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PRACTICAL CHEMISTRY FOR
MEDICAL STUDENTS.

УДК 62-50



PRACTICAL CHEMISTRY

FOR MEDICAL STUDENTS:

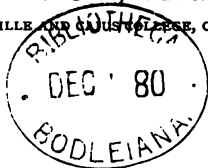
SPECIALLY ARRANGED FOR

THE FIRST M.B. COURSE.

BY

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PREFACE.

THE object of this little book is to supply a guide to the Medical Student in his study of practical Chemistry. Many books have been already written for the same purpose. None, so far as I am aware, confines itself rigidly within the limits of the information which the student *must* acquire. I believe that the text-books which are put into the hands of the Medical Student usually fail by attempting to teach too much. The student has a vague remembrance of coloured precipitates, of soluble and insoluble substances, of additions of reagents, and such things, but he has no idea of what it all means.

I have not written this little book in the hope that the student may be better able to "cram" for examination by its aid than he could do with the help of more detailed text books. But I have endeavoured so

to arrange the facts, and the methods, that what the student does he may do thoroughly, that he may learn as much as possible during his necessarily limited course, and that he may lay the foundation for future work, should he have time and inclination for such work.

Experience has convinced me that to burden the Medical Student with a long series of reactions for each metal and acid, and to attempt to teach him to perform more or less difficult separations of metals and acids, is altogether unwise. Far better that he should be able to perform the analysis of a simple salt well, than to blunder through the separation of half-a-dozen groups.

M. M. P. M.

PRACTICAL CHEMISTRY.

QUALITATIVE ANALYSIS is a branch of Practical Chemistry. The object of this analysis is the determination of the composition of chemical compounds and of mixtures of compounds. Mixtures may be resolved into two or more definite compounds, each of which may be again subdivided into its constituent elements. The determination of the composition of a compound therefore means the determination of the elementary bodies of which it is composed. But in a scheme of qualitative analysis, such as is contained in this book, compounds are regarded as made up of two parts—a metallic, and a non-metallic, or acid, radicle: the *metallic radicle* is, in almost every case, an elementary body; the *acid radicle* is, generally, a group of elementary bodies. The primary object of the analyst is, therefore, to discover what metallic and what non-metallic radicle is present in the compound given him

for examination. The course of analysis given in the following pages includes likewise the detection of a few of the commoner alkaloids, bodies which cannot be regarded (analytically) as made up of two distinct parts, and which must therefore be tested for as definite chemical wholes.

The substances to be tested for, in the analysis of salts, are subdivided—as we have already learned—into metallic and non-metallic radicles. Each of these groups is again subdivided into sections, the members of each of which have certain common properties. To illustrate the method of such subdivision the student must perform the following experiments :—

A small quantity of each of the following salts is to be dissolved in distilled water, in a *clean* test tube.

If the salt be not in the state of moderately fine powder it is to be reduced to that state by rubbing in a clean mortar ; solution is aided by warming the test tube over the Bunsen flame.

The salts to be used are—lead nitrate, corrosive sublimate, alum, calcium chloride, magnesium sulphate, and common salt.

The test tubes containing the solutions are placed in the stand, and to each a few drops of dilute *hydrochloric acid* are added.

In number one tube (lead nitrate) a white solid is immediately formed, and slowly settles to the bottom

of the tube.¹ The remaining solutions are unchanged.

A solution of *sulphuretted hydrogen* gas in water is now added to each tube, beginning at number two—a brownish-yellow precipitate, changing, on addition of more sulphuretted hydrogen, to black, is produced in number two tube; the other liquids remain unchanged.

Ammonium chloride, and subsequently *ammonium hydrate* (ammonia) and *ammonium sulphide* solutions are added to the remaining tubes—in number three a white precipitate is produced.

Ammonium carbonate solution is added to those tubes in which precipitates have not been as yet produced—a white precipitate forms in tube number four.

On adding *sodium phosphate* solution to liquids five and six, number five is alone precipitated.

These experiments teach that by the action of certain reagents (*hydrochloric acid, sulphuretted hydrogen, &c.*) certain metals may be distinguished from one another, inasmuch as some of these metals are precipitated by a reagent which does not cause precipitates in the other cases.

Each of the metals, a solution of whose salts have been employed, represents a class: one set of metals

¹ A solid formed in a liquid by the addition of another liquid, or of a gas, is called a **Precipitate**.

behaves like lead, they are all precipitated by hydrochloric acid; another set behaves like mercury, inasmuch as they are not precipitated by hydrochloric acid, but are precipitated by sulphuretted hydrogen, and so on.

Make solutions of **silver nitrate**, of **barium chloride**, and of **copper sulphate**, and to each add a little *hydrochloric acid*; in the first case only is a precipitate produced. Now add, to tubes two and three, *sulphuretted hydrogen*, a black precipitate forms in the case of the copper sulphate. To the remaining liquid add *ammonium carbonate*, a white precipitate is produced. **Silver**, therefore, belongs to the same group as **lead**; **barium** to the same group as **calcium**; and **copper** to the same group as **mercury**.

The reagents which have been used in the foregoing experiments are called *group reagents*, inasmuch as they precipitate, each, a group of metals. The members of each group are possessed of the common property of being precipitated by the group reagent, and by this property they are distinguished from the members of all other groups.

The experiments just performed teach that the action of each group reagent is not interfered with by the presence of those group reagents which have been previously added; this only holds good provided the group reagents are added in the order in which they

were used in the foregoing experiments. This is a point of some importance; to illustrate it further the student should perform the following experiment :—

To aqueous solutions of **lead nitrate**, **alum**, and **barium chloride** add *sulphuretted hydrogen* water—in the first liquid a black, and in the second a white precipitate is produced ; to the **barium chloride** solution add *sodium phosphate*—a white precipitate forms.

You are probably inclined to conclude that lead and aluminium belong to the sulphuretted hydrogen, and barium to the sodium phosphate group, but your former experiments have taught that lead belongs to that group, the members of which are precipitated by hydrochloric acid ; aluminium to that precipitated by ammonium chloride ammonia and ammonium sulphide, and barium to that precipitated by ammonium carbonate.

The non-metallic radicles cannot be subdivided into groups with the same exactness as is possible in the classification of the metallic radicles.

Make solutions in water of the following salts, attending to the directions given on page 8 ; be more especially careful that your test tubes are clean :—
(1) **sodium sulphate**, (2) **sodium phosphate**, (3) **sodium chloride**, (4) **sodium borate (borax)**, and (5) **potassium nitrate**.

To each solution add *barium chloride*—a white pre-

precipitate is produced in numbers 1, 2, and 4; to these tubes add a little hydrochloric acid—the precipitate in 1 remains, the precipitates in 2 and 4 dissolve.

Prepare fresh solutions of **common salt**, of **borax**, and of **potassium nitrate**, and to each add *silver nitrate* solution—in the first and second cases a white precipitate is produced; while the liquid in the third tube remains unchanged. Add a little nitric acid to the two precipitates—that produced in the solution of borax dissolves, the other remains.

These experiments teach that **phosphoric**, **boric**, and **sulphuric acids** belong to the same group, inasmuch as they yield white precipitates, on addition of barium chloride; but that the group may be subdivided by taking advantage of the fact that barium sulphate is insoluble, while barium phosphate and barium borate are soluble in hydrochloric acid. Further, that **boric acid** belongs to the same group as **hydrochloric acid**, inasmuch as both are precipitated by silver nitrate, but that these acids are distinguished by the action of nitric acid upon the precipitates thus obtained.

The group reagents for the non-metallic radicles cannot be added in succession to the same liquid, inasmuch as the action of one reagent is, in many cases, interfered with by the presence of another group reagent.

In examining an unknown substance, the first step

will evidently consist in determining the group to which the metallic and the non-metallic radicle severally belong: by the action of special reagents the individual radicle will then be recognised. But it is necessary that the learner should reverse this order of things; he must first acquire a knowledge of the principal properties—from an analytical point of view—of the individual members of each group of radicles, metallic and non-metallic; he must then learn how to detect one of these, the group to which it belongs being known; and, finally, he must make himself acquainted with the methods employed for determining the composition of a compound when no preliminary knowledge concerning the compound is given to him.

