

QD

83

H4

UC-NRLF



\$B 620 363

Elementary
Practical
Chemistry.

Inorganic and Organic.

HEWITT and POPE.

LONDON: WHITTAKER & CO.

GIFT OF

PROF. W. B. RISING



EX LIBRIS

H. P. ...

573
1871

ELEMENTARY
PRACTICAL CHEMISTRY.

WHITTAKER'S
Library of Popular Science.

GEOLOGY: An Elementary Handbook. By A. J. JUKES BROWNE, F.G.S. With 94 Illustrations. 4s.

ELECTRICITY AND MAGNETISM: A Popular Introduction. By S. BOTTONE. With 102 Illustrations. 3s. 6d.

PICTORIAL ASTRONOMY. By G. F. CHAMBERS, F.R.A.S. Second Edition, Revised. 284 pages, 134 Illustrations. 4s.
"An elegantly printed and profusely illustrated work, which is worthy of the author's reputation."—*Athenæum*.

MINERALOGY: The Characters of Minerals, their Classification and Description. By F. H. HATCH, Ph.D., F.G.S. With 115 Illustrations. 3s. 6d.

"Dr. Hatch has admirably united brevity and clearness in his treatment of the crystallographical and physical characters of minerals."—*Nature*.

LIGHT. By Sir H. TRUEMAN WOOD, M.A., Secretary of the Society of Arts. With 86 Illustrations. 2s. 6d.

THE PLANT WORLD: Its Past, Present, and Future. By G. MASSE, of Kew Gardens. With 56 Illustrations. 3s. 6d.

LONDON:
WHITTAKER & CO., PATERNOSTER SQUARE.

ELEMENTARY PRACTICAL CHEMISTRY.

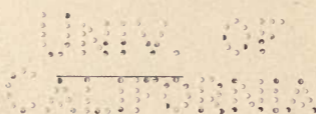
INORGANIC AND ORGANIC.

BY

J. T. HEWITT, M.A., D.Sc., Ph.D., F.C.S.,
Professor of Chemistry;

AND

F. G. POPE,
*Assistant Lecturer and Demonstrator in the
People's Palace Technical Schools.*



London:

WHITTAKER AND CO., PATERNOSTER SQUARE, E.C.

NEW YORK: 66, FIFTH AVENUE.

QD83

H4

UNIVERSITY OF CALIFORNIA

P R E F A C E .

THIS small work on qualitative analysis is intended to supply a text-book for students working according to the syllabus of the elementary stage of Practical Inorganic and Organic Chemistry. The substances for which tests are given are those contained in the new syllabus (1894), but it is hoped that the methods given for their detection and separation are such that the student will have nothing to unlearn when he proceeds to a more advanced course of qualitative analysis.

Directions are given in the making up of reagents for students who are working without the aid of a teacher.

Objection may be taken by some to the way in which it is recommended that results should be stated, but the authors find after several years practical experience in laboratory teaching, that this method leads to clearness of expression, and the rapid examination of a student's work.

*Chemical Laboratory,
People's Palace, E.*

J. T. H.
F. G. P.

HINTS FOR LABORATORY WORK.

It is necessary that all apparatus should be kept scrupulously clean, as good results cannot be expected if dirty apparatus is used.

Reagent bottles should be replaced on the shelves directly after use, and the stoppers should on no account be mixed.

Write down the results observed as soon as an experiment is made: it is hard to remember all the work done when an analysis is finished. Do not leave out an account of an experiment because it has yielded a negative result.

Before systematic analysis is begun, preliminary tests should be made.

Distilled water should always be used—both for making up reagents and for analytical purposes.

Silver and platinum residues should not be thrown away, but put into separate stock-bottles for recovery.

Students should practise using small quantities of substance and reagents, as much time is wasted in having large quantities to filter.

Equations should be given wherever possible, to illustrate the reactions that occur.

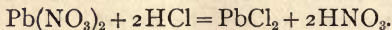
For the method of stating the results of an analysis, see the sample analyses given at the end of the analytical tables.

REACTIONS OF THE METALS.

Lead—Dry reaction.—Heated on charcoal in the reducing flame, lead compounds give a bead of the metal. This is malleable, and marks paper.

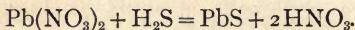
Wet reactions.—Use a solution of lead nitrate $\text{Pb}(\text{NO}_3)_2$.

Hydrochloric acid gives a white precipitate (PbCl_2).



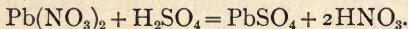
The precipitate is soluble in boiling water, and crystallizes out again on cooling.

Hydrogen sulphide gives a black precipitate of lead sulphide (PbS).

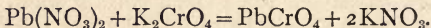


In presence of much HCl the precipitate may be red. If so, dilute and pass more gas.

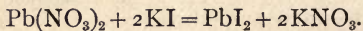
Sulphuric acid precipitates white lead sulphate (PbSO_4).



Potassium chromate gives a yellow precipitate of yellow lead chromate (PbCrO_4).



Potassium iodide precipitates yellow lead iodide (PbI_2).



The precipitate dissolves in much boiling water, and separates as yellow scales on cooling.

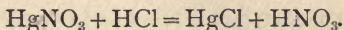
Mercury.—The salts of mercury are of two sorts: mercurous salts, corresponding to mercurous oxide Hg_2O ; and mercuric salts, corresponding to mercuric oxide HgO . The wet reactions of these two series of salts differ.

Dry reactions.—Mercury salts volatilize when heated on charcoal in the blowpipe flame.

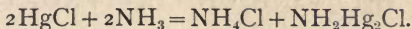
Heated with sodium carbonate in a dry tube, a mirror of metallic mercury is formed.

Wet reactions—Mercurous salts.—Use a solution of mercurous nitrate (HgNO_3).

Hydrochloric acid gives a white precipitate of mercurous chloride (calomel).



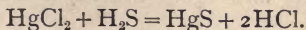
The precipitate is insoluble in boiling water, and turned black by ammonia.



Mercuric salts.—Use a solution of mercuric chloride (HgCl_2 ; corrosive sublimate).

[*Note.*—Mercuric chloride, unlike mercurous chloride, is soluble in water; hence mercuric salts are not precipitated by addition of hydrochloric acid.]

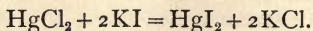
Hydrogen Sulphide gives a grayish ppt., passing through yellow to black mercuric sulphide (HgS).



