compare with 6 (*b*) and results of Experiment No. 5.

7. Make a mixture of concentrated sulphuric and nitric acids (10 cc. sulphuric and 5 cc. nitric). Cool the mixture to room temperature. Immerse in this for one minute a small piece of absorbent cotton; then wash the cotton thoroughly in much cold water. Wring out all the water possible and allow to dry in the open air **at room temperature** on blotting paper. This material must be carefully handled.

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*These parts may be omitted.

(*a*) Ignite on a wire gauze *a small portion* of the dried nitrated cotton and also a small piece of absorbent cotton. Compare rates of combustion.

(*b*) Agitate a piece of the nitrated cotton with a mixture of 5. cc. of ether and 3 cc. of alcohol. Pour the solution on to a glass plate. Allow to stand and note result. **Keep all flames away.**

Observations.—State your observations, numbering as above.

Deductions.—S your conclusions, numbering as above.

Questions.—(*a*) What evidence have you obtained, by experiments previously performed, with regard to the composition of the carbohydrates?

(*b*) Write the formulas for the carbohydrates worked on.

(*c*) Why do we perform Experiment No. 3 (*b*)?

(*d*) Of what use are the carbohydrates?

(*e*) Write the equation for the reaction in Experiment 6 (c) (starch and sulphuric acid).

(*f*) Write a note on the preparation of—

1. Glucose,
2. Cane sugar,
3. Milk sugar,
4. Starch.

EXERCISE No. XLVI

PROTEIDS

SUPPLIES.—*Beaker, Bunsen burner, clamp, funnel, filter paper, mortar, test tubes and rack, test tube holder, thermometer, stand and ring, gauze.*

Ammonium hydroxide, dried egg albumen, fresh egg, flour, gelatine, conc. hydrochloric acid, iodine solution, lead acetate solution, milk, conc. nitric acid, potassium hydroxide solution, red litmus paper, soda lime, woollen cloth.

Sketch.—Apparatus used in No. 2 (*b*).

1. **Experiments.**—(*a*) Heat in a test tube a mixture of soda lime and dried egg albumen or gelatine. Note odor, and test the gas given off with red litmus paper.

(*b*) To 4 or 5 cc. of egg albumen solution add an equal volume of strong potassium hydroxide and 1 or 2 drops of lead acetate solution; boil the mixture for one minute. Note what happens. (See Exercise XXVI, Exp. 3.)

(*c*) Warm a little gelatine in a test tube—note cool part of the tube.

(*d*) Heat the tube used in (*c*) strongly. Note residue.

2. (*a*) Try the solubility of albumen obtained from a fresh egg in cold water, and in boiling water.

(*b*) Place a little egg albumen obtained from a fresh egg in a test tube and put a thermometer in the tube. Clamp the test tube in a beaker of water placed on a wire gauze and gradually raise the temperature. Note the temperature at which the albumen coagulates.

3. Mix 10 grms. of flour in **just sufficient** water to make a dough. Place the dough in a mortar and fill the mortar

with water. Knead with the fingers and pour the milky fluid into a clean beaker. Add other portions of water and knead until the water poured off is no longer milky.

(*a*) Test the liquid poured off with a drop of iodine solution. Note what happens.

(*b*) Examine the gummy substance left in the mortar. Note its properties.

*4. **Xanthoproteic Test.**— (*a*) This is a test for the proteids. To 2 or 3 cc. of nitric acid add an equal volume of protein solution (egg albumen solution) and heat. Note the white precipitate turning yellow and dissolving to a yellow solution. Cool under the water tap and float ammonium hydroxide on the mixture. Note the orange ring.

(*b*) Try the action of nitric acid and ammonia on a piece of woolen cloth.

5. To 10 cc. of milk in a test tube add a little (1 cc.) hydrochloric acid and shake. Note what happens. Separate the curd from the whey by filtering.

*Try Xanthoproteic test on the curd.

Observations.—State your observations, numbering as above.

Deductions. State your conclusions, numbering as above.

Questions.— (*a*) (1) Of what importance are the proteids to animal life? (2) From Experiment No. 1 state the elements which you found in the proteids.

(*b*) What is the curd which separates out in Experiment No. 5 called?

(*c*) What substance already studied can be obtained from whey?

(*d*) Explain carefully why the following are such excellent foods (1) milk, (2) wheat flour, (3) beans.

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*These parts may be omitted.

EXERCISE No. XLVII

SILICON

SUPPLIES.—*Cover glass, knife, test tube, test tube holder, test tube rack.*

Hydrochloric acid, marble, quartz, water-glass (Na_2SiO_3).

Sketch.—None.

Experiments.—1. Examine a piece of quartz. See if it will scratch glass. Try to scratch it with a knife.

2. Examine a piece of marble. See if it will scratch glass. Try to scratch it with a knife.

3. Place a chip of quartz and one of marble in a test tube. Add dilute hydrochloric acid and note what happens.

4. Examine some water-glass (sodium silicate). Test its solubility in water. Add some hydrochloric acid to the solution and note the result.

Observations.—State your observations.

Deductions.—State your conclusions.

Questions.—(*a*) Mention the different varieties of silicon.

(*b*) What is water-glass chemically? How is it prepared? For what is it used?

(*c*) Write the equation for the reaction which occurs on the addition of hydrochloric acid to water-glass. (Simple metathetical reaction.)

(*d*) Mention some artificially prepared silicates of commercial importance.

(*e*) Write a note on carborundum.

EXERCISE No. XLVIII

BORON

SUPPLIES. *Bunsen burner, evaporating dish, filter paper, gauze, iron stand and ring, pipe clay triangle, platinum wire (sealed into glass tube), test tubes, test tube holder, test tube rack.*

Absolute alcohol, borax, boric acid, copper foil, litmus paper, sulphuric acid conc.

Sketch. None.

Section A, Boric Acid.

Weigh out 2 grms. of boric acid crystals, and place them on a piece of paper.

Experiments. 1. Note the physical properties, especially the feel.

2. *(a)* Place 2 grms. (already weighed out) in a clean test tube and add 10 cc. of cold water. Close the tube with the thumb and shake vigorously. Note what happens to the solid.

(b) Heat the test tube containing the water and boric acid. Note what happens.

(c) Try the action of the solution on blue litmus paper.