Any mean whereby the chemist seeks to determine the composition of a substance is called a *test*. Chemical tests may be broadly divided into two groups—*dry tests* and *wet tests*. The former consist of the application of reagents in the solid form to the substance in the solid form, the agency of heat being employed to aid the reactions. In the latter the substance under examination is dissolved and subjected to the action of reagents themselves also in solution. In a few tests reagents in solution are applied to the solid substance, or *vice versa*.

The more commonly employed *dry tests* may be subdivided into two main groups. In the first group

are comprised those tests in which no reagents other than heat (and it may be the surrounding atmosphere) are employed. In the second group are placed those tests in which the agency of chemical substances is employed, in addition to an increased temperature.

To illustrate the employment of dry tests, perform the following experiments:—Heat a small quantity of **arsenious oxide (white arsenic)** in a small glass tube closed at one end; the white solid gradually disappears from the hot portion of the tube, and is deposited in the form of a ring of minute crystals on the other part of the tube.

Such a deposition of a substance on a cold surface is called a *Sublimate*.

Heat a very little **lead nitrate** in a small glass tube—brown fumes (oxides of nitrogen) are evolved.

Mix a very little **red oxide of lead** in a mortar with two or three times as much bicarbonate of soda. Scoop a little hole in a piece of good wood charcoal, place the mixture in the hole, and subject it to the action of the reducing flame of the blowpipe; after some minutes remove what remains on the charcoal into a clean mortar, add water, grind up, pour off the water quickly, and repeat this operation until there remain only small heavy metal-like particles at the bottom of the water in the mortar. Examine these particles more closely, they are evidently metallic. By the combined

action of the blowpipe flame, the sodium carbonate, and the charcoal, the oxygen has been removed from the lead oxide, and the metal lead remains.

This is an instance of *Reduction by the blowpipe*.

Place a small piece of **lead** on charcoal, and subject it to the action of the oxidising blowpipe flame; the metal fuses and gradually disappears, while a reddish-yellow circular film is formed at a little distance from the original position of the metal. This film consists of lead oxide.

This is an instance of *Oxidation by the blowpipe*.

Make a small bead of borax on the end of a piece of clean platinum wire. Moisten the bead and take up on to it a *very small* quantity of **manganese dioxide**, now heat the bead in the oxidising flame of the blowpipe for a few minutes, allow it to cool and examine—the bead is transparent, but of an amethyst colour; now heat the coloured bead in the reducing flame of the blowpipe for a few minutes, the amethyst colour disappears, and the bead becomes colourless.¹

These are instances of *Bead tests*.

Bring a small portion of a salt of **strontium**, supported on a *clean* platinum wire,² into a Bunsen flame

¹ When a test with a bead is completed, heat the bead, knock it off by a sharp jerk, and place the wire in dilute hydrochloric acid until it is again required.

² A platinum wire is clean when it does not colour the non-luminous Bunsen flame.

close to the top of the burner—the flame becomes coloured crimson.

This is an instance of a *Flame test*.

By the application of *wet tests* precipitates are produced which are characterised by (1) colour, (2) solubility in different menstrua.

To solutions of **lead nitrate**, **arsenious oxide** in dilute hydrochloric acid, **ferric chloride**, and **ammonium oxalate**, add, respectively, *hydrochloric acid*, *sulphuretted hydrogen*, *ammonia* and *ammonium sulphide*, and *calcium chloride*.

In the first case a white precipitate, in the second a yellow, in the third a black, and in the fourth a white precipitate is produced. Shake up the contents of each tube, allow the precipitates to subside, pour off the supernatant liquids, add water, shake up again, again allow to subside and pour off the water; repeat this operation a second time, and then add to the precipitates, in order, the following reagents—*Ammonia*, *ammonium sulphide*, *hydrochloric acid*, and *acetic acid*; warm the contents of each tube; the first and fourth precipitates are unchanged, the second and third are dissolved.

Lead is characterised by a *white* precipitate with hydrochloric acid, *insoluble* in ammonia; **arsenic** by a *yellow* precipitate with sulphuretted hydrogen, *soluble* in ammonium sulphide; **iron** by a *black* precipitate

with ammonia and ammonium sulphide, *soluble* in hydrochloric acid; and **oxalic acid** by a *white* precipitate with calcium chloride, *insoluble* in acetic acid.

*In all cases it is necessary that a precipitate be well washed with water before proceeding to test the solubility of that precipitate.*¹

To two portions of a solution of **potassium tartrate** in water add *calcium chloride*, and shake well for a few minutes, a white precipitate is gradually formed in each tube. Add *caustic potash* to one tube and shake up, the precipitate does *not* dissolve. Pour off the liquid from the precipitate in the second tube, add water, shake up, allow the precipitate to settle, repeat this operation twice, and finally add *caustic potash* to the washed precipitate; it *does* dissolve.

To a solution of **calcium chloride** in a third tube add *caustic potash*; a white precipitate is produced. It is evident that in the first case the precipitated tartrate of calcium appeared to be insoluble in potash, because as quickly as it was dissolved a precipitate was produced by the action of the potash upon the calcium chloride, remaining *as such* in the liquid above the precipitated tartrate, and hence the production of a clear liquid free

¹ Unless special directions are given, hot water should be employed for washing.

Dilute acids are to be used for the various tests except in special instances.

from precipitate was impossible, until the *excess* of calcium chloride had been removed by washing. This experiment illustrates the danger of drawing conclusions from the action of solvents upon unwashed precipitates ; in such cases the analyst is testing not one compound but a mixture—often a somewhat complex mixture—of compounds.

We now proceed to a description of the tests for the individual non-metallic radicles. The distinctive tests will alone be described.

GENERAL RULES FOR WORK.

Keep your test tubes and all apparatus clean.

Do not make messes on your bench.

Do not mix the stoppers of the reagent bottles.

Keep your platinum wire in acid ; make sure that the wire does not itself colour the flame before you use it.

Wash all precipitates *well* before testing their solubility.

Use *small quantities* both of reagents and of the substance under examination.

Make short, clear notes of your work.

GROUP I.

Metals, whose chlorides are insoluble in water and in dilute acids, and which are therefore precipitated from solutions of their salts on addition of dilute hydrochloric acid.

SILVER. MERCUROSUM.¹ LEAD.

A. SILVER.—Silver nitrate is used.

Before blowpipe R.F.² on charcoal, with sodium bicarbonate, white malleable bead, easily soluble in nitric acid. Dissolve a few crystals in water, and add—

Hydrochloric Acid: White curdy precipitate of silver chloride,³ soluble in ammonia, insoluble in hot water.

B. MERCUROSUM.—Use mercurous nitrate.

Hydrochloric Acid: White precipitate of mercurous chloride, insoluble in hot water, blackened by ammonia (black compound = $\text{NH}_2\text{Hg}_2\text{Cl}$).

C. LEAD.—Use lead nitrate.

Hydrochloric Acid: White precipitate of lead chloride, soluble in hot water, unchanged by ammonia.

¹ *Mercuriosum* is used to denote mercury as it occurs in proto-mercurous salts.

² R. F., reducing flame.

³ Wash precipitate before testing solubility.

TABLE A.

TO DETECT ONE METAL BELONGING TO THE
SILVER GROUP.

To a portion of solution add *hydrochloric acid*, shake up, allow precipitate to subside, pour off liquid, add water, shake up again, and again pour off; now add *ammonia* and shake well.

	PRECIPITATE	
Dissolves.	Is blackened.	Unchanged.
Silver.	Mercurosum.	Lead.

GROUP II.

Metals, (other than those of Group I.) whose sulphides are insoluble in dilute acids, and which are therefore precipitated, from acid solutions of their salts, on addition of sulphuretted hydrogen.

MERCURICUM. COPPER. BISMUTH.
CADMIUM. ARSENIC. TIN. ANTIMONY.