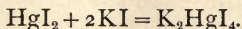
This precipitate does not dissolve in hot dilute nitric acid ; but if boiled with HCl and Bromine-water, a solution of HgCl_2 is obtained.

Copper turnings become coated with a white shining deposit of metallic mercury.

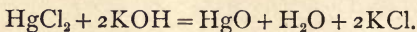
Potassium iodide gives a red precipitate of mercuric iodide (HgI_2).



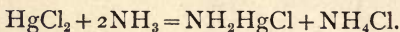
This precipitate is soluble in excess of potassium iodide.



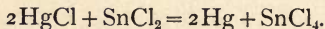
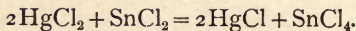
Soda and *potash* precipitate *yellow* mercuric oxide.



Ammonia gives a white precipitate.



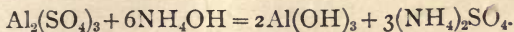
Stannous chloride gives a precipitate—at first white (HgCl), then turning gray (Hg).



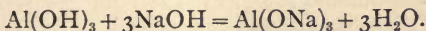
Aluminium—Dry reaction.—Aluminium compounds heated on charcoal in the oxidizing flame yield a white mass of the oxide. If this is moistened with cobalt nitrate solution ($\text{Co}(\text{NO}_3)_2$) and again heated, a blue mass is produced.

Wet reactions.—Use a solution of potash alum, $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$.

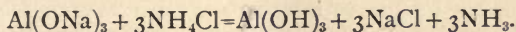
Ammonia gives a white gelatinous precipitate of aluminium hydroxide, $Al(OH)_3$, insoluble in excess.



Soda and *potash* give a similar precipitate, soluble in excess.



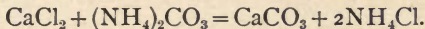
The alkaline solution gives a precipitate of $Al(OH)_3$ on boiling with ammonium chloride.



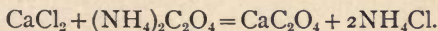
Calcium — Dry Reaction.—Calcium salts moistened with hydrochloric acid impart an orange colour to the Bunsen flame.

Wet reactions.—Use a solution of calcium chloride, $CaCl_2$.

Ammonium Carbonate gives a white precipitate of calcium carbonate, $CaCO_3$.



Ammonium Oxalate precipitates white calcium oxalate, CaC_2O_4 .



Sulphuric acid gives a precipitate of calcium sulphate, $CaSO_4$, in strong solutions, if, however the solution be dilute, the precipitate will not

appear, as calcium sulphate is slightly soluble in water.



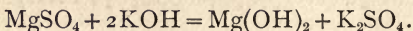
Magnesium—Dry reaction.—Heated before the blowpipe, magnesium salts leave a white residue of magnesium oxide, MgO . If this is treated with a drop of cobalt nitrate solution and again heated in the oxidizing flame a pink mass is obtained.

Wet reactions.—Use a solution of magnesium sulphate, MgSO_4 .

The solution will give precipitates with ammonium hydroxide and carbonate if ammonium chloride is not present. If, however, ammonium chloride be present, the double chloride of ammonium and magnesium ($2\text{NH}_4\text{Cl}$, MgCl_2) is formed, which gives no precipitate with these reagents.

[*N.B.*—In this way calcium and magnesium may be separated. Mix solutions of calcium and magnesium chlorides, add ammonium chloride, and then ammonia and ammonium carbonate. The white precipitate will consist of calcium carbonate, the magnesium remains in the solution.]

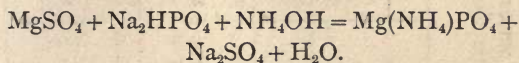
Caustic potash and soda produce white precipitates of magnesium hydroxide, $\text{Mg}(\text{OH})_2$.



The precipitate is soluble in ammonium chloride; magnesium hydroxide will not be

thrown down if ammonium chloride is present in the original solution.

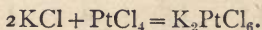
Sodium phosphate added to a solution of a magnesium salt which contains ammonium chloride and ammonia gives a white crystalline precipitate of magnesium ammonium phosphate.



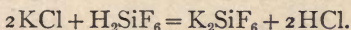
Potassium—Dry reaction.—Potassium salts colour the Bunsen flame violet. Lead salts communicate a blueish violet colour to the flame, hence, if lead salts are present, potassium must be looked for in the residue left on ignition, and not in the original mixture (see Table F).

Wet reactions.—Use a solution of potassium chloride, KCl.

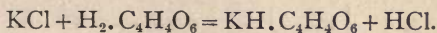
Platinum chloride gives a yellow crystalline precipitate of potassium chlorplatinite, K_2PtCl_6 (the solution must not be too dilute).



Fluosilicic acid gives a white gelatinous precipitate of potassium fluosilicate, K_2SiF_6 .



Tartaric acid precipitates acid potassium tartrate from a fairly concentrated solution of a potassium salt.



The substance given for examination will be soluble in water or dilute acid. Before doing the wet reactions, an examination of the substance should be made in the dry way.

EXPERIMENT.	OBSERVATION.	INFERENCE.
1. Heat some of the substance in a bulb tube or dry test tube.	(a) White sublimate. (b) Smell of ammonia. (c) Metallic mirror.	A salt of Hg or NH_4 . Hg.
2. Mix with dry Na_2CO_3 , and heat in a bulb tube.	Metallic mirror.	Hg.
3. Mix the substance with dry Na_2CO_3 , and heat on charcoal in the reducing flame.	(a) A metallic bead, which is malleable and marks paper. (b) Place the residue on a silver coin, and moisten with water; a black stain on the silver.	Pb. A sulphate.
4. (1) Heat on charcoal at the point of the oxidizing flame. (2) Moisten the white residue with $\text{Co}(\text{NO}_3)_2$, and again heat in the oxidizing flame.	(a) Yellow incrustation. (b) Deflagrates. (c) White shining residue. (Treat by 4(2).) (a) Blue mass. (b) Pink mass.	(a) Pb. (b) A nitrate. (c) Al, Ca, or Mg. Al. Mg.

EXPERIMENT.	OBSERVATION.	INFERENCE.
5. Heat some of the substance moistened with a little HCl on wire in the Bunsen flame.	Flame is coloured. (a) Violet. (b) Orange.	K. Ca.