3. **Test for Boric Acid.**

Pour 1 cc. of the solution prepared in Experiment No. 2 *(b)* into an evaporating dish. Add 2 cc. of absolute alcohol. Place the dish on a wire gauze and warm gently. Remove Bunsen burner, ignite the vapors given off and note the color of the flame.

Section B, Borax.

Weigh out 2 grms. of borax crystals and put the substance on a piece of paper.

Experiments. 1. Examine its physical properties.

2. Place a small piece of borax in a clean, dry test tube and heat. Note the cool part of the tube. Note what happens to the borax on heating.

3. Try the action of borax on red litmus paper. Compare with No. 2 (*c*), Section A.

4. (*a*) Place a piece of copper foil (1½ inches x 1½ inches) on a pipe clay triangle, supported by an iron stand. Heat until the surface of the copper is oxidized. Cool and place 1 grm. of borax on the foil. Heat until the borax fuses to a thin liquid, allow to cool. Compare the uncovered surface of the metal with the surface covered by the borax.

(*b*) **Borax Bead Test**—(Optional).

Draw a piece of tubing out to a jet; insert into the jet a piece of platinum wire and melt the glass round the wire (Figs. 56 A and B). Bend the end of the platinum wire into a small loop. This can be done by bending around the pointed end of a lead pencil. Heat the platinum wire until it is red hot and plunge into some borax. You will find that the wire will pick up some of the borax. Heat the wire, with the borax adhering, in the hottest part of the flame, until the borax fuses. This is called a borax bead. Place a **tiny particle** (pin point) of cobalt nitrate on the bead; again heat until you get a thin liquid. Cool and examine the bead.

FIG. 56.

If members of the class work on different salts the beads may be tabulated. (Salts suggested are nickel, manganese, cobalt, iron, chromium.)

5. Dissolve 5 grms. of borax in 10 cc. of hot water. Allow to cool somewhat, and add **slowly** and **carefully** 5 cc. of conc. sulphuric acid, with constant stirring. Note crystals formed.

Allow to stand in your locker until next day and again examine.

Question.—(*a*) Write the formulas for borax and boric acid.

(*b*) State the uses of boric acid and borax.

(*c*) Does Experiment No. 4 (*a*) Section B suggest any use to which borax may be put? Explain.

(*d*) Write equation for the reaction in Experiment No. 5 above.

EXERCISE No. XLIX

PREPARATION OF SODIUM HYDROXIDE

SUPPLIES.— *Bunsen burner, beakers, evaporating dish, iron stand and ring, stirring rod, watch glass, wire gauze.*

Dilute hydrochloric acid, quicklime (CaO), red litmus paper, sodium carbonate (Na_2CO_3, $10H_2O$); solutions of silver nitrate and copper sulphate.

Sketch.—None.

Experiments.

1. Weigh out 10 grms. of sodium carbonate, place the material in the 250 cc. beaker and dissolve in 50 cc. of water.

2. Weigh out 5 grms. of powdered quicklime; place the material in the large beaker; add water until a thin milky liquid is obtained.

3. Testing for carbonate. Test in test tubes, 2 cc. of each of the above solutions for carbonate by the addition of 2 or 3 drops of hydrochloric acid. Note results.

4. Pour the sodium carbonate into the "milk of lime" ($Ca(OH)_2$), stirring constantly.

5. Boil the mixture for some time (10 minutes) with constant stirring; add water to replace that lost by evaporation.

6. Allow to settle and test a little of the supernatant liquid with dilute hydrochloric acid. If the presence of carbonate is noted, continue boiling until you fail to get the test for carbonate.

7. (*a*) Allow to settle, pour off the supernatant liquid and evaporate it in an evaporating dish. Note product obtained.

(*b*) Test residue left in beaker with dilute hydrochloric acid. Note result.

8. Dissolve the substance obtained in 7 (*a*) in a little water, and

(*a*) Try action on red litmus paper.

(*b*) Try action on silver nitrate solution and copper sulphate solution.

(*c*) Rub a little between the fingers.

9. Examine a little sodium hydroxide solution obtained from the beuches as follows:—

(*a*) Try action on red litmus paper.

(*b*) Try action on silver nitrate and copper sulphate solutions.

(*c*) Rub a little between the fingers.

Compare these results with the results of Experiment No. 8.

Observations.—State your observations, numbering as above.

Deductions. State your conclusions, numbering as above.

Questions.—(*a*) Write the equation for the preparation of sodium hydroxide from "milk of lime" and sodium carbonate.

(*b*) What is the composition of the residue left in the beaker after the supernatant liquid is poured off?

(*c*) Under what name is sodium hydroxide sold commercially?

(*d*) State uses to which sodium hydroxide may be put.

(*e*) Calculate the quantity of quicklime required to convert 10 grms. of sodium carbonate into sodium hydroxide, using the formulas given at the top of this paper.

(*f*) What kind of anhydride is CaO?

EXERCISE No. L

CALCIUM COMPOUNDS

SUPPLIES.—*Bunsen burner, crucible, crucible tongs, filter paper, funnel, glass tube 8" long, iron stand and ring, pipe clay triangle, test tube, test tube holder, test tube rack.*

Gypsum, hydrochloric acid (dil.), plaster of Paris, powdered marble or precipitated chalk, red litmus paper, soap solution.

Sketch.– None.

Experiment.

1. Place in a crucible ½ grm. of precipitated chalk or finely powdered marble.

Set the uncovered crucible on a triangle, placed on an iron stand and gradually heat the crucible until it is raised to the highest temperature attainable in the Bunsen flame. Heat for 15 minutes. Allow to cool.

(*a*) Put a little of the precipitated chalk (or marble) on some moistened red litmus paper and note result.

(*b*) Put a little of the heated chalk (or marble) on some moistened red litmus. Note result. Compare with (*a*).

(*c*) Pour 5 cc. of water into a test tube. Hold the tube by the closed end and add the material which has been heated in the crucible. Note what happens to the hand holding the test tube by the closed end.

(*d*) Shake the test tube and filter the liquid into a clean test tube. Add 10 cc. of water to the filtrate and

blow into it by means of a glass rod. Note what happens. Carefully examine the density of the substance formed.

(*e*) Continue blowing into the test tube for several minutes and again examine the density of the material.

(*f*) If the liquid in the test tube does not entirely clear up, filter and divide into two parts and treat as in (*g*) and (*h*).