A. MERCURICUM.—Use mercuric chloride.

Sulphuretted Hydrogen: Yellowish black precipitate, changing to black (mercuric sulphide) on addition of more of the reagent. Precipitate is insoluble in warm ammonium sulphide.

Stannous Chloride : Greyish precipitate (mercurous chloride), changing to grey-black (mercury) on addition of more of the reagent.

B. COPPER.—Use copper sulphate.

Sulphuretted Hydrogen : Black precipitate (copper sulphide), insoluble in warm ammonium sulphide.

Ammonia : Blue liquid (ammonia copper sulphate).

C. BISMUTH.—Use bismuth carbonate dissolved in hydrochloric acid.

Sulphuretted Hydrogen : Dark brown, or nearly black precipitate (bismuth sulphide), insoluble in warm ammonium sulphide.

Ammonia : White precipitate (bismuth hydrate).

D. CADMIUM.—Use cadmium nitrate.

Sulphuretted Hydrogen : Yellow precipitate (cadmium sulphide), insoluble in warm ammonium sulphide.

E. ARSENIC.—Use arsenious oxide, dissolved in dilute hydrochloric acid.

Sulphuretted Hydrogen : Yellow precipitate (arsenious sulphide), soluble in warm ammonium sulphide ; soluble, also, in ammonium carbonate.

F. TIN.—*a. Stannous Salts.* Use stannous chloride dissolved in hydrochloric acid.

Sulphuretted Hydrogen : Brown precipitate (stannous sulphide), not so dark in colour as pre-

precipitate in case of bismuth, soluble in warm ammonium sulphide.

b. Stannic Salts. Use solution of stannic chloride in hydrochloric acid.

Sulphuretted Hydrogen : Yellow precipitate (stannic sulphide), soluble in warm ammonium sulphide, insoluble in ammonium carbonate.

G. ANTIMONY.—Use antimony chloride dissolved in hydrochloric acid.

Sulphuretted Hydrogen : Orange precipitate (antimony sulphide), soluble in warm ammonium sulphide.

TABLE B.

TO DETECT ONE METAL BELONGING TO THE COPPER GROUP.

To portion of original solution add a few drops of hydrochloric acid, then saturate with *sulphuretted hydrogen* : observe colour of precipitate.

PRECIPITATE is

a. BLACK OR DARK BROWN : Presence of *Mercuricum*, *Copper* (original solution would be more or less blue in colour), *Bismuth*, or perhaps *Tin* (stannous).

Wash precipitate well ; add a little *ammonium sulphide* and warm ; precipitate dissolves—*Tin* (stannous).

Precipitate does not dissolve—one of the others mentioned above.

To portions of original add successively,¹

a. *Stannous Chloride*: Grey precipitate—**Mercuricum**.

β. *Ammonia*: White precipitate—**Bismuth**.

γ. *Ammonia*: Blue liquid—**Copper**.

b. BROWN: *Tin* (stannous); to make certain wash well, add a little ammonium sulphide and warm; precipitate dissolves—**Tin** (stannous).

c. YELLOW: *Tin* (stannic), *Arsenic*, or *Cadmium*. Wash precipitate and warm with ammonium sulphide; precipitate does not dissolve—**Cadmium**.

Precipitate dissolves; *Tin* or *Arsenic*. Precipitate fresh portion of original with sulphuretted hydrogen; wash precipitate, add a little piece of solid ammonium carbonate, a little water, and warm *very gently*; precipitate dissolves—**Arsenic**. Precipitate does not dissolve—**Tin** (stannic).

¹ That is, if a gives no reaction proceed to β, and so on. Perform the tests in the order given.

GROUP III.

Metals, (other than those of Groups I. and II.) whose sulphides—in some instances, whose hydroxides—are insoluble in alkaline solutions, and which are, therefore, precipitated on addition of ammonia and ammonium sulphide to solutions of their salts.

IRON. ALUMINIUM. CHROMIUM. NICKEL.
COBALT. MANGANESE. ZINC.

A. IRON.—*a. Ferrous Salts.* Use ferrous sulphate dissolved in *cold* water. Borax bead.—Red-brown when hot in O.F., nearly colourless when cold. Bottle green when hot in R.F., reddish when cold.

Ammonium Sulphide: Black precipitate (ferrous sulphide).

Potassium Ferrocyanide: Deep blue precipitate (Iron cyanide, prussian blue).

Potassium Ferricyanide: Blue precipitate (Iron cyanide, Turnbull's blue).

b. Ferric Salts. Use ferric chloride solution.

Potassium Ferrocyanide: Deep blue precipitate.

Potassium Ferricyanide: Brownish-red colour, no precipitate.

B. ALUMINIUM.—Use alum dissolved in water.

Ammonium Sulphide : White gelatinous precipitate (aluminium hydrate).

Caustic Potash : White precipitate (aluminium hydrate), soluble on addition of more of the reagent. This solution yields a white precipitate (aluminium hydrate) on addition of ammonium chloride.

C. CHROMIUM—Use a solution of chromium alum in water.

Ammonium Sulphide : Greenish-white precipitate (chromium hydrate).

Caustic Potash : Pale green precipitate (chromium hydrate), soluble in excess of reagent, but reprecipitated when the solution is boiled for three or four minutes.

D. NICKEL.—Use a solution of nickel sulphate.

Ammonium Sulphide : Black precipitate (nickel sulphide), insoluble in *cold dilute* hydrochloric acid.

Caustic Potash : Pale apple-green precipitate (nickel hydrate), insoluble in excess of reagent.

E. COBALT.—Use a solution of cobalt nitrate.
Borax bead, blue in both flames.

Ammonium Sulphide : Black precipitate, insoluble in *cold dilute* hydrochloric acid.

Caustic Potash : Blue precipitate (basic nitrate of cobalt), insoluble in excess of reagent.

F. MANGANESE.—Use manganese sulphate solution.

Ammonium Sulphide : Flesh-coloured precipitate (manganese sulphide).

Caustic Potash : Nearly white precipitate, gradually darkening in colour, especially if warmed (manganese hydrate).

G. ZINC.—Use zinc sulphate solution.

Ammonium Sulphide : White precipitate (zinc sulphide).

Caustic Potash : White precipitate (zinc hydrate), soluble in an excess of the reagent. On addition of ammonium chloride to this solution, *no* precipitate is produced.

TABLE C.

TO DETECT ONE METAL BELONGING TO THE IRON GROUP.

To portion of original solution add *ammonia* and *ammonium sulphide* (a precipitate on addition of ammonia is overlooked), shake up *well*, allow to settle, and observe colour of precipitate.

PRECIPITATE is

a. BLACK : *Iron, Nickel or Cobalt.*

Original solution would probably be coloured pale

green with more or less brown, or even brownish-red without green if iron; green if nickel; and pink, or perhaps blue, if cobalt.

To portions of original add, successively (see note, p. 23),

- a. *Potassium ferrocyanide*: Deep blue precipitate—**Iron**.

(To fresh portion of original add *potassium ferricyanide*: blue precipitate—Iron exists as a *ferrous*; brownish colour—as a *ferric* salt.)

- β. *Caustic Potash*: Green precipitate—**Nickel**.

- γ. *Caustic Potash*: Blue precipitate—**Cobalt**.

- b. LIGHT COLOURED: *Manganese, Chromium, Aluminium, or Zinc*.

Original would probably be colourless or faint pink if manganese; green or violet if chromium; and colourless if aluminium or zinc.

To portions of original add, successively,

- a. *Caustic Potash*: White precipitate, turning brown, and insoluble in excess of reagent—**Manganese**.

- β. *Caustic Potash*: Greenish precipitate, soluble in excess of reagent—**Chromium**.

- γ. *Caustic Potash*: White precipitate, soluble in excess of reagent, *aluminium or zinc*; to the

solution in caustic potash add ammonium chloride ; white precipitate—**Aluminium** : No precipitate—**Zinc**.

GROUP IV.

Metals, (other than those of Groups I., II., and III.) whose carbonates are insoluble in an alkaline liquid, and which are therefore precipitated on addition of ammonium carbonate to solutions of their salts.

CALCIUM. BARIUM. STRONTIUM.