The following preliminary tests should also be made :—

EXPERIMENT.	OBSERVATION.	INFERENCE.
1. Warm some of the substance with NaOH.	NH ₃ given off.	NH ₄ .
2. Heat with concentrated H ₂ SO ₄ .	(a) Pungent white fumes given off. (b) Slightly brownish fumes, having strong smell. (c) No gas given off.	A chloride. A nitrate.
3. Add dilute HCl.	Carbon dioxide evolved, which turns lime-water milky.	Oxide or sulphate. A carbonate.

TABLE A—SEPARATION OF THE METALS INTO GROUPS.

Dissolve the substance in water if possible—if not, in dilute hydrochloric acid, and regard any residue as a precipitate of lead or mercurous chloride (Table B). When a clear solution has been obtained, add dilute hydrochloric acid to the well-cooled solution; and if a precipitate forms, filter and wash the precipitate with cold water, adding the washings to the filtrate.

White ppt. indicates the presence of Pb or Hg(ous).	Pass excess of H_2S through the filtrate, or add a considerable excess of a solution of H_2S ; warm gently, and filter.* Wash the precipitate on the filter.	
Black ppt., if Pb† or Hg(tc) salts are present.	Boil off excess of H_2S ; then add a few drops of HNO_3 ; then boil, and add NH_4Cl , NH_4OH in excess, and a little $(NH_4)_2S$. Filter off precipitate, and wash on the filter.	
A white ppt. indicates Al.	To the filtrate add excess of $(NH_4)_2CO_3$. If a precipitate forms, filter it off, and wash on the filter.	If a precipitate forms, filter it off, and wash on the filter.
	White ppt., if Ca salts are present.	Divide solution into two parts. 1. Add a solution of Na_3HPO_4 . Warm very gently, and stir. White ammonium ppt. Mg. 2. Evaporate other portion to dryness, ignite residue to expel ammonium salts, and test residue by flame test. Violet flame = K.

* The solution must not be too acid, or the precipitation of the metals by H_2S will be hindered. † Lead is found in the precipitate formed by H_2S as well as in the precipitate of chlorides, as $PbCl_2$ is slightly soluble in water.
 For the further separation of the precipitates obtained, and the confirmation of the metals, see the following tables.

TABLE B.

The precipitate obtained by the addition of HCl may contain PbCl_2 and HgCl (Group I. ppt.). These chlorides may be separated by treatment with boiling water; the PbCl_2 dissolves, and the solution is filtered from the insoluble HgCl .

The insoluble residue on the filter consists of HgCl . Confirm its composition by adding ammonia, when it will turn black from formation of $\text{NH}_2\text{Hg}_2\text{Cl}$.

Divide hot filtrate into three parts.

(a) To one part add K_2CrO_4 . An immediate yellow ppt. consists of PbCrO_4 .

(b) Add KI to another portion, and allow to cool. PbI_2 separates in glistening yellow scales on cooling.

(c) Cool and add H_2SO_4 ; a white ppt. of PbSO_4 is formed.

TABLE C.

The black ppt. obtained by the action of H_2S may be tested for Pb and Hg(ic) in the following way. It is boiled with dilute HNO_3 , which dissolves the PbS , forming $\text{Pb}(\text{NO}_3)_2$; whilst HgS is not dissolved by this treatment. Filter and wash.

To confirm the presence of Hg in the residue, dissolve it in HCl, with addition of a little bromine-water; boil off the excess of Br,* and add a solution of SnCl_2 . A ppt., at first white (HgCl), then turning gray (Hg), indicates the presence of Hg.

Evaporate the filtrate to a small bulk; cool, and add a few drops of dilute sulphuric acid. A white ppt. of PbSO_4 indicates the presence of Pb. Confirm the presence of Pb by heating some of the original substance on charcoal in the reducing flame—a malleable metallic bead should be obtained.

* The excess of bromine must be carefully removed, or the stannous chloride will be oxidized at the expense of the Br, and not by the HgCl_2 ; hence a ppt. of HgCl and Hg will not be obtained.

TABLE D.

The ppt. obtained by addition of NH_4Cl , NH_4OH , and $(\text{NH}_4)_2\text{S}$, consists of $\text{Al}(\text{OH})_3$. Note that it is the ammonia which effects the precipitation, not the $(\text{NH}_4)_2\text{S}$.* To confirm the presence of Al, dissolve the ppt. in the least possible quantity of dilute HCl , add NaOH in slight excess, and then NH_4Cl , and boil. A white gelatinous ppt. of $\text{Al}(\text{OH})_3$ indicates the presence of Al.

TABLE E.

The ppt. obtained by addition of $(\text{NH}_4)_2\text{CO}_3$ consists of CaCO_3 . The calcium may be confirmed by dissolving a portion of the ppt. in HCl , adding NH_4Cl , NH_4OH , and $(\text{NH}_4)_2\text{C}_2\text{O}_4$. A white ppt. of CaC_2O_4 is produced.

Another portion of the ppt. should be moistened with HCl , and heated on wire in the Bunsen flame—the flame is coloured orange.

TABLE F.

The filtrate from the calcium ppt. contains magnesium and potassium. Divide into two parts.

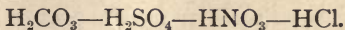
To one part add Na_2HPO_4 , warm, and allow to stand. A white cryst. ppt. ($\text{Mg}(\text{NH}_4)\text{PO}_4$) indicates Mg.

Evaporate the other portion to dryness; ignite to expel ammonium salts, and test the residue (if any), after moistening with HCl by the flame test.

Violet flame = K.

* A ppt. will be obtained in this group, even if Al is not present, if the metals Pb and Hg have not been completely removed by H_2S .

THE REACTIONS OF THE COMMON ACIDS.



These acids may be divided into four different groups, viz. :—

Group I.—The acid precipitated by barium chloride, but having its barium salt insoluble in acid solution—*Sulphuric acid*.

Group II.—The acid precipitated from its neutral solution by barium chloride, the barium salt being insoluble in water—*Carbonic acid*.

Group III.—The acid precipitated by silver nitrate, its silver salt being insoluble in dilute HNO_3 —*Hydrochloric acid*.

Group IV.—The acid whose salts are all soluble in water, and which, therefore, is not precipitated by any reagent—*Nitric acid*.

Reactions of Acid in Group I.

SULPHURIC ACID, H_2SO_4 .