(*g*) Boil part of the filtrate and note what happens.

(*h*) Add to part of the filtrate some soap solution and note result.

2. Try the flame test for calcium salts. See Exercise XXXVIII, 4 (*b*).

3. (*a*) Heat a piece of gypsum in a test tube (Fig. 7). Note what happens.

(*b*) Examine some plaster of Paris. Add a little water to a little plaster of Paris and allow to stand for some time. Note result.

Observations.—State your observations, numbering as above.

Conclusions. State your conclusions, numbering as above.

Questions.—Write the equation for: —

(*a*) The heating of marble.

(*b*) The slaking of lime.

(*c*) The action of carbon dioxide on lime-water.

(*d*) Carbon dioxide causing calcium carbonate to dissolve.

(*e*) The heating of gypsum.

(*f*) The setting of plaster of Paris.

(*g*) The setting of mortar.

QUALITATIVE ANALYSIS OF SINGLE SALTS

The outline which follows is provided for use only where the time for laboratory work is ample. It is not intended to teach analytical chemistry, but merely to give an idea, in a very simple way, of how certain practical results are obtained—the object is to stimulate interest (resulting perhaps in the securing of recruits for more advanced chemical work), not to train analysts. For more information on the subject, one of the larger works on qualitative analysis must be consulted.

It must be remembered that the scheme which follows is applicable only in the case of single salts—not mixtures.

Inasmuch as the general subject of bringing solids into solution is very complex, the instructor will do well to provide the single salts in the form of solutions, except in those cases where they can be easily and completely dissolved in water. The solution thus provided, or prepared by the pupil, is what is known as the *original solution*.

In using the scheme, it is suggested that pupils, working singly, be first given solutions the composition of which they are told; they can then see from the outline just what results they should get as they work them through. Having obtained a certain amount of experience in this way, they are then ready to proceed to the examination of salts, the composition of which is known only to the teacher.

All reactions are carried out in ordinary test tubes, unless otherwise directed.

In examining a new substance, the pupil must always start at the beginning of the scheme: the later portions of the table presup; ose negative results in the former portions, as indicated by the directions.

In reporting results, metallic and acid radicle of the salt examined should be given, and also its proper name: e.g., copper, sulphuric acid—copper sulphate.

All apparatus used must be scrupulously clean. Test tubes must be washed out with the aid of the test-tube brush and afterwards rinsed out with fresh, clean water.

Contractions used

Insol. . . . . Insoluble.	Sol. . . . . Soluble.
Ppt. . . . . Precipitate.	Soln . . . . . Solution.

GROUPING OF THE METALLIC RADICLES

Group	Metals	Characteristics of the Groups
I. Silver Group	Silver Ag′ Lead Pb″ Mercurosum Hg′	The chlorides are insoluble in H_2O and dil. HCl, and so are pptd. from solution by dil. HCl.
II. Copper and Arsenic Group	(a) Copper Cu″ Mercuricum Hg″ Lead Pb″ Bismuth Bi‴ Cadmium Cd″ (b) Arsenic As‴ Antimony Sb‴ Tin Sn″	The chlorides are sol. in H_2O and therefore are not pptd. by HCl. The sulphides are insol. in dil. HCl and are therefore pptd. by H_2S in dilute acid solution. Sulphides of metals under (a) are insol. in $(NH_4)_2$ Sx. Those under (b) are sol. in this reagent.

GROUPING OF THE METALLIC RADICLES — *Continued*

Group	Metals		Characteristics of the Groups
III			
Iron Group	(a) Iron Fe'' or Fe'''		The chlorides are sol. in H_2O and therefore are not pptd. by HCl.
	Aluminium	Al'''	
	Chromium	Cr'''	
	(b) Manganese	Mn''	The sulphides and hydroxides are sol. in dil. acids and are therefore not pptd. by H_2S in presence of HCl.
	Zinc	Zn''	
	Nickel	Ni''	
	Cobalt	Co''	
			The sulphides are insol. in alkaline soln. and are pptd. by $(NH_4)_2S$.
			Metals under *a)* are pptd. by NH_4OH in presence of NH_4Cl and $(NH_4)_2S$ as hydroxides; those under (b) are not.
			Metals under (b) are pptd. by $(NH_4)_2S$ in presence of NH_4Cl and NH_4OH as sulphides.
IV.			
Barium Group	Barium	Ba''	The chlorides are soluble in H_2O and are therefore not pptd. by HCl.
	Strontium	Sr''	
	Calcium	Ca''	
			The sulphides are not formed in presence of H_2O and are therefore not pptd. by H_2S in acid or alkaline soln.
			The hydroxides are sol. in NH_4Cl (which is added in Gr. III to prevent their pption. there).
			The carbonates are insoluble, and are pptd. by $(NH_4)_2CO_3$ in presence of NH_4Cl.

GROUPING OF THE METALLIC RADICLES — *Continued*

Group	Metals	Characteristics of the Groups
V. Magnesium Group	Magnesium Mg''	The chloride is sol. in H_2O and is therefore not pptd. by HCl. The sulphide is not formed in presence of HCl and is therefore not pptd. by H_2S. The hydroxide is sol. in NH_4Cl and is therefore not pptd. in Gr. III or IV. The carbonate is not pptd. in presence of NH_4Cl. gNH_4PO_4 is pptd. on addition of NH_4OH and NH_4Cl and Na_2HPO_4.
VI. Potassium Group	Potassium K' Sodium Na Ammonium NH_4'	The chlorides, sulphides, hydroxides, carbonates and phosphates are sol. in H_2O and are therefore not pptd. by HCl, H_2S, $(NH_4)_2S$, NH_4OH, $(NH_4)_2CO_3$, Na_2HPO_4.

GROUPING OF THE ACID RADICLES

Group	Radicle of	Characteristics of the Group
A. Carbonate Group	H_2CO_3, Carbonic acid H_2S, Hydrosulphuric acid H_2SO_3, Sulphurous acid	Salts of these acids give off characteristic gases when acted on by dil. HCl or HNO_3.