A. CALCIUM.—Use calcium chloride.

Colours non-luminous flame reddish-yellow.

Ammonium Carbonate : White precipitate (calcium carbonate).

Calcium Sulphate : No precipitate.

Ammonium Oxalate : White precipitate (calcium oxalate), insoluble in acetic acid.

B. BARIUM.—Use barium chloride. Colours non-luminous flame pale green.

Ammonium Carbonate : White precipitate (barium carbonate).

Calcium Sulphate : White precipitate (barium sulphate).

C. STRONTIUM.—Use strontium chloride. Colours non-luminous flame crimson.

Ammonium Carbonate : White precipitate (strontium carbonate.)

Calcium Sulphate : White precipitate (strontium sulphate), after standing and shaking for some time.

TABLE D.

TO DETECT ONE METAL BELONGING TO THE CALCIUM GROUP.

Dilute portion of original and add *calcium sulphate* solution.

Precipitate forms at once—**Barium**.

Precipitate forms only on shaking up for some time—**Strontium**.

No precipitate forms even on warming ; to fresh portion of original add *ammonia*, *acetic acid*, and *ammonium oxalate* ; white precipitate—**Calcium**.

GROUP V.

Remaining Metals—no Group Precipitant.

MAGNESIUM. POTASSIUM. AMMONIUM.
SODIUM.

A. MAGNESIUM. — Use a solution of magnesium sulphate.

Ammonia : White precipitate (magnesium hydroxide), soluble in ammonium chloride.

Ammonium Chloride, Ammonia, and Sodium Phosphate :¹ White precipitate (magnesium-ammonium phosphate).

Ammonium Chloride and Ammonium Carbonate :
No precipitate.

B. POTASSIUM.—Use potassium chloride.

Colours non-luminous flame violet.

Platinum Tetrachloride : Yellow precipitate (platinum-potassium chloride). The formation of this precipitate is hastened by adding alcohol and shaking briskly.

C. AMMONIUM.—Use ammonium chloride.

Platinum Tetrachloride : Yellow precipitate (platinum-ammonium chloride).

Caustic Potash : On boiling evolves ammonia recognised by its smell, and its forming thick white fumes (ammonium-chloride) when a rod moistened with strong hydrochloric acid is brought to the mouth of the test tube.

D. SODIUM.—Use sodium chloride.

Colours non-luminous flame intensely yellow.

These should be mixed before being used as a test ; the mixture should be clear ; should a precipitate form, add more ammonium chloride.

A piece of paper coated with red mercuric iodide appears fawn-coloured, when brought near the yellow flame.

TABLE E.

TO DETECT MAGNESIUM, POTASSIUM, AMMONIUM,
OR SODIUM.

- a. To portion of original add considerable quantity of *ammonium chloride*, a few drops of *ammonia*, and *sodium phosphate*, and shake briskly ; white crystalline precipitate—**Magnesium**.
- β. To another portion of original, add *hydrochloric acid*, boil for three or four minutes, add *platinum tetrachloride* and *alcohol*, and shake up for some time : Yellow crystalline precipitate—*Ammonium* or *Potassium*.
To distinguish, boil portion of original with *caustic potash*: ammonia is evolved—**Ammonium** ; no ammonia is evolved—**Potassium**.
- γ. *Magnesium, Ammonium, and Potassium are proved absent*, and original gives deep yellow colour to non-luminous flame—**Sodium**.

TABLE F.

A SUBSTANCE IS GIVEN TO BE TESTED FOR ANY ONE OF THE FOREGOING METALS.

A. The Substance is already in solution. Proceed to add the group reagents ; that is to say, to a portion of the original liquid add *hydrochloric acid*—white precipitate ; add a little more acid, if precipitate remains, a metal of Group I. is present ; test the white precipitate by Table A. If hydrochloric acid gives no precipitate, to the same liquid add *sulphuretted hydrogen* ; precipitate forms, examine for metal of Group II. by Table B ; no precipitate forms, to same liquid add *ammonium chloride*, *ammonia*, and *ammonium sulphide* ; precipitate forms, examine for metal of Group III. by Table C. Ammonium chloride, &c., give no precipitate ; to same liquid add *ammonium carbonate* ; white precipitate shows presence of metal of Group IV., examine by Table D. Ammonium carbonate gives no precipitate ; to same liquid add *sodium phosphate* and shake up ; white crystalline precipitate shows presence of magnesium. If sodium phosphate has given no precipitate, examine original for ammonium, potassium, and sodium by Table E.

1. **The Substance is a Solid.**—Powder a portion, if not already in powder; boil a *very small quantity* with *water* in a test tube; substance dissolves, proceed as under A; substance does not dissolve, pour off water, add a little *dilute hydrochloric acid*, and warm: if substance dissolves, metal present cannot belong to Group I.; proceed to test by other group reagents. If hydrochloric acid does not dissolve the substance, pour off the acid, add *concentrated hydrochloric acid*, and warm; if substance dissolves, boil off larger portion of acid, dilute, and proceed to addition of group reagents. If substance is insoluble in hydrochloric acid, to fresh portion of original add *dilute nitric acid* and boil; if substance does not dissolve, attempt to dissolve it in *concentrated nitric acid*; if insoluble, boil it with a mixture of *concentrated nitric and hydrochloric acids*. If substance is insoluble, examine it by Table L, p. 52. If the substance dissolves in nitric acid or in aqua regia (mixed nitric and hydrochloric acids), the solution must be evaporated *nearly to dryness*, then hydrochloric acid must be added, evaporation must be again performed, and finally the liquid must be diluted, before adding sulphuretted hydrogen (sulphuretted hydrogen is decomposed by nitric

acid). If the liquid is free from precipitate before adding sulphuretted hydrogen, it is evident that no metal of Group I. can be present.

TESTS FOR NON-METALLIC RADICLES.¹

It has been already pointed out (p. 11) that the grouping of the acid radicles is much less definite than that of the metallic radicles. The arrangement adopted in this book is one of several possible methods.

GROUP I.

Acid, whose barium salt is insoluble in dilute hydrochloric or nitric acid.

SULPHURIC ACID.—Use a solution of sodium sulphate.

Barium Chloride: White precipitate (barium sulphate), insoluble on addition of dilute hydrochloric acid.

¹ Among the acid radicles are included oxalic, tartaric, citric, and acetic acids. The other carbon acids, inasmuch as they are of comparatively rarer occurrence, are grouped together in an appendix to the present part, and a special table is given for their detection.

GROUP II.

Acid, whose calcium salt is insoluble in acetic acid.

OXALIC ACID.—Use a solution of ammonium oxalate.

Calcium Chloride: White precipitate (calcium oxalate), insoluble on addition of acetic acid.

Strong Sulphuric Acid: On heating causes evolution of carbon monoxide, and dioxide—former recognised by burning with pale flame, latter by giving turbidity in lime-water.

GROUP III.

Acids, whose barium salts are insoluble in neutral, but not in acid liquids.

BORIC, PHOSPHORIC, SULPHUROUS, CARBONIC, SILICIC, CHROMIC ACIDS.

A. BORIC ACID.—Use borax.

Barium Chloride: White precipitate (barium borate), soluble in hydrochloric acid, soluble, also, in ammonium chloride or nitrate.

Turmeric Paper: When soaked in solution of a borate which has been rendered acid by addition of hydrochloric acid, becomes reddish-brown

when dried; potash or soda solution makes a greenish-black stain on this paper.

B. PHOSPHORIC ACID.—Use sodium phosphate.

Barium Chloride: White precipitate, soluble in hydrochloric acid.

Ammonium Molybdate, and a little Nitric Acid:

On warming, yellow precipitate (contains molybdic and phosphoric acids and ammonium).

A. SULPHUROUS ACID.—Use sodium sulphite.

Barium Chloride: White precipitate, soluble in hydrochloric acid.¹

Sulphuric Acid: On warming causes evolution of sulphur dioxide.

D. CARBONIC ACID.—Use sodium carbonate.

Barium Chloride: White precipitate, soluble, with effervescence, in hydrochloric acid.