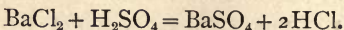
Sulphates are precipitated by barium chloride in the presence of hydrochloric acid, as insoluble barium sulphate.

Tests.—1. Dry sulphates heated with solid Na_2CO_3 on charcoal in the reducing flame are converted into sodium sulphide, which when

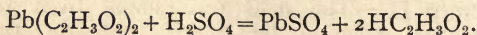
placed on a silver coin and moistened with water, gives a black stain (*i.e.*, the silver is converted into black silver sulphide, Ag_2S).

2. Soluble sulphates give with—

(A) Barium chloride or nitrate, a white precipitate of barium sulphate (BaSO_4) insoluble in hydrochloric acid, nitric acid, and ammonia.



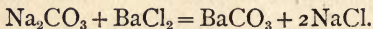
(B) Lead acetate gives a white precipitate of lead sulphate, soluble in ammonium acetate.



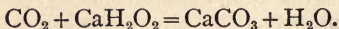
Reactions of Acid in Group II.

CARBONIC ACID, H_2CO_3 .

Carbonates are precipitated by barium chloride in a neutral solution as insoluble barium carbonate.



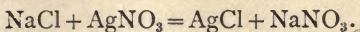
Tests.—1. The addition of acids (*e.g.*, HCl , HNO_3) gives an evolution of carbonic acid gas (CO_2), which on passing through lime-water turns it milky, owing to formation of calcium carbonate.



2. Barium chloride gives in neutral solutions a white precipitate of barium carbonate, soluble in dilute acids with effervescence.

Reactions of Acid in Group III.**HYDROCHLORIC ACID, HCl.**

Chlorides are precipitated by silver nitrate as insoluble silver chloride, *e.g.*—



Tests.—1. Dry chlorides on treating with strong sulphuric acid evolve hydrochloric acid gas, which turns blue litmus red, and gives dense white fumes of ammonium chloride in the presence of strong ammonia.

2. Dry chlorides heated with sulphuric acid and potassium bichromate evolve chlorine, which can be recognised by its smell, and by its bleaching of *moist* red litmus paper.

3. Solutions of chlorides give with silver nitrate a white precipitate of silver chloride, soluble in ammonia, and reprecipitated on the addition of excess of nitric acid.

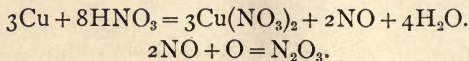
4. Solutions of chlorides give with mercurous nitrate a white precipitate of calomel, which is turned black on the addition of ammonia.

Reactions of Acid in Group IV.**NITRIC ACID, HNO₃.**

This acid is not precipitated by any reagent, as all its salts are soluble.

Tests.—1. Solid nitrates evolve oxygen when heated, and some evolve brown nitrous fumes as well. The oxygen may be tested with a glowing splinter.

2. Solid nitrates heated with strong sulphuric acid, an equal bulk of water, and a piece of copper, give nitric oxide, turning brown on exposure to the air.



3. Add to the dry substance some strong sulphuric acid and mix well. Cool and add carefully a cold solution of ferrous sulphate. If nitric acid be present, a black ring is formed at the junction of the two liquids.

[The H_2SO_4 first liberates HNO_3 . Then the nitric acid is reduced by some of the ferrous sulphate to nitric oxide, which cannot escape except by passing through the excess of ferrous sulphate; in this it dissolves, forming the black compound.

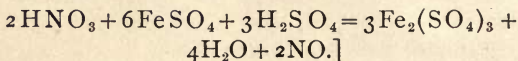


TABLE G.

DETECTION OF ACIDS.

Test separate portions of the original substance for chlorides, nitrates, sulphates, and carbonates, as follows:—

- (A) To the original substance add dilute HNO_3 . Effervescence without smell, with a white precipitate formed on passing the gas into lime-water, indicates a carbonate.
- (B) To the original substance add strong H_2SO_4 , cool and add a solution of FeSO_4 , a black

ring at the junction of the two liquids indicates a nitrate. Confirm by warming the original substance with sulphuric acid and a strip of metallic copper. Brown fumes evolved.

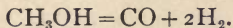
- (C) Dissolve the original substance in HCl (filter if a precipitate is formed), and add BaCl_2 . A white precipitate insoluble in HCl and HNO_3 indicates a sulphate. Confirm by dry test.
- (D) Dissolve the original substance in HNO_3 , and add AgNO_3 . A white precipitate soluble in NH_4OH indicates a chloride. Confirm by the preliminary tests.

Reactions of Organic Compounds.

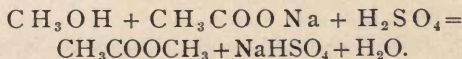
METHYL ALCOHOL, CH_3OH .

1. Heat with soda lime and it is converted into formic acid.

2. Distil over zinc-dust and it yields CO and H.

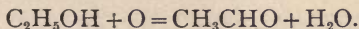


3. Heat with sodium acetate and strong sulphuric acid and it yields methyl acetate.



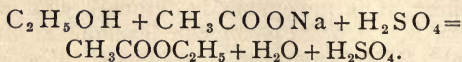
ETHYL ALCOHOL, $\text{C}_2\text{H}_5\text{OH}$.

1. Heat with $\text{K}_2\text{Cr}_2\text{O}_7$ and H_2SO_4 and aldehyde is evolved.



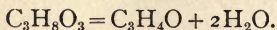
2. Add KHO, a strong solution of I in KI, till faint brown colour is produced, and then a drop or two of KHO till colour is destroyed, boil, and a yellow ppt. of iodoform (CHI_3) falls.

3. Heat with sodium acetate and strong sulphuric acid it yields ethyl acetate.



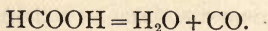
GLYCERIN, $\text{C}_3\text{H}_5(\text{OH})_3$.

1. Evaporate to small bulk and heat with dry KHSO_4 , and acrolein is evolved, recognised by its sharp and penetrating smell.



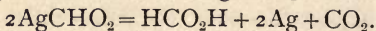
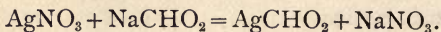
FORMIC ACID, HCOOH .

1. Solid formates heated with strong H_2SO_4 evolve CO , which burns with a blue flame, forming CO_2 . No charring takes place.