GROUPING OF THE ACID RADICLES—*Continued*

Group	Radicle of	Characteristics of the Group
B. Chloride Group	HCl, Hydrochloric acid HBr, Hydrobromic acid HI, Hydriodic acid	Salts of these acids give ppts. with $AgNO_3$ which are insol. in dil. HNO_3.
C. Nitrate Group	HNO_3, Nitric acid	Nitrates give no ppts. with ordinary reagents.
D. Phosphate Group	H_3PO_4, Phosphoric acid	Phosphates give a ppt. with $AgNO_3$ which is sol. in HNO_3 and also in NH_4OH.
E. Sulphate Group	H_2SO_4, Sulphuric acid	Sulphates give a ppt. with $BaCl_2$ which is insol. in hot dil. HCl.

ANALYSIS OF SINGLE SALTS

I.—EXAMINATION FOR THE METALLIC RADICLE

GROUP I

To a portion of the original soln. add dil. HCl.

No ppt. forms. Pass on to Group II.

A ppt., white, indicates Ag, Pb, or Hg′.

Treat the ppt. with NH_4OH.

(A) NH_4OH dissolves ppt. Indicates Ag.

Confirm by adding NaOH to some of the original soln.

A dark brown ppt. confirms Ag.

(B) NH_4OH turns ppt. black. Indicates Hg.′

Confirm by adding K_2CrO_4 to some of the original soln.

A scarlet ppt. confirms Hg.

(C) NH_4OH produces no visible change in ppt. Indicates Pb.

Confirm by adding dil. H_2SO_4 to original soln.

A white ppt. confirms Pb.

GROUP II

To the portion of the original soln. in which HCl has produced no ppt. add H_2S in excess and warm.

No ppt. forms. Pass on to Group III.

A ppt. indicates Hg″, Bi, Cu, Cd, (Pb), As, Sb, or Sn.

Treat ppt. with $(NH_4)_2S_x$.

(**A**) Ppt. is insol. in $(NH_4)_2S_x$. Indicates Hg″, Bi, Cu, Cd (or Pb).

1. *To original soln. add NaOH.*

No yellow ppt. forms. Pass on to (2).

Yellow ppt. indicates Hg″.

Confirm by adding $SnCl_2$ to original soln.

A grey or black ppt. confirms Hg″.

2. *To original soln. add* NH_4OH.

(*a*) Formation of deep blue soln. indicates Cu.

Confirm by adding $K_4Fe(CN)_6$ to original soln.

A chocolate ppt. confirms Cu.

(*b*) White ppt. (perhaps rapidly redissolving) indicates Bi or Cd.

Ppt. dissolves in excess of NH_4OH. Indicates Cd.

Confirm by adding HCl and H_2S to original soln.

A yellow ppt. confirms Cd.

Ppt. remains undissolved in excess of NH_4OH. Indicates Bi.

Confirm by adding HCl and H_2S to original soln.

A black ppt. confirms Bi.

(**B**) Ppt. is sol. in $(NH_4)_2S_x$. Indicates As, Sb, or Sn.

1. Ppt. is yellow. Indicates As.

Confirm by adding a few pieces of copper turnings or wire and some HCl to original soln. and boiling.

A greyish deposit on the copper confirms As.

2. Ppt. is orange. Indicates Sb.

Confirm by allowing a piece of zinc to lie in contact with a piece of platinum foil in original soln., to which some HCl has been added.

Black stain on the platinum confirms Sb.

3. Ppt. is brown. Indicates Sn.

Confirm by adding $HgCl_2$ to original soln.

White or grey ppt. confirms Sn.

GROUP III

To a fresh portion of the original soln. add an excess of NH_4Cl and then NH_4OH.

No ppt. forms. Pass on to (**B**).

(**A**) A ppt. indicates Fe″, Fe‴, Al, or Cr.

1. Ppt. is dull green. Indicates Fe″.

Confirm by adding $K_3Fe(CN)_6$ to original soln.

Deep blue ppt. confirms Fe″.

2. Ppt. is reddish-brown. Indicates Fe‴.

Confirm by adding $K_4Fe(CN)_6$ to original soln.

Deep blue ppt. confirms Fe‴.

3. Ppt. is white and translucent. Indicates Al.

Confirm: To about 12 drops of the original soln. add about 3 drops of $Co(NO_3)_2$; absorb in a small piece of filter paper, dry and ignite on an inverted crucible lid, and heat very strongly by directing Bunsen flame downwards directly on to the ash.

Blue mass confirms Al.

4. Ppt. is pale bluish-green. Indicates Cr.
Confirm by borax bead test. (Exercise XLVIII, B.)
Emerald green bead confirms Cr.

(**B**) *To soln. to which NH_4Cl, and NH_4OH have been added, add $(NH_4)_2S$.*

No ppt. Pass on to Group IV.
A ppt. indicates Zn, Mn, Ni, or Co.
1. Ppt. is white. Indicates Zn.
Confirm by $Co(NO_3)_2$ test, as described above under Al.
Green mass confirms Zn.
2. Ppt. is flesh-colored. Indicates Mn.
Confirm by borax bead test.
Amethystine bead confirms Mn.
3. Ppt. is black. Indicates Ni or Co.
Add NaOH to original soln.
(*a*) Ppt. is apple-green. Indicates Ni.
Confirm by borax bead test.
Reddish-brown bead confirms Ni.
(*b*) Ppt. is pale blue. Indicates Co.
Confirm by borax bead test.
Blue bead confirms Co.

GROUP IV

To a portion of the original soln. add NH_4Cl, NH_4OH, and $(NH_4)_2CO_3$.

No. ppt. Pass on to Group V.
White ppt. indicates Ba, Sr. or Ca.
To original soln. add $CaSO_4$.
1. An immediate white ppt. Indicates Ba.
Confirm by flame test. (Exercise XXXVIII, 4 (b)).
Green flame confirms Ba.

2. A ppt. after standing some time, or on warming, indicates Sr.

Confirm by flame test.

Crimson flame confirms Sr.

3. No ppt. indicates Ca.

Confirm by flame test.

Brick-red flame confirms Ca.

GROUP V

To a portion of the original soln. add NH_4Cl, NH_4OH and Na_2HPO_4.

No ppt. on standing. Pass on to Group V.

White ppt. indicates Mg.

Confirm by $Co(NO_3)_2$ test as described above under Al.

Pink mass confirms Mg.

GROUP VI

(*a*) **To a portion of the original soln. add NaOH and warm.**

No NH_3 evolved. Pass on to (*b*).

NH_3 is evolved, recognized by odor and its (the gas's) action on red litmus paper. Indicates NH_4.