Dilute Sulphuric Acid: Added to solid sodium (or other) carbonate, causes effervescence; if the escaping gas be decanted into lime-water a turbidity is produced in the latter.

E. SILICIC ACID.—Use sodium silicate. *Soluble silicates give alkaline solutions.*

¹A small quantity of the precipitate generally remains, from presence of sulphate. On addition of chlorine water to this solution the barium sulphite is oxidised to sulphate, which is again precipitated.

Barium Chloride : White precipitate, decomposed by hydrochloric acid, with separation of jelly-like mass (silicic acid).

Take a very little silica on a bead of microcosmic salt and heat in Bunsen flame, the little particles of silica are seen floating about undissolved in the hot bead.

F. CHROMIC ACID.—Use potassium chromate.

Barium Chloride : Yellow precipitate, soluble in hydrochloric acid.

GROUP IV.

Acids, whose silver salts are insoluble in neutral liquids, but are dissolved by nitric acid.

SULPHYDRIC, THIOSULPHURIC ACIDS.

A. SULPHYDRIC ACID.—Use ammonium sulphide.

Silver Nitrate : Black precipitate, dissolved on addition of nitric acid, with separation of sulphur, and evolution of sulphuretted hydrogen.

Sulphuric Acid : Causes evolution of sulphuretted hydrogen.

B. THIOSULPHURIC ACID.—Use sodium thio-sulphate.

Silver Nitrate : White precipitate, rapidly darken-

ing in colour, especially on heating (silver sulphide is formed), soluble in nitric acid.

Sulphuric Acid : On warming causes evolution of sulphur dioxide—smell of burning sulphur—and deposition of sulphur.

GROUP V.

Acids, whose silver salts are insoluble in dilute nitric acid.

HYDROCHLORIC, HYDROBROMIC, HYDRIODIC, HYDROCYANIC ACIDS.

A. HYDROCHLORIC ACID.—Use sodium chloride.

Silver Nitrate : White precipitate insoluble in nitric acid, readily soluble in ammonia.

Sulphuric Acid : Causes evolution of hydrochloric acid, recognised by fumes in air, and by giving dense white fumes when ammonia is brought near the mouth of the test tube.

B. HYDROBROMIC ACID. — Use potassium bromide.

Silver Nitrate : White (or very faintly yellow) precipitate, insoluble in nitric acid, less easily soluble in ammonia than silver chloride.

Sulphuric Acid : On warming causes evolution of

hydrobromic acid and bromine, recognised by brownish-red colour and intensely irritating odour.

Chlorine Water : Liberates bromine, recognised by adding chloroform or bisulphide of carbon and shaking up ; the chloroform becomes reddish-brown.

C. HYDRIODIC ACID.—Use potassium iodide.

Silver Nitrate : Light yellow precipitate, insoluble in nitric acid ; with difficulty soluble in ammonia.

Sulphuric Acid : On warming sets free iodine, recognised by violet vapours.

Chlorine Water : Liberates iodine, recognised by chloroform (or bisulphide of carbon), which becomes coloured violet ; or recognised by adding a drop of cold starch paste, when deep blue colour is produced.

D. HYDROCYANIC ACID.—Use potassium cyanide.

Silver Nitrate : White precipitate, soluble in considerable quantity of ammonia.

Dilute Sulphuric Acid : Sets free hydrocyanic acid, recognised by its odour. (Perform this test with a *small* quantity of the salt.)

Ferrous Sulphate : Containing a little ferric chloride, and followed by addition of caustic

potash, gives a brownish precipitate (mixture of ferric and ferrous hydrate and prussian blue); on addition of hydrochloric acid, brown colour disappears, but a blue precipitate remains (prussian blue).

GROUP VI.

Acids which are not grouped with any of the foregoing.

ACETIC, NITRIC, CHLORIC, TARTARIC, CITRIC, FERROCYANIC, FERRICYANIC, SULPHOCYANIC ACIDS.

A. ACETIC ACID.—Use sodium acetate.

Dilute Sulphuric Acid: On warming liberates acetic acid, recognised by its smell.

Alcohol and Sulphuric Acid: On warming produce acetic ether, recognised by its smell.

B. NITRIC ACID.—Use potassium nitrate.

Ferrous Sulphate: Added to a nitrate previously mixed with strong sulphuric acid produces a brown or black colour (nitric oxide dissolved in ferrous sulphate).

This test is best carried out by mixing the nitrate solution with an equal bulk of strong sulphuric acid

cooling, and pouring a solution of ferrous sulphate down the tube, which is held in a slanting position. The ferrous sulphate must be dissolved in cold water. The brown colour appears at the point where the heavier (under), and the lighter (upper), layers of liquid come into contact.

C. CHLORIC ACID.—Use potassium chlorate.

Strong Sulphuric Acid : Causes evolution of oxides of chlorine which rapidly decompose into chlorine and oxygen. This action is explosive. Use a very small crystal of the chlorate, and only a little acid.

D. TARTARIC ACID.—Use potassium tartrate.

Strong Sulphuric Acid : On heating causes evolution of carbon monoxide (recognised on bringing a light to mouth of tube), and carbon dioxide ; mixture *rapidly* chars (separation of carbon) and sulphur dioxide is evolved, recognised by odour.

Potassium Acetate : Preceded by acetic acid, causes precipitation of white acid potassium tartrate. This precipitate forms more readily on stirring.

Calcium Chloride : white precipitate, especially on stirring.

E. CITRIC ACID.—Use sodium citrate.

Strong Sulphuric Acid : On heating causes evolu-

tion of carbon monoxide; mixture chars *slowly*, and sulphur dioxide is evolved only after somewhat prolonged heating.

Potassium Acetate and Acetic Acid : No precipitate.

Calcium Chloride : White precipitate, only produced on boiling.

F. FERROCYANIC ACID.—Use potassium ferrocyanide.

Strong Sulphuric Acid : On heating hydrocyanic acid is evolved ; colour of original is changed to white.

Ferrous Sulphate : Deep blue precipitate.

Ferric Chloride : Deep blue precipitate.

G. FERRICYANIC ACID.—Use potassium ferricyanide.

Strong Sulphuric Acid : On heating hydrocyanic acid is evolved ; colour changes from greenish to nearly white ; slight precipitate is produced.

Ferrous Sulphate : blue precipitate.

Ferric Chloride : Brownish-red colour ; no precipitate.

H. SULPHOCYANIC ACID.—Use potassium sulphocyanide.

Strong Sulphuric Acid : On boiling peculiar odour, resembling mixture of sulphur dioxide and prussic

acid; fumes redden paper moistened with ferric chloride.

TABLE G.

TO DETECT ONE OF THE FOREGOING ACIDS.

Observe the colour of the solution obtained by dissolving the original substance in water—

A solution containing **Chromic Acid** is usually *yellow* or *red-yellow*.

A solution containing **Ferrocyanic Acid** is usually *greenish-yellow*.

A solution containing **Ferricyanic Acid** is usually *brownish-red*.

Solutions of sulphates and nitrates may be very variously coloured.

Solutions of the commoner salts of the remaining acids are for the most part colourless.

To a portion of the original solid (or solution if a solid be not given) add—

- I. *Dilute Sulphuric Acid*.—Effervescence occurs; gas evolved is colourless, and has no particular odour—probably **Carbonic Acid**: confirm by test D. 2, p. 36.¹

¹All confirmatory tests are to be carried out with the original solution, or original solid dissolved in water or acid, unless specially directed otherwise.

A colourless gas smelling of almonds is evolved, more marked on gently warming—probably **Hydrocyanic Acid**: confirm by D. 3, p. 39.

A colourless gas, smelling of rotten eggs, is evolved, with effervescence—**Sulphydric Acid**.

On heating, a colourless gas, smelling of vinegar, is evolved—probably **Acetic Acid**: confirm by A. 2, p. 40.

On heating, sulphur dioxide is evolved, but no precipitate is caused, the solid dissolving in the acid—probably **Sulphurous Acid**: confirm by C. 1, p. 36.

On heating, sulphur dioxide is evolved, and sulphur is separated as a yellowish-white finely-divided solid—**Thiosulphuric Acid**.