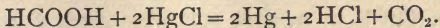
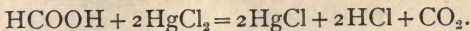


2. To a solution of a formate add FeCl_3 , a deep brown red colour is formed, and, on boiling, a reddish ppt. of basic ferric formate is formed.

3. AgNO_3 in strong neutral solutions gives a white ppt. of silver formate, which is decomposed on warming, with the deposition of metallic silver on the tube.



4. HgCl_2 gives a white ppt. of HgCl , which on heating is decomposed, and Hg is deposited as a black powder.

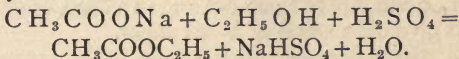


5. A solution of KMnO_4 is at once decolorized by a formate.

ACETIC ACID, $\text{CH}_3\text{CO}_2\text{H}$.

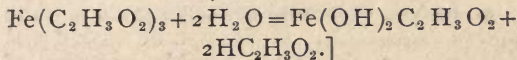
1. Solid acetates heated with H_2SO_4 give off acetic acid, recognised by its smell.

2. Solid acetates heated with strong H_2SO_4 and a drop or two of absolute alcohol give off ethyl acetate.

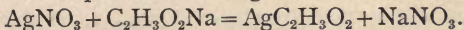


3. FeCl_3 in strong solutions gives a red coloration, which, on boiling, forms a deep brown red ppt. of basic ferric acetate.

[The normal acetate, $\text{Fe}(\text{C}_2\text{H}_3\text{O}_2)_3$, is first formed, and this is decomposed on boiling by the excess of water, thus:—



4. AgNO_3 gives a white ppt. of $\text{AgC}_2\text{H}_3\text{O}_2$, *not* decomposed on boiling.

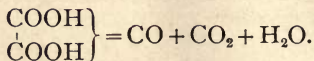


OXALIC ACID COOH .

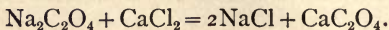


1. Solid oxalates on heating with strong

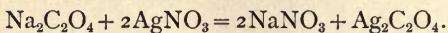
H_2SO_4 evolve CO and CO_2 , and do *not* char.



2. CaCl_2 in neutral solutions gives a white ppt. of CaC_2O_4 , readily soluble in HCl.



3. AgNO_3 gives a white ppt. of $\text{Ag}_2\text{C}_2\text{O}_4$, soluble in acids and ammonia.

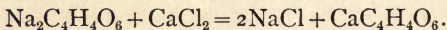


TARTARIC ACID, $\text{CH}(\text{OH})\text{CO}_2\text{H}$.
 $\text{CH}(\text{OH})\text{CO}_2\text{H}$.

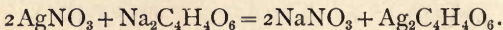
1. Solid tartrates, on heating in a tube, blacken and give off a smell of burnt sugar.

2. Solid tartrates, heated with strong H_2SO_4 , blacken and evolve CO and CO_2 .

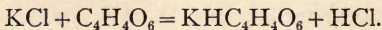
3. CaCl_2 in neutral solutions gives a white ppt. of $\text{CaC}_4\text{H}_4\text{O}_6$, soluble in HCl; also in *cold* strong KHO, but reprecipitated on boiling.



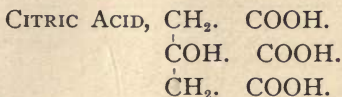
4. AgNO_3 in neutral solutions gives a white ppt. of $\text{Ag}_2\text{C}_4\text{H}_4\text{O}_6$. If this ppt. be washed and dissolved in the least possible quantity of NH_4OH and the solution warmed, Ag will be deposited on the tube.



5. KCl in presence of a little alcohol gives a white ppt. of $\text{KHC}_4\text{H}_4\text{O}_6$.



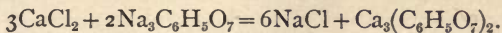
6. Tartrates with a strongly alkaline solution of KMnO_4 give a pink colouration, which on boiling forms a brown ppt.



1. Solid citrates on heating blacken and give off unpleasant fumes.

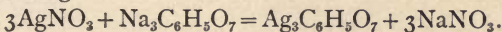
2. Solid citrates on heating with strong H_2SO_4 , evolve CO , then blacken, evolving CO_2 , acetone, &c.

3. CaCl_2 in neutral solutions gives a white ppt. of $\text{Ca}_3(\text{C}_6\text{H}_5\text{O}_7)_2$ on boiling.

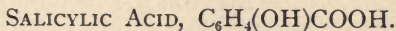


No ppt. is formed in the cold.

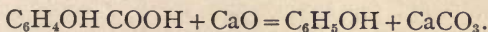
4. AgNO_3 gives a white ppt. of $\text{Ag}_3\text{C}_6\text{H}_5\text{O}_7$ soluble in NH_4OH , but it is *not* reduced on heating.



5. Citrates boiled with a strongly alkaline solution of KMnO_4 give a green coloration, but *no* ppt.



1. Solid salicylates heated with CaO yield phenol, recognised by smell.



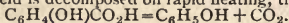
2. FeCl_3 gives a deep purple coloration, even in very dilute solutions.

3. Bromine-water gives a white ppt.

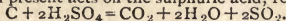
Before proceeding with the systematic analysis, the following preliminary tests should be made :

EXPERIMENT.	OBSERVATION.	INFERENCE.
1. Heat a small portion of the substance in a small dry tube.	(A) Substance blackens, swells, and gives odour of burnt sugar. (B) A white sublimate is formed. (C) Smell of phenol.*	Presence of a tartrate or citrate. Presence of an oxalate. Presence of a salicylate.
2. Heat a small portion of substance in a dry tube with strong H_2SO_4 .	(A) No blackening after long heating. (B) Rapid effervescence with charring, and CO , CO_2 , and ultimately SO_2 † given off. (C) CO ‡ only evolved; no charring. (D) CO and CO_2 evolved; no charring. (E) Odour of acetic acid; no charring.	Absence of tartrates and citrates. Presence of a tartrate or citrate. Presence of a formate. Presence of an oxalate. Presence of an acetate.