(*b*) **To a portion of the original soln. add strong solution of sodium acid tartrate, $NaHC_4H_4O_6$, and shake vigorously.**

No ppt. Pass on to (*c*).

White ppt. indicates K.

Confirm by flame test.

Violet flame confirms K.

(*c*) Apply flame test to original soln.

Bright persistent golden yellow flame confirms Na.

II.—Examination for the Acid Radicle

GROUP A

To a portion of the original soln. add dil. HNO_3.

No gas is evolved. Pass on to Group B.

A gas is evolved.

1. Gas is odorless, CO_2. Indicates H_2CO_3.

Confirm by holding a drop of lime-water on the end of a glass rod in the gas.

Lime-water turns milky. Confirms H_2CO_3.

2. Gas smells like burning sulphur, SO_2. Indicates H_2SO_3.

Confirm by holding a drop of K_2CrO_4 on the end of a glass rod in the gas.

K_2CrO_4 turns pale green. Confirms H_2SO_3.

3. Gas smells like rotten eggs. Indicates H_2S.

Confirm by holding a drop of $Pb(C_2H_3O_2)_2$ on a glass rod in the gas.

$Pb(C_2H_3O_2)_2$ turns brownish-black. Confirms H_2S.

GROUP B

To the portion of the original soln. in which HNO_3 has produced no effect, add $AgNO_3$.

No ppt. Pass on to Group C.

A ppt. indicates HCl, HBr, or HI.

1. Ppt. is white. Indicates HCl.

Confirm by treating ppt. with excess of NH_4OH.

Ppt. dissolves. Confirms HCl.

2. Ppt. is yellowish-white. Indicates HBr.

(This ppt. is slightly sol. in NH_4OH.)

Confirm by adding MnO_2 and conc. H_2SO_4 to original soln. and warming.

Reddish-brown fumes of Br confirm HBr.

3. Ppt. is yellow. Indicates HI.

Confirm by adding MnO_2 and conc. H_2SO_4 to original soln. and warming.

Violet vapors are evolved, which turn a drop of starch soln. on the end of a glass rod held in them blue. Confirms HI.

GROUP C

To about half an inch of original solution in a test tube add an equal volume of conc. H_2SO_4; mix well and cool by running water over the outside of the tube. Pour a soln. of $FeSO_4$ in a gentle stream down the inclined test tube, so that the solns. mix as little as possible. If no immediate reaction, allow to stand five minutes.

No brown ring. Pass on to Group D.

A brown ring at the junction of the two solutions indicates HNO .

Confirm by adding a little strong H_2SO_4 to original soln. and some copper turnings or wire, and warming.

Reddish-brown fumes confirm HNO_3.

GROUP D

To about a quarter of an inch of $(NH_4)_2MoO_4$ in a test tube add about half its volume of original soln. to which a little HNO_3 has been added; if no immediate result, warm (do not boil) and allow to stand.

No yellow ppt. Pass on to Group E.

A bright yellow ppt. indicates H_3PO_4.

Confirm by adding $AgNO_3$ to the *neutral* original soln.

Yellow ppt., sol. in HNO_3 or in NH_4OH, confirms H_3PO_4.

GROUP E

To a portion of the original soln. add dil. HCl and $BaCl_2$.

A white ppt. indicates H_2SO_4. This ppt. is insol. in boiling dil. HCl.

SUPPLIES

The following lists contain the apparatus and chemicals that should be in a well-furnished laboratory. As has already been pointed out, these supplies can be very much cut down, where this is imperative, by a proper selection of experiments, and the use of a little ingenuity on the part of the instructor in devising substitutes.

PERMANENT SET OF APPARATUS FOR EACH GROUP OF TWO PUPILS WORKING TOGETHER

2 Beakers, one 250 cc. low form, lipped.
one 350 cc. " " "

3 Cover glasses (window glass, 3″ x 3″).

1 Porcelain evaporating dish, 80 mm. diam.

1 Erlenmeyer flask, 250 cc.

3 Gas bottles (tall jelly jars, 250 cc. capacity. Quantities used in experiments have been arranged for this size gas bottle).

4 ft. Glass tubing, 6 mm. outside diam. To be bent and cut according to directions in Exercise No. I.

6 Test tubes—soft glass (5″ long x ⅝″ inside diameter).

1 Test tube brush.

1 Test tube holder.

1 Test tube rack to hold six tubes.

1 Thistle tube (stem, 6 mm. outside diam., 10″ long).

1 Tin spoon—handle can be used as spatula for removing chemicals from bottles. May also be used as a deflagrating spoon.

1 Watch glass (3½″ diam.).

1 Wire gauze (6″ x 6″).

Additional Apparatus for Each Group of Two Pupils Working Together

(This apparatus to be loaned as required, and may be used by all classes in common.)

1 Bunsen burner.

1 Burette clamp.

1 Clay tobacco pipe.

1 Crucible, sheet iron, 1¾″ diameter.

1 Crucible and lid, porcelain (37 mm. diameter, No. 00).

1 pair Crucible tongs, single bend.

1 File, triangular, 4″ long.

1 Funnel, 2½″ diameter, long stem preferred.

1 Iron stand. Base 6½″ x 4″; rod 18″ high.

1 Iron ring, 3½″ diameter, for stand.

1 Mortar and pestle, porcelain (3″ diameter).

1 Pipe clay triangle to fit crucible.

1 Pneumatic trough, 12″ x 9″ x 5″, with overflow.

1 Retort, 50 cc. capacity.

2 Rubber stoppers.

1 One-hole, to fit glass test tube ⅝″ (16 mm.) diam.

1 Two-hole, to fit 250 cc. Erlenmeyer flask.

The size of this cork depends on the make of flask purchased; care should be taken that the large t.t. is got to fit this cork.

1 Rubber delivery tube (18″, white rubber tubing to properly fit glass tubing 6 mm. outside diameter).

1 Rubber tube, 18″ long, to fit Bunsen burner.

1 Test tube, hard glass (6″ x ⅝″).

1 Test tube, large (suggested 6″ x 1″), must fit two-hole cork used in Erlenmeyer flask.

1 Thermometer from – 10°C to 110°C, numbers etched on glass, must fit holes in rubber corks.

1 Wing top to fit Bunsen burner.

1 Wire gauze, copper or brass, 6″ x 6″, 48 mesh to the inch, for Exercise No. XXXVIII.

Allowance must be made for breakage. Beakers, 20%. Hard glass test tubes, 10%. Evaporating dishes, 15%. Soft glass test tubes, 50%. Flasks, 20%. Crucibles, 15%. It is also advisable to have a few extra pieces of the other apparatus to replace breakage.