Dilute sulphuric acid has given no special reaction; to a fresh portion of original solid add—

II. *Strong Sulphuric Acid*: Substance partially dissolves, forming deep red liquid, and an explosive gas is evolved—**Chloric Acid**.

Colour of original was greenish, and is changed to white; on heating, hydrocyanic acid is evolved, and a nearly colourless precipitate is formed—**Ferro- or Ferri-cyanic Acid**; confirm by F. 3, and G. 3, p. 42.

Colourless but strongly acid fumes are evolved,

which, on coming into the air, form thick white clouds—probably **Hydrochloric Acid**: confirm by bringing rod moistened with ammonia to mouth of test-tube (A, 2, p. 38), and by A. 1, p. 38.

Brownish fumes with very irritating odour, and fuming much in air, are produced—probably **Hydrobromic Acid**: confirm by B. 3, p. 39.

Violet fumes are evolved, more marked on heating, and especially on adding a very little manganese dioxide—probably **Hydriodic Acid**: confirm by C. 3, p. 39.

No special action until the solid is heated with the acid, when—

Mixture *rapidly* chars, gases are evolved which burn on bringing a light to the mouth of the tube; but this phenomenon soon ceases, and smell of burning sulphur and of charring organic matter becomes very apparent—probably **Tartaric Acid** confirm by D. 3, p. 41, after boiling original with sodium carbonate, filtering if precipitate is produced, and neutralising with nitric acid.

Mixture chars *slowly*; combustible gases are evolved for some time; finally, smell of charred organic matter and of sulphur dioxide becomes apparent—probably **Citric Acid**: confirm by C. 2 and 3, p. 42, after boiling with sodium carbonate, filtering if necessary, and neutralising.

Mixture does not char; carbon monoxide and dioxide are evolved (for method of recognition, see *Oxalic Acid*, p. 35)—**Oxalic Acid**.

Faint smell of prussic acid mingled with that of burning sulphur; no coloured gases; bring paper moistened with ferric chloride over mouth of tube, it is reddened—**Sulphocyanic Acid**.

Possibly reddish fumes not possessed of irritating odour of hydrobromic acid may be evolved—test original for **Nitric Acid** (see B, p. 40).

If no indication is obtained by use of sulphuric acid, dissolve a portion of original in water (or in nitric acid, if it is insoluble in water), and test in portions of this liquid successively for **Sulphuric Acid** (p. 34), **Boric Acid** (A. 2, p. 35), **Phosphoric Acid** (B. 2, p. 36), **Chromic Acid** (F. 1, p. 37), **Silicic Acid** (E. 1, p. 37: in this case original solution in water would be alkaline), and for **Nitric Acid** (for this test a nitric acid solution must, of course, *not* be used). If none of these be found, an acid may be present which should have been discovered, or at any rate the presence of which should have been indicated by the examination with sulphuric acid: those acids which are most likely to be overlooked here are *hydrochloric*, *sulphocyanic*, *hydriodic*, and perhaps *sulphurous*. Special tests should now be made for each of these.

TABLE H.

EXAMINATION OF UNKNOWN SUBSTANCE FOR ACID
AND METAL.

Bring a very small portion of substance on platinum wire into the non-luminous flame; if flame is coloured

<i>Green,</i>	probably a	Barium	Salt is present.
<i>Crimson,</i>	„	Strontium	„ „
<i>Red-yellow,</i>	„	Calcium	„ „
<i>Violet,</i>	„	Potassium	„ „
<i>Intense yellow,</i>	„	Sodium	„ „

In case of an indication being thus obtained, dissolve the substance (see Table F), and examine at once for metal indicated; otherwise proceed according to Table F for detection of metal present.

If *arsenic* be found, it is well to continue the search for another metal, as the arsenic may exist as arsenious or arsenic acid; if a second metal be found, to a fresh portion of original dissolved in water or in nitric acid (in which case the liquid must be neutralized by ammonia) add *silver nitrate*—yellow precipitate shows **Arsenious**, red precipitate shows **Arsenic Acid**.

Should the preliminary flame-test have pointed to presence of *potassium*, but should *platinum chloride* give a *deep red colour*, in place of a yellow precipitate, either **Hydriodic** or **Sulphocyanic Acid** is most probably

present. Test for these acids by tests C 3, p. 39, and H 1, p. 42, respectively.

If the *original substance* is *greenish-red* or *yellow*, gives the flame-reaction for *potassium*, but *no* precipitate with *platinum chloride*, **Ferro-** or **Ferri-cyanic Acid** is probably present. Test for these by F 3 and G 3, p. 42, respectively.

If the addition of *sulphuretted hydrogen* to the original liquid cause a *change of colour* from yellow or yellowish-red to green, and a deposition of sulphur, a **chromate** is probably present.

Having found the metal present, before proceeding to test for the acid by Table G, *observe the solubility of the original solid*; thus, should a metal of Group I. be present, and should the solid be soluble in water, hydrochloric, carbonic, and a few other acids must be absent, inasmuch as the chlorides and carbonates of lead, silver, and mercury are insoluble in water.

Should a *metal* of Group I. be found, the test for *sulphuric acid* must be modified by adding *barium nitrate* in place of barium chloride, because the latter would cause a precipitate of metallic chloride whether sulphuric acid were present or not.

When the student has familiarised himself with the methods of testing for single salts as illustrated in the

preceding tables, he should perform the following experiments:—

To solutions of **calcium chloride** and **calcium phosphate** in hydrochloric acid add *ammonium chloride* and *ammonia*; in the first case no precipitate, in the second a white precipitate is produced.

To a solution of **calcium oxalate** in hydrochloric acid add *ammonium chloride* and *ammonia*; a white precipitate is produced.

If, therefore, phosphoric or oxalic acid be present along with calcium, the method of analysis given in preceding pages will require to be modified. Oxalates and phosphates of a few metals other than calcium also cause peculiar reactions.

The following table for the detection of the commoner phosphates and oxalates is founded upon the reactions of these bodies with reagents.

TABLE I.

GIVEN A SALT KNOWN TO BE A PHOSPHATE OR
OXALATE TO DETERMINE ITS COMPOSITION. ¹

Test a small portion of original, dissolved in dilute nitric acid, for phosphoric acid by the ammonium molybdate test (B. 2, p. 36), and, if this acid be absent, for oxalic acid by the calcium chloride test (p. 35).

¹ The commoner phosphates and oxalates are alone included in this table.

A. Phosphoric Acid is present.

To portion of original dissolved in hydrochloric acid add *ammonium chloride* and *ammonia*.

a. A GREENISH-BROWN or RED PRECIPITATE is produced—**Iron**: confirm by prussian-blue test (p. 24).

β. A WHITE PRECIPITATE is produced.

To another portion of original add *caustic potash*—a white precipitate is produced, *insoluble in excess* of potash; to another portion of original add *ammonium acetate* and *ammonium oxalate*; a white precipitate indicates **calcium**, **barium**, or **strontium** (as phosphate). To distinguish apply flame test to original solid (p. 28), or to original liquid, after dilution with water, apply calcium sulphate test (p. 28).

No precipitate is produced by ammonium acetate and oxalate, add *ammonia*—white precipitate indicates **Magnesium**.

If the precipitate which caustic potash produced in the original liquid was *soluble in excess*, and if from this solution ammonium chloride throws down a white precipitate, **Aluminium** is present.

B. Oxalic Acid is present.

Ammonium Chloride and *Ammonia*, added to a solution of the solid in acid, cause

- a.** REDDISH PRECIPITATE.—Iron must be tested for in original.
- β.** WHITE PRECIPITATE.—To a fresh portion of original liquid add *caustic potash*; a white precipitate *insoluble in excess* points to presence of **calcium, barium, or strontium**. Test original solid in flame, or original liquid by means of calcium sulphate. If ammonium chloride and ammonia give *no precipitate*, add *sodium phosphate*; a white precipitate indicates **Magnesium**.

TABLE K.

A SALT IS GIVEN CONTAINING ONE METALLIC AND ONE NON-METALLIC RADICLE.