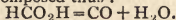
* Salicylic acid is decomposed on rapid heating, thus :—



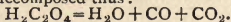
† The carbon present acts on the sulphuric acid, reducing it, thus :



‡ Formic acid is decomposed thus :—



|| Oxalic acid is decomposed thus :—



If the substance given is a liquid, it should be tested for methyl and ethyl alcohols and glycerine in the following manner :—

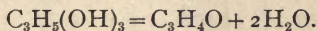
(A) *Methyl and ethyl alcohols.*—Should the mixture smell of alcohol, make it alkaline with $NaOH$ and distil a large portion, collect the

distillate and redistil it over half its bulk of freshly ignited K_2CO_3 . Repeat the operation and take first portion of distillate only. Now note the boiling point of the liquid.

Methyl alcohol boils at $67^\circ C$ and ethyl alcohol at $78^\circ C$.

The liquid should give a smell of aldehyde when heated with dilute H_2SO_4 and $K_2Cr_2O_7$.

(B) *Glycerine*.—Evaporate liquid to small bulk on water bath. A thick viscid liquid remains, which on heating with dry $KHSO_4$ gives pungent smell of acrolein.



PREPARATION OF SOLUTION TO BE TESTED FOR ORGANIC ACIDS.

I. Dissolve small portion of substance in a little water—if possible. If solution is neutral and does not contain heavy metals (*i.e.*, gives no ppt. on treating portions with HCl , H_2S and Na_2CO_3) it can be used at once for the detection of the acids.

II. If substance does not dissolve in water or if it contains heavy metals, dissolve it in HNO_3 , add H_2S , and if a ppt. is formed pass H_2S in excess and filter, boil filtrate to expel H_2S and add solid Na_2CO_3 till very alkaline, boil, and if necessary, filter. To solution add litmus and slight excess HNO_3 , boil off CO_2 , add ammonia till slightly alkaline and boil till excess of ammonia is expelled. Solution should now be neutral.

[H_2S is added to ppt., AS and Sb, and Na_2CO_3 to remove all remaining metals, except those of Group V.]

TABLE H.

SEPARATION OF THE ORGANIC ACIDS.

To a strong, cold, neutral solution, free from heavy metals, add a strong solution of CaCl_2 , and allow to stand for some time. Filter, if necessary.

PRECIPITATE.		SOLUTION.
The ppt. may contain calcium oxalate or tartrate, or both. Wash and treat with cold KHO , free from K_2CO_3 . Filter, if necessary.		Boil filtrate for some time, replacing the evaporated H_2O . If a ppt. forms, filter.
PRECIPITATE.	SOLUTION.	PRECIPITATE.
The ppt. consists of calcium oxalate. Dissolve in HCl , and add NH_4OH in excess; a white ppt., insoluble in acetic acid, confirms oxalic acid.	The filtrate may contain calcium tartrate. Boil filtrate; a white ppt. confirms tartaric acid. Confirm also by AgNO_3 test.	The ppt. consists of calcium citrate. Ppt. is soluble in HCl .
		SOLUTION. To solution add FeCl_3 . A purple coloration indicates salicylic acid (confirm by preliminary tests). A dark brown coloration, and a brown ppt. on boiling, indicates formic or acetic acid.

TO TEST FOR FORMIC ACID.

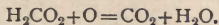
- (A) *In absence of tartaric or citric acids.*—To solution add strong AgNO_3 solution. A white ppt. is formed which immediately blackens on heating the solution, owing to reduction of AgNO_3 to Ag .
- (B) *In presence of tartaric and citric acids.*—Distil a portion of the substance with *dilute* H_2SO_4 , stopping the distillation before blackening occurs.* Neutralize distillate and test as above.

TO TEST FOR ACETIC ACID.

- (A) *In absence of formic acid.*—To solution add FeCl_3 —a brown coloration, giving a dark brown ppt. on boiling, indicates *acetic acid*.
- (B) *In presence of formic acid and alcohol.*—If alcohol be present, boil it off. Add dilute H_2SO_4 and distil off the acetic and formic acids, boil distillate for some minutes with an equal bulk of a solution of $\text{K}_2\text{Cr}_2\text{O}_7$, and dilute H_2SO_4 in a flask with reflux tube.† Distil, neutralize distillate, cool and add FeCl_3 —brown coloration and brown ppt. on boiling indicates acetic acid.

* If distillation is carried too far SO_2 might be evolved, and a black ppt. would be formed with AgNO_3 .

† This destroys formic acid and does not act on acetic.



Typical Analyses.

Inorganic Mixtures.

(A) The substance is a white powder.

PRELIMINARY EXAMINATION FOR METALS AND ACIDS.

EXPERIMENT.	OBSERVATION.	INFERENCE.
1. Heat some of substance in bulb tube.	A white sublimate.	Presence of an ammonium salt.
2. Mix with dry Na_2CO_3 , and heat in bulb tube.	No metallic mirror.	Absence of a mercury salt.
3. Mix substance with dry Na_2CO_3 , and heat on charcoal in reducing flame.	A malleable metallic bead formed.	Presence of a lead salt.
4. Heat on charcoal in oxidizing flame.	(a) Yellow incrustation. (b) Substance degrades.	Presence of a lead salt. Presence of a nitrate.
5. Heat substance moistened with HCl in Bunsen flame.	A bluish-violet flame coloration.	Presence of a potassium or lead salt.
6. Warm some of substance in a tube with NaOH solution.	NH_3 given off.	Presence of an ammonium salt.
7. Heat some of substance in a tube with strong H_2SO_4 .	Brownish fumes evolved.	Presence of a nitrate.
8. Add dilute HCl to original substance.	No effervescence.	Absence of a carbonate.

Systematic Analysis.

Substance is easily soluble in hot water. Cool thoroughly, and add HCl in excess.

A white ppt. formed.	Filter, and add H_2S in excess.	Filter, boil off H_2S , add a few drops of HNO_3 , and then NH_4Cl , NH_4OH in excess, and a little $(NH_4)_2S$.
Presence of Pb or Hg'.	A black ppt. formed; presence of Pb or Hg''.	
No ppt.; absence of Al.		Add $(NH_4)_2CO_3$. No ppt.; absence of Ca.
Add Na_2HPO_4 .		
No ppt.; absence of Mg.		Evaporate to dryness, and ignite.
No residue; absence of K.		

EXAMINATION OF GROUP I. PPT.

EXPERIMENT.	OBSERVATION.	INFERENCE.
Wash ppt. with cold H_2O , and boil with H_2O .	Ppt. completely dissolves.	Presence of Pb.
Divide solution into three parts :— To (1) add K_2CrO_4 .	A yellow ppt.	Presence of Pb.
„ (2) „ KI.	A yellow ppt.	Presence of Pb.
„ (3) Cool, and add dilute H_2SO_4 .	A white ppt.	Presence of Pb.