Apparatus to be Used in Common by Every Eight Pupils

(This apparatus can be used by all classes in common.)

2 Chemical balances sensitive to .01 grm. with wts. 100 grms. to .01 grm.

2 Battery or hydrometer jars.

2 Deflagrating spoons without cover.

4 Bottles, 1 litre (Exercise No. X).

2 Burettes, 50 cc., in 10ths, complete with pinch cocks.

1 pk. Filter paper, 9 cm. diam.

4 pieces Glass tubing (hard), 6 mm. outside diam. 1 mm. wall.

2 Gas measuring tubes, 50 cc. in 10ths.

2 Graduates, 100 cc.

2 Horseshoe magnets.

2 Magnifying glasses (linen testers).

2 Pipettes, 10 cc.

Platinum foil, 1 sq. cm. (for Qual. Anal. only).

Platinum wire, 4 cms.

2 Round bottom flasks, 250 cc.

1 Rough balance (Roberval) with wts. (100 grms. to 1 grm.).

2 Rubber corks, 1-hole, to fit 250 cc. round bottom flask.

2 Screw pinch cocks.

2 Water baths—to rest on 3½″ ring of iron stand (enamel mug will answer).

Access to one complete set of reagent bottles.

Racks may be used to hold rubber corks; rubber delivery tubes may be left in the pneumatic troughs; burners, iron stands with ring and clamp attached may be left on the work bench; crucible tongs, funnels, hard glass test tubes, large glass test tubes, files, etc., may be lent as needed.

It is advisable to have pupils sign a receipt for the apparatus contained in their cupboard (permanent set) and to sign orders for glassware to replace broken articles. A small cash deposit from each pupil is an excellent means of rendering the pupils careful.

The teacher is recommended to have part of the class perform a quantitative experiment, while the rest carries out one which does not require the use of an accurate balance. In this way each pair has the use of a balance, and no time is lost in making weighings.

Chemicals for Eight Pupils

4 ozs. Acid, Acetic.
1 lb. Acid, Hydrochloric.
1 lb. Acid, Nitric.
2 lbs. Acid, Sulphuric.
4 ozs. Acetone.
8 ozs. Alcohol (pure).
8 ozs. Alcohol (methylated).

½ oz. Ammonium Carbonate.
4 ozs. Ammonium Chloride.
1 lb. Ammonium Hydroxide.
4 ozs. Ammonium Nitrate, C.P.
4 ozs. Ammonium Sulphate.
1 oz. Antimony Metal (powdered).
2 ozs. Barium Chloride, C.P. xtls.
8 ozs. Benzol.
1 oz. Bismuth (metal).
1 oz. Boric Acid.
2 ozs. Borax.
1 oz. Cadmium (metal.)
½ oz. Cadmium Sulphate, C.P.
4 ozs. Calcium Carbide.
1 oz. Calcium Carbonate (precipitated chalk).
1 oz. Calcium Chloride (anhydrous).
1 oz. Calcium Fluoride (powdered).
1 lb. Calcium Oxide (lime).
1 oz. Calcium Sulphate (precipitated).
1 oz. Camphor.
8 ozs. Carbon Bisulphide.
2 ozs. Charcoal (animal).
3 ozs. Charcoal (wood).
4 ozs. China Clay.
1 oz. Citric Acid.
1 oz. Copper Foil, very thin.
1 oz. Copper Turnings.
16 inches Copper Wire, No. 16 gauge.
3 ozs. Copper Oxide (wire form).

1 oz. Copper Sulphate, C.P.
4 ozs. Ether.
1 pkg. Cotton (absorbent).
1 oz. Cream of Tartar.
50 cc. Fehling's Solution, A.
50 cc. Fehling's Solution, B.
½ oz. Ferric Chloride, C.P.
1 oz. Ferrous Sulphate, C.P.
4 ozs. Glucose.
8 ozs. Glycerine.
1 oz. Gypsum (lump).
4 ozs. Hydrogen Peroxide.
2 ozs. Iodine (xtls.).
1 oz. Iron Filings.
2 ozs. Iron Powder (by hydrogen).
2 ozs. Iron Pyrites (powdered).
4 ozs. Iron Sulphide (Ferrous) (lump).
1 oz. Lamp-black.
2 ozs. Lead Foil.
1 oz. Lead Nitrate, C.P.
1 oz. Lead Acetate.
1 bottle Lime-water Tablets.
1 oz. Litmus Cubes.
2 bks. Litmus Paper, red and blue.
1 oz. Magnesium Ribbon.
1 oz. Magnesium Powder.
1 oz. Magnesium Sulphate.
8 ozs. Marble (chips).
1 oz. Milk Sugar.

½ lb. Manganese Dioxide.
1 oz. Mercury
1 oz. Mercuric Oxide.
1 oz. Nickel Sulphate.
4 ozs. Paraffin Wax.
1 oz. Phosphorus (yellow)
1 oz. Potassium Bromide.
2 ozs. Potassium Chlorate.
2 ozs. Potassium Hydroxide, C.P. sticks.
1 Potassium
1 Pyrogallic
Quinine (humps).
Rochelle Salts.
oz. Silver (solid).
½ Silver Nitrate.
1 oz. Sodium Acetate (dry).
1 oz. Soda Lime.
4 Sodium Carbonate (xtls., washing
1 Sodium Bicarbonate, C.P.
Sodium Chloride (table salt).
½ lb. Sodium Hydroxide sticks, C.P.
½ lb. Sodium Nitrate.
1 ozs. Sodium Nitrite.
Sodium Sulphate (crystals).
Sodium Sulphite.
lb. Sulphur (roll).
½ lb. Sulphur (flowers).
1 oz. Tin, granulated.
1 oz. Tartaric Acid.
1 lb. Zinc, granulated (must not contain much arsenic).
1 oz. Zinc Sulphate, C.P.