Test a portion for *Phosphoric Acid*.

If a yellow precipitate be produced by ammonium molybdate, to a fresh portion of the solid dissolved in dilute nitric acid add silver nitrate; a yellow precipitate shows **Phosphoric acid**: if no precipitate be produced, add ammonia drop by drop, a bright red precipitate shows **Arsenic acid**. (Arsenic acid yields a yellow precipitate with ammonium molybdate.)

If phosphoric acid is absent, test another portion for **oxalic acid**.

If either of these acids be found, proceed with examination of substance by Table I.

If neither be found, proceed to detection of metallic radicle by Table F, p. 32, taking into consideration the precautions in the first part of Table H, p. 47.

Having found the metallic radicle, proceed to detect the non-metallic by the aid of Table G, p. 43, noting the precautions in the latter part of Table H, p. 48. Should no metal be found, the substance consists probably of an acid only; in such a case the substance will generally be a liquid, and will give an acid reaction with litmus paper.

Should no acid be found the substance will probably be an alkaline hydrate, and will give an alkaline reaction with litmus paper.

Should neither metal nor acid be found, evaporate a portion of the original liquid to dryness, on platinum foil, or on a watch glass; if no solid matter remains, the liquid consists of water only.

If the original solid be found to be insoluble in water and in acids (see Table F, p. 33) it must be examined as an insoluble salt.

TABLE L.

EXAMINATION OF AN INSOLUBLE SALT (THE COMMONER SALTS ONLY ARE INCLUDED).

Heat a portion of the substance on a piece of platinum foil.

It melts to yellow drops, and then burns with a

blue flame, accompanied by smell of sulphur dioxide—**Sulphur**.

It melts gradually but does not volatilise—probably **Silver Chloride**. In this case original would be colourless and soluble in ammonia.

It disappears on heating—**Carbon**. Original would be black.

Its *colour changes* on heating, but is restored on cooling—**Oxide of Tin** or of **Antimony**. Fuse a portion of original with potassium nitrate and sodium carbonate in a *porcelain* crucible, dissolve fused mass in hydrochloric acid (filter if necessary), and add *sulphuretted hydrogen* till liquid smells strongly—*yellow* precipitate shows **Tin**; *orange* precipitate shows **Antimony**.

The original is *green* and is *unaltered on heating*—probably **Chromic Oxide**. Fuse a little on platinum foil with nitre, fused mass is *yellow*—**Chromium**.

The original is *white* and is *unaltered on heating*—**Silica**, **alumina**, **lead barium** or **strontium sulphate**, or **calcium fluoride**.

Test a portion of original by *microcosmic bead* test for **Silica** (p. 37).

Test another portion for alumina by moistening with *cobalt nitrate* and heating (support on platinum wire). Production of a *blue* odour indicates **Alumina**.

Test another portion for calcium fluoride by mixing

with a little *sand*, warming mixture in test tube with *strong sulphuric acid*, and bringing a *moist rod* into the vapours which are evolved; if the moisture becomes coated with a film of silica, the original is **Calcium Fluoride**. (In this test silicon fluoride gas is produced, and is decomposed by the water with production of silica).

Test another portion on *charcoal* before blowpipe for lead (see p. 14).

Test another portion for **barium** or **strontium sulphate**, by boiling with *sodium carbonate*, and water, filtering, acidulating filtrate with hydrochloric acid, and adding *calcium sulphate* (p. 28, 29).

APPENDICES.

I.

TABLE FOR EXAMINATION OF A SALT BY DRY REACTIONS.

Heat a portion of the solid in a small glass tube closed at one end.

A. It fuses. An alkaline salt.

B. It fuses and changes colour.

<i>While hot.</i>	<i>Cold.</i>	
<i>Yellow.</i>	<i>Dark-yellow.</i>	Bismuth Oxide.
<i>Yellow.</i>	<i>Dark-red.</i>	Lead Oxide.

C. It does not fuse, but changes colour.

<i>While hot.</i>	<i>Before heating.</i>	
<i>Yellow.</i>	<i>White.</i>	Zinc Oxide.
<i>Dark-yellow.</i>	<i>Straw.</i>	Tin "
<i>Black.</i>	<i>Brown-red.</i>	Iron "
<i>Brown-red.</i>	<i>Red.</i>	Mercuric "
		(Oxygen is evolved.)

D. A sublimate is formed.

<i>Reddish drops.</i>	Sulphur.
<i>White</i>	Oxide of Arsenic or Antimony,
	or Chloride of Mercury.
<i>Metallic mirror.</i>	Arsenic.

E. It blackens, and evolves smell of burnt sugar—**An organic Salt.**¹

¹See Appendix II.

F. A gas is evolved.

a. Gas is colourless and odourless.

1. *Oxygen.* Certain Peroxides and Nitrates.2. *Carbon monoxide.* An Oxalate.β. Gas is coloured *brown-red*--a Nitrate.

γ. Gas is colourless, but smells of—

1. *Ammonia.* An Ammonium Salt.2. *Sulphur dioxide.* A Sulphite.3. *Cyanogen.* A Cyanide.

G. Bring a portion of original, supported on platinum wire, into non-luminous flame.

Flame is coloured	<i>Yellow.</i>	Sodium	Salt.
"	<i>Crimson.</i>	Strontium	"
"	<i>Green.</i>	Barium	"
"	<i>Bluish-green.</i>	Copper	"
"	<i>Lavender.</i>	Potassium	"
"	<i>Yellowish-red.</i>	Calcium	"

H. Heat a portion with borax on platinum wire in blowpipe flame.

Colour of bead in—

Reducing Flame.	Oxidizing Flame.		Salt.
<i>Yellow-green.</i>	<i>Yellow-red.</i>	Iron	Salt.
<i>Green.</i>	<i>Green (blue when cold).</i>	Copper	"
<i>Blue.</i>	<i>Blue.</i>	Cobalt	"
<i>Nearly colourless</i> <i>—opaque.</i>	} <i>Brownish-red.</i>	Nickel	"
<i>Nearly colourless.</i>		<i>Amethyst.</i>	Manganese
<i>Emerald green.</i>	} <i>Emerald green</i> (hot and cold).	Chromium	"

I. Heat a portion on platinum foil, moisten with cobalt nitrate, and heat again.

<i>Blue colour.</i>	...	Aluminium Salt.
<i>Green</i> "	...	Zinc "

II.

EXAMINATION OF A SALT WHICH MAY CONTAIN ANY ONE OF THE FOLLOWING ORGANIC ACIDS: TARTARIC, CITRIC, ACETIC, BENZOIC, SUCCINIC, URIC, GALLIC, TANNIC, MALIC, HYDROCYANIC, FERRO- OR FERRI-CYANIC, SULPHOCYANIC OR OXALIC.

A. Heat a portion of solid in a small tube closed at one end, and notice smell (if any).

Smell of <i>burnt sugar</i> .	Substance	Probably a
Same, and in addition a <i>pungent smell</i> .	<i>Chars much</i> .	Tartrate.
Same, and in addition a <i>fragrant smell</i> .	Do.	Citrate.
Smell of <i>frankincense</i> .	<i>Chars very little</i> .	Acetate.
<i>Gases cause coughing</i> .	<i>No charring</i> .	Benzoate.
Smell of <i>singed feathers</i> , with faint trace of prussic acid and ammonia.	<i>Very little charring</i> .	Succinate.
Slight smell of <i>burnt sugar</i> .	<i>Chars easily</i> .	Urate.
Marked smell of <i>burnt sugar</i> .	Do.	Gallate.
Same, but <i>more irritating</i> odour than last.	Do.	Tannate.
<i>Singed</i> smell, with traces of ammonia.	<i>Chars slowly</i> .	Malate.
<i>Sulphur is separated</i> ; smell of <i>ammonium sulphide</i> .	<i>Little or no charring</i> .	Cyanide or double cyanide.
	<i>No charring</i> .	Sulphocyanide.

No smell; substance *volatilizes*.

Sometimes a *little charring* when heat is prolonged.

Oxalate.