EXAMINATION OF GROUP II. PPT.

EXPERIMENT.	OBSERVATION.	INFERENCE.
Boil ppt. with dilute HNO_3 .	Ppt. completely dissolves.	Presence of lead ; absence of Hg.
Evaporate solution to small bulk, cool, and add dilute H_2SO_4 .	A white ppt.	Presence of Pb.

TEST ORIGINAL SUBSTANCE FOR AMMONIA.

EXPERIMENT.	OBSERVATION.	INFERENCE..
Boil with NaOH.	Ammonia gas evolved; recognised by smell and by giving dense white fumes (of NH_4Cl), when a rod moistened with strong HCl is brought near.	Presence of ammonium.

TEST FOR ACID.

EXPERIMENT.	OBSERVATION.	INFERENCE.
To substance add strong H_2SO_4 ; cool, and add $FeSO_4$ solution.	A black ring formed at junction.	Presence of a nitrate.
Boil substance with sulphuric acid and a strip of copper.	Brown fumes evolved.	Presence of a nitrate.

Substance contains, therefore, lead, ammonium, and nitric acid; and is, therefore, probably a mixture of lead and ammonium nitrates.

(B) The substance is a white powder.

 PRELIMINARY EXAMINATION FOR METALS
AND ACIDS.

EXPERIMENT.	OBSERVATION.	INFERENCE.
1. Heat substance in dry tube.	No sublimate. No smell of ammonia. No metallic mirror.	Abs. of mercury or ammonium salts. Abs. of an ammonium salt. Abs. of a mercury salt.
2. Heat with dry Na_2CO_3 .	No metallic mirror.	Abs. of a mercury salt.

PRELIMINARY EXAMINATION FOR METALS AND
ACIDS—*continued.*

EXPERIMENT.	OBSERVATION.	INFERENCE.
3. Mix substance with dry Na_2CO_3 ; heat on charcoal in reducing flame.	(a) No metallic bead. (b) Place residue on a silver coin, and moisten with H_2O . A black stain on the silver.	Abs. of a lead salt. Presence of a sulphate.
4. Heat on charcoal in oxidizing flame.	No incrustation; white shining residue.	Abs. of a lead salt; presence of an aluminium, calcium, or magnesium salt.
Moisten white residue with $\text{Co}(\text{NO}_3)_2$, and heat again.	No distinct coloration (<i>i.e.</i> , neither quite pink nor quite blue).	(?) Presence of aluminium and magnesium.
5. Heat substance moistened with HCl in Bunsen flame.	No flame coloration.	Abs. of potassium and calcium salts.
6. Warm substance with NaOH solution.	No NH_3 evolved.	Abs. of ammonium salts.
7. Heat substance with strong H_2SO_4 .	No white fumes evolved. No brown fumes evolved.	Abs. of chlorides. Abs. of nitrates.
8. Add dilute HCl to original substance.	No effervescence.	Abs. of a carbonate.

Systematic Analysis.

Substance is easily soluble in water. Cool thoroughly, and add HCl.

No ppt. ; abs. of Pb and Hg'	Add H ₂ S.	
No ppt. ; abs. of Pb and Hg''	Boil off H ₂ S, add a few drops HNO ₃ , and then NH ₄ Cl, NH ₄ OH in excess, and a few drops of (NH ₄) ₂ S.	
	A white ppt. ; presence of Al.	Filter, and add (NH ₄) ₂ CO ₃ .
	No ppt. ; abs. of Ca.	Add Na ₂ HPO ₄ .
	White ppt. ; presence of Mg.	Evaporate to dryness, and ignite.
		No residue ; abs. of K.

EXAMINATION OF GROUP III. PPT.

EXPERIMENT.	OBSERVATION.	INFERENCE.
Dissolve ppt. in very small quantity of dilute HCl, add slight excess of NaOH, and then NH_4Cl , and boil. Confirm ppt. by heating on charcoal, and moistening with $\text{Co}(\text{NO}_3)_2$.	A white ppt.	Presence of Al.
	A blue mass.	Confirms Al.

TO CONFIRM Mg.

EXPERIMENT.	OBSERVATION.	INFERENCE.
Heat ppt. on charcoal moistened with $\text{Co}(\text{NO}_3)_2$.	A pink mass.	Presence of Mg.

TEST ORIGINAL SUBSTANCE FOR AMMONIUM.

EXPERIMENT.	OBSERVATION.	INFERENCE.
Boil with NaOH.	No NH_3 evolved.	Abs. of NH_4 .

TEST FOR ACID.

EXPERIMENT.	OBSERVATION.	INFERENCE.
Dissolve substance in HCl, and add BaCl_2 . Confirm by dry test.	A white ppt., insoluble in HCl and HNO_3 .	Presence of H_2SO_4 .

Substance contains aluminium and magnesium and sulphuric acid, and is therefore probably a mixture of aluminium and magnesium sulphates.

Organic Mixtures.

(A) The substance is a white powder.

PRELIMINARY EXAMINATION.

EXPERIMENT.	OBSERVATION.	INFERENCE.
Heat substance in a dry tube.	Immediate blackening and smell of burnt sugar.	Presence of a tartrate or citrate.
Heat substance with strong H_2SO_4 .	Rapid effervescence, with charring and evolution of CO , CO_2 , and ultimately SO_2 .	Presence of a tartrate or citrate.

Systematic Analysis.

EXPERIMENT.	OBSERVATION.	INFERENCE.
To a strong and exactly neutral solution, free from heavy metals, add $CaCl_2$, and allow to stand for ten minutes.	No ppt.	Absence of oxalates and tartrates.
Boil solution for five minutes.	White ppt.	Presence of a citrate.
Filter, and add $FeCl_3$.	Dark brown coloration and dark brown ppt. on boiling.	Presence of a formate or acetate.

EXAMINATION OF PPT. PRODUCED BY CaCl_2 .

EXPERIMENT.	OBSERVATION.	INFERENCE.
Boil ppt. with HCl. Confirm by reactions, page 25.	It dissolves.	Presence of a citrate.

TO CONFIRM FORMIC OR ACETIC ACID.

EXPERIMENT.	OBSERVATION.	INFERENCE.
Distil portion of original substance with dilute H_2SO_4 , stopping distillation before blackening occurs; and to distillate add AgNO_3 .	A white ppt., blackening on warming.	Presence of a formate.