Materials Readily Obtained

1 Apple.
4 ozs. Baking powders, different kinds
1 bottle Soda water.
5 Candles.
4 oz. Coal (soft).
1 piece colored Cotton to bleach.
2 ozs. Cane sugar.
1 fresh Egg.
4 ozs. Flour.
2 ozs. Gelatine.
1 oz. Icing sugar.
4 ozs. Kerosene.
4 ozs. Lard.
1 Lemon.
1 oz. Meat.
4 ozs. Milk.
4 boxes Matches.
4 ozs. Olive oil.
1 Potato.
1 lb. Soap, Castile.
Splints (wood).
1 oz. Starch.
4 ozs. Turpentine.
4 ozs. Vinegar.
1 qt. Water (distilled).
4 ozs. Water-glass.
1 cake Yeast.

Bench Reagents

(Quantities here mentioned are extra and are required for eight pupils if Qualitative Analysis is to be undertaken.)

All reagents are C.P.

Acids: Hydrochloric (HCl) required, 3 lbs.
Nitrate (HNO_3) required, 3 lbs.
Sulphuric (H_2SO_4) required, 6 lbs.

The above-mentioned acids should be diluted with five times their volume of distilled water for ordinary use.

Ammonium Carbonate ($(NH_4)_2CO_3$) required, 1 lb.
250 grms of the salt: 100 cc. of Ammonium Hydroxide: dilute to 1 litre.

Ammonium Chloride (NH_4Cl) required, 1 lb.
80 grms to the litre.

Ammonium Hydroxide (NH_4OH) required, 6 lbs.
(Prepared same as the acids.)

Ammonium Sulphide (colorless) $(NH_4)_2S$ should be made frequently, as it goes over into yellow ammonium sulphide.
Saturate 250 cc. of ammonia (sp.g. .90 with hydrogen sulphide; add 150 cc. of ammonia (sp.g. .90) and 300 cc. of water.

Ammonium Sulphide (yellow) $(NH_4)_2S_x$. Add flowers of sulphur to colorless ammonium sulphide.

Hydrogen Sulphide (H_2S) required, 2 lbs. of iron sulphide and 3 lbs. of commercial hydrochloric acid.
Saturate distilled water with hydrogen sulphide, keep in amber-colored bottles.

Sodium Hydroxide ($NaOH$) required, 1 lb.
40 grms. to the litre.

Sodium Phosphate (Na_2HPO_4) required, ½ lb. 20 grms. to litre.

Special Solutions

Ammonium Molybdate: $(NH_4)_2MoO_4$, dissolve 30 grms. Ammonium Molybdate in 200 cc. distilled water, and pour with constant stirring into a mixture of 100 cc. conc. nitric acid and 100 cc. water.

Keep the liquid in a warm place for some hours and decant the clear solution for use.

Fehling's Solution:

A	Copper Sulphate	34.64 grms.
	Cold water	500 cc.
B	Sodium Hydroxide	50 grms.
	Sodium Potassium Tartrate	173 grms.
	Cold water	500 cc.

Mix equal quantities of A and B when it is desired to make a test for a reducing sugar.

Iodine Solution.—2 grms. of iodine and 5 grms. of Potassium Iodide, distilled water 100 cc.

Lead Acetate. $(Pb\ (C_2H_3O_2)_2.3H_2O$.

100 grms of the salt to 1 litre of water. Clear, by addition of glacial acetic acid.

Litmus Solution: Digest 5 or 6 grms. of coarsely powdered litmus with 200 cc. of distilled water for a few hours. Decant the clear liquid from the sediment and add dilute HNO_3 drop by drop with stirring until a violet tint is obtained. Keep in loosely stoppered bottles. A few drops of chloroform tends to prevent the formation of mould.

Neutralization Solutions: *For the purposes of Exercise XXIV, it is not necessary for the teacher to standardize the solutions. Make them up using the quantities here indicated and assume that the sodium hdyroxide contains 0.02 grms. NaOH per cc.*

Half Normal Sodium Hydroxide (N/2)—contains 20 grms. of NaOH dissolved in water and the total volume of solution made up to 1 litre. This solution will eontain 0.02 grm. of NaOH per cc.

Half Normal Hydrochloric Acid (N/2) contains 18.25 grms. of HCl per litre.

Dilute 42 cc. of HCl (Sp. g. 1.19—37% HCl) to 1 litre.

Half Normal Potassium Hydroxide (N/2) contains 28 grms. of KOH per litre.

Phenol Phthaleïn: Dissolve 5 grms. of phenol phthalein in 100 cc. of warm methylated spirit, dilute to one litre by the addition of a mixture of equal volumes of methylated spirit and water.

Soap Solution.—1 grm. of white Castile soap dissolved in 100 cc. of diluted alcohol (66 cc. alcohol 34 ce. water). If not clear, filter. Keep in a stoppered bottle.

Stannous Chloride—$SnCl_2$.—

Heat an excess of granulated tin with concentrated HCl (adding serap platinum to faeilitate the solution). Dilute with an equal volume of water and keep the solution in well stoppered bottles containing metallic tin.

Special List of Salts for Qualitative Analysis

This list is intended to give the requirements for eight pupils working separately. The amount of material used depends entirely on the methods followed by the teacher; the quantities mentioned below are for work done on a liberal scale.

All chemicals must be chemically pure (C.P.) and the quantities mentioned should be dissolved in a litre of distilled water.

Salt	Formula	Quantity required for eight Pupils, to be dissolved in 100 cc. water
Aluminium Sulphate	$Al_2(SO_4)_3$	80 grms.
Ammonium Thiocyanate	NH_4CNS	10 grms.
Arsenious Oxide	As_2O_3	10 grms.
Barium Chloride	$BaCl_2$	10 grms.
Bismuth Nitrate	$Bi(NO_3)_3$	10 grms.
Cadmium Sulphate	$CdSO_4$	10 grms.
Calcium Chloride	$CaCl_2$	80 grms.
Calcium Hydroxide	$Ca(OH)_2$. A saturated solution	5 grms. CaO
Calcium Sulphate	$CaSO_4$, $2H_2O$. A saturated solution	5 grms.
Chromium Sulphate	$Cr_2(SO_4)_3$	20 grms.
Cobalt Nitrate	$Co(NO_3)_2$	20 grms.
Copper Sulphate	$CuSO_4$	20 grms.
Ferric Chloride	$FeCl_3$	10 grms.
Ferrous Sulphate	$FeSO_4$, best to prepare fresh as needed	10 grms.
Lead Nitrate	$Pb(NO_3)_2$	20 grms.
Manganese Chloride	$MnCl_2$	10 grms.
Mercuric Chloride	$HgCl_2$	10 grms.
Mercurous Nitrate	$HgNO_3$, best to prepare as needed	10 grms.
Nickel Sulphate	$NiSO_4$	10 grms.
Potassium Antimonyl Tartrate	$KSbOC_4H_4O_6$	10 grms.
Potassium Bromide	K Br	20 grms.
Potassium Chloride	KCl	20 grms.
Potassium Chromate	K_2CrO_4	10 grms.
Potassium Ferricyanide	$K_3Fe(CN)_6$	10 grms.
Potassium Ferrocyanide	$K_4Fe(CN)_6$	10 grms.
Potassium Iodide	KI	10 grms.
Potassium Nitrate	KNO_3	40 grms.
Silver Nitrate	$AgNO_3$	10 grms.
Sodium Chloride	NaCl	10 grms.