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B. To another portion of original solid add strong sulphuric acid and heat.

COLOUR OF ORIGINAL CHANGES.

Original.

After adding Acid.

Greenish. Nearly white (ppt.).

Hydrocyanic acid is evolved.

Probably a
**Ferro- or ferri-
cyanide.**

Colourless. Faint pink.

Faint smell of hydrocyanic acid, also very slight smell of sulphur dioxide; gases reddened paper moistened with ferric chloride.

Sulphocyanide.

Substance chars rapidly.

A little carbon monoxide, much dioxide and sulphur dioxide evolved.

Tartrate.

” chars slowly.

Much carbon monoxide and dioxide, little sulphur dioxide until heating is long continued.

Citrate.

” chars slowly.

Carbon monoxide is evolved; slight fruity smell.

Malate.

APPENDICES.

Substance chars very slowly; when charring commences it proceeds with considerable rapidity.	Probably a Urate,	Carbon dioxide and sulphur dioxide evolved.
Substance does not char.	Formate.	Carbon monoxide is evolved.
"	Oxalate.	Carbon monoxide and dioxide are evolved.
Substance darkens in colour rapidly; a purple-black liquid with very little separated carbon is produced.	Gallate.	Irritating odour.
Same; a green shade is noticeable in liquid.	Tannate.	Sweetish odour, succeeded by irritating odour.
Little charring till high temperature is reached, when intensely irritating odour, causing coughing.	Succinate.	No carbon oxides, much sulphur dioxide.
No charring; substance partly sublimes on tube.	Benzoate.	Peculiar sweet smell
No charring until heating long continued, then considerable charring.	Acetate.	Smell of vinegar, after considerable time of sulphur dioxide.

c. Dissolve original in water or acid, add a large excess of sodium carbonate, boil for three or four minutes, filter, wash with hot water, add a very slight excess of nitric acid to filtrate, boil off all carbon dioxide, add ammonia until very faint odour, boil till odour just disappears, filter if necessary, and apply following tests to portions of this liquid:—

- | | | |
|-----------------------------|-----------------------------|--|
| 1. <i>Ferric Chloride</i> . | Deep-blue precipitate. | Ferrocyanide. |
| " | Reddish colour. | Ferricyanide. |
| " | Red colour. | Sulphocyanide, acetate or formate;
add hydrochloric acid, colour
changes to yellow— acetate or
formate (distinguish by mercuric
chloride in original, white precipi-
tate shows formate , no precipitate
shows acetate). |
| " | Deep greenish-black colour. | Original liquid is not precipitated
by gelatine—a gallate . |
| " | Deep bluish-green colour. | Original is precipitated by gelatine
—a tannate . |
| " | A buff-red precipitate. | Soluble in hydrochloric acid—a
succinate . |
| " | Brownish-red precipitate. | Decomposed by hydrochloric acid
with separation of white crystalline
flakes (benzoic acid)— benzoate . |

2. *Calcium Chloride, and shake well.* White precipitate, insoluble in acetic acid—an oxalate.
 " " White precipitate, soluble in acetic acid; precipitate fresh portion of original by calcium chloride, collect and WASH precipitate, and add cold caustic potash; precipitate dissolves—a tartrate; precipitate remains—a citrate.
3. *No Precipitate by Calcium Chloride.* Boil; no precipitate (a precipitate would show citric acid, overlooked above); add alcohol; white precipitate—a malate.
4. *Add hydrochloric acid to liquid, drop by drop.* White powdery precipitate forming gradually—probably a urate.
 Pour off liquid, add three or four drops nitric acid, evaporate to dryness, and add one drop of ammonia—purple colour (murexide) shows **Uric Acid**.

In testing for metal, heat a portion of original solid on platinum foil so long as fumes are evolved, dissolve residue in dilute acid, filter, and proceed to addition of group reagents, &c.

If no organic acid be found, test for phosphoric and oxalic acids; if one of these be present, proceed by Table I.; if both are absent, proceed by Tables F, G, H.

III.

TESTS FOR THE COMMON ALKALOIDS.

The tests are performed with the solid substances.

Deep red colour, changing to yellow on heating, and to violet on addition of stannous chloride.

BRUCINE.—*Concentrated Nitric Acid.*

A blue colour; add a few drops of starch-paste to the alkaloid, and move about a crystal of iodic acid in the liquid.

MORPHINE.—*Iodic Acid and Starch.*

Colourless liquid; on adding a crystal of manganese dioxide or potassium dichromate, a violet coloration is produced.

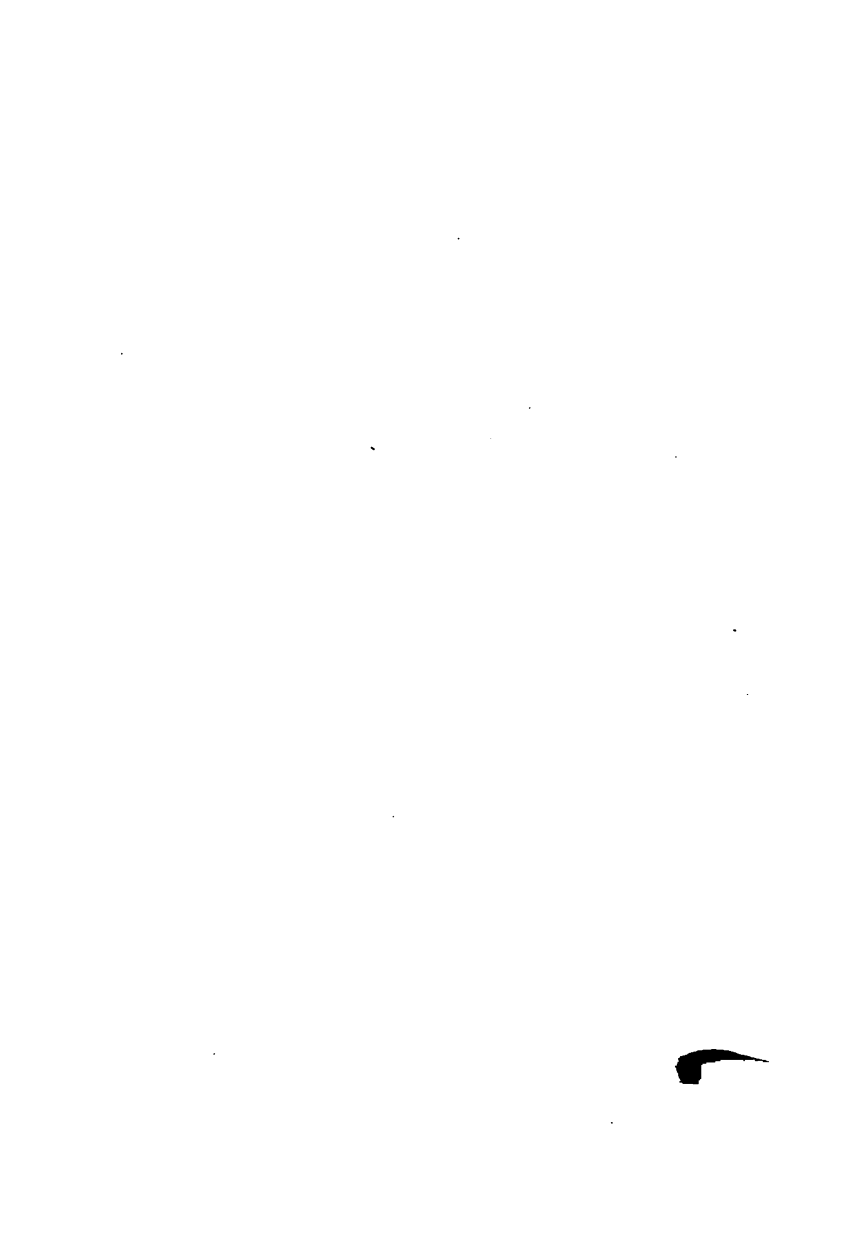
STRYCHNINE.—*Concentrated Sulphuric Acid.*

QUININE.—*Chlorine Water*, followed by addition of *Ammonia*. Emerald-green liquid.

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