Salt	Formula	Quantity required for eight Pupils, to be dissolved in 100 cc. water
Sodium Hydrogen Tartrate	$NaHC_4H_4O_6$	10 grms.
Stannic Chloride	$SnCl_4$	10 grms.
Strontium Nitrate	$Sr(NO_3)_2$	80 grms.
Zinc Sulphate	$ZnSO_4$	10 grms.

For additional chemicals needed for Qualitative Analysis see list under Bench Reagent Bottles.

Emergency Supplies

In a special place in the laboratory should be kept a bottle of hydrogen peroxide, to be used for washing wounds (or a saturated solution of boric acid may be employed); a bottle of carron-oil (equal parts of lime-water and linseed or olive oil, well shaken up), for burns; absorbent cotton, and narrow bandages; a pair of scissors and some small safety pins.

Buckets or boxes of sand for extinguishing burning oil, etc., should be at hand.

TABLES

TENSION OF AQUEOUS VAPOR, VAPOR PRESSURE OF WATER, IN MM. OF MERCURY

11° c.	9.8 mm.	17° c.	14.5 mm.
12°	10.5	18°	15.4
13°	11.2	19°	16.4
14°	11.9	20°	17.4
15°	12.7	21°	18.5
16°	13.5	22°	19.6

SOLUBILITIES OF SOME COMMON SOLIDS

Salt	Formula	Weight in grms. dissolved by 100 grms. of water	
		20°C	100°C
Ammonium Chloride	NH_4Cl	37.3	77.3
Barium Chloride	$BaCl_2.2H_2O$	42.2	73.5
Borax	$Na_2B_4O_7.10H_2O$	7.88	201.4
Calcium Chloride	$CaCl_2.H_2O$	74.5	205.0
Calcium Hydroxide	$Ca(OH)_2$	0.165	0.08
Calcium Sulphate	$CaSO_4.2H_2O$	0.25	0.222
Copper Sulphate	$CuSO_2.5H_2O$	42.31	203.32
Potassium Alum	$K_2SO_4.Al_2(SO_4)_3.24H_2O$	15.4	422.0
" Bromide	KBr	64.5	102.0
" Chlorate	$KClO_3$	7.2	60.0
" Chloride	KCl	35.0	56.6
" Iodide	KI	143.0	205.6
" Nitrate	KNO_3	31.7	247.0
Sodium Chloride	NaCl	36.0	39.7
" Nitrate	$NaNO_3$	84.9	180.0
" Sulphate	$Na_2SO_4.7H_2O$	58.35	202.6
Zinc Sulphate	$ZnSO_4.7H_2O$	161.60	633.6

SOLUBILITIES OF SOME COMMON GASES

Gas	Formula	1 cc. of water under 760 mm. dissolves at	
		0° C	40° C
Ammonia	NH_3	1148 cc.	403 cc.
Carbon Dioxide	CO_2	1.71 cc.	0.53 cc.
Hydrochloric Acid	HCl	506.0 cc.	387.0 cc.
Hydrogen	H_2	0.0214 cc.	0 0164 cc.
Hydrogen Sulphide	H_2S	4.686 cc.	.....
Nitrogen	N_2	0.0238 cc.	0.0118 cc.
Oxygen	O_2	0.0489 cc.	0.0218 cc.
Sulphur Dioxide	SO_2	79 78 cc.	18.76 cc.

VALENCIES OF SOME COMMON GROUPS

Group	Valence	Name of Compound Formed
CO_3	2	.....carbonate
NH_4	1	Ammonium .....
OH	1	..... hydroxide
NO_3	1	..... nitrate
SO_4	2	..... sulphate
PO_4	3	..... phosphate
CH_3	1	Methyl .....
C_2H_5	1	Ethyl ....

LIST OF THE MORE IMPORTANT ELEMENTS, WITH THEIR SYMBOLS, ATOMIC WEIGHTS AND MORE COMMON VALENCIES*

Element	Symbol	Atomic Weight	Valence
Aluminium	Al	27.1	3
Antimony	Sb	120.2	3
Arsenic	As	74.9	3 or 5
Barium	Ba	137.4	2
Bismuth	Bi	208.0	3
Boron	B	11.0	3
Bromine	Br	79.9	1
Cadmium	Cd	112.4	2
Calcium	Ca	40.0	2
Carbon	C	12.0	4
Chlorine	Cl	35.5	1
Chromium	Cr	52.0	3
Cobalt	Co	59.0	2
Copper	Cu	63.6	2
Fluorine	F	19.0	1
Gold	Au	197.2	3
Hydrogen	H	1.008	1
Iodine	I	126.9	1
Iron	Fe	55.8	2 or 3
Lead	Pb	207.1	2
Magnesium	Mg	24.3	2
Manganese	Mn	54.9	2 or 4
Mercury	Hg	200.6	1 or 2
Nickel	Ni	58.7	2
Nitrogen	N	14.0	3 or 5
Oxygen	O	16.00	2
Phosphorus	P	31.0	3 or 5
Platinum	Pt	195.2	4
Potassium	K	39.1	1
Silicon	Si	28.3	4
Silver	Ag	107.9	1
Sodium	Na	23.0	1
Strontium	Sr	87.6	2
Sulphur	S	32.0	2, 4 or 6
Tin	Sn	119.0	2 or 4
Zinc	Zn	65.4	2

*For a more complete list, see text book, p. 263