Substance was therefore a mixture of a formate and a citrate.

(B) The substance is a colourless liquid.

EXPERIMENT.	OBSERVATION.	INFERENCE.
Heat substance in a dry tube.	Liquid boils; the vapour has an alcoholic smell.	Presence of methyl or ethyl alcohol.
Heat residual liquid with strong H_2SO_4 .	A very irritating odour of acrolein.	Presence of glycerine.
Test reaction of original solution.	Neutral.	No free organic acid.
Burn a drop or two of liquid on Pt foil.	No residue left.	Absence of salts of organic acids.

Distil a portion of the original liquid, collect the distillate, redistil it over half its bulk of freshly ignited K_2CO_3 , repeat the process and take the first portion of the distillate. Determine its boiling point—found to be 78° . The substance is ethyl alcohol.

Test for glycerine in the residual liquid left after distilling off the alcohol, by evaporating with $KHSO_4$ and heating strongly. A pungent odour of acrolein indicates glycerine.

The substance is therefore a mixture of glycerine and ethyl alcohol.

Preparation of Reagents.

In making up reagents for use in the laboratory, distilled water must be always used.

Hydrochloric acid.—The strong pure acid should be diluted with three times its volume of water.

Nitric acid.—The strong pure acid should be diluted with three times its volume of water.

Sulphuric acid.—The strong pure acid should be diluted with four times its volume of water, allowed to stand overnight to allow the lead sulphate to settle, and then siphoned off. [Care must be taken to pour the strong acid into the water, and NOT the water into the acid.]

Sodium hydrate.—Dissolve one part by weight of the solid in ten times its weight of water.

Ammonium hydrate.—Dilute .880 ammonia with three times its volume of water.

Lime-water.—Shake up one part of slaked lime with about one hundred times its weight of water, allow to stand overnight and decant the clear liquid. Preserve in a tightly stoppered bottle.

Ammonium chloride.—Dissolve one part by weight of the solid in eight times its weight of water.

Ammonium carbonate.—Dissolve one part by weight of the solid in five times its weight of water, and add its own weight of .880 ammonia.

Barium chloride.—Dissolve one part by weight of the solid in ten times its weight of water.

Calcium chloride.—Make a saturated solution.

Cobalt nitrate.—Dissolve one part by weight of the solid in ten times its weight of water.

Ferrous sulphate.—Dissolve one part by weight of the solid in ten times its weight of *cold* water, and add a few drops of dilute sulphuric acid.

Ferric chloride.—Dissolve one part by weight of the solid in ten times its weight of water.

Potassium iodide.—Dissolve one part by weight of the solid in twenty times its weight of water.

Potassium chromate.—Dissolve one part by weight of the solid in twenty times its weight of water.

Sodium phosphate.—Dissolve one part by weight of the solid in ten times its weight of water.

Stannous chloride.—Dissolve one part by weight of the solid in its own weight of strong hydrochloric acid, and dilute with four times its volume of water. A small piece of granulated tin should always be kept in the solution.

Silver nitrate.—Dissolve one part by weight of the solid in twenty times its weight of water.

For organic analysis dissolve one part by weight of the solid in five times its weight of water.

Platinum chloride.—Dissolve one part by weight of the solid in ten times its weight of water.

Ammonium oxalate.—Dissolve one part by weight of the solid in twenty-four times its weight of water.

Sulphuretted hydrogen.—Make a saturated solution of the gas. The gas should first be washed through water to free it from any small quantities of acid present.

Bromine-water.—Add about five grammes of bromine to one hundred grammes of water, and shake well.

Ammonium sulphide.—Add to three volumes of the strong solution twenty volumes of water and two volumes of .880 ammonia.

Lead acetate.—Dissolve one part by weight of the solid in ten times its weight of water, and add a little acetic acid.

Mercuric chloride.—Dissolve one part by weight of the solid in sixteen times its weight of water.

TABLE OF SOLUBILITY OF SALTS.

	Aluminium.	Ammonium.	Calcium.	Lead.	Magnesium.	Mercury (ous).	Mercury (ic).	Potassium.	Sodium.
Acetate	(w)	w	w	w	w	(w)	w	w	w
Carbonate		w	a	a	a	a	a	w	w
Citrate	w	w	a	a	w	a	a	w	w
Formate		w	w	w	w	w	w	w	w
Chloride	w	w	w	(w)	w	a	w	w	w
Nitrate	w	w	w	w	w	w	w	w	w
Oxalate	a	w	a	a	a	a	a	w	w
Salicylate		w	w					w	w
Sulphate	w	w	(w)	i	w	w	(w)	w	w
Tartrate		w	a	a	a	a	a	w	w

w signifies that the compound is soluble in water.

(w) signifies that the compound is difficultly soluble in water.

a signifies that the compound is soluble in acids.

i signifies that the compound is insoluble in water and acids.

Works Published by WHITTAKER & CO.



WORKS BY G. E. BONNEY.

The Electro-Plater's Handbook. A Practical Manual for Amateurs and Young Students in Electro-Metallurgy. With Full Index and 61 Illustrations. *Second Edition*, revised. 3s.

"An amateur could not wish for a better exposition of the elements of the subject. . . . The work has an excellent index and 61 illustrations, and will form a useful addition to Messrs. Whittaker's valuable series of practical manuals."

Electrical Review.

"The work is of evident utility, and has before it a future."

Chemical News.

Electrical Experiments. With 144 Illustrations. 2s. 6d.

"This is an excellent book for boys."—*Electrical Review.*

"One of the most delightful of volumes for thoughtful young people."—*Liverpool Mercury.*

Induction Coils. A Practical Manual for Amateur Coil Makers. With 101 Illustrations. 3s.

"In Mr. Bonney's useful book every part of the coil is described minutely in detail, and the methods and materials required in insulating and winding the wire are fully considered."—*Electrical Review.*

WORKS BY S. R. BOTTONE.

Electrical Instrument-Making for Amateurs. A Practical Handbook. With 71 Illustrations. *Sixth Edition*, revised and enlarged. 3s.

"To those about to study electricity and its application, this book will form a very useful companion."—*Mechanical World.*

Electric Bells and all about them. A Practical Book for Practical Men. With more than 100 Illustrations. *Fourth Edition*, revised. 3s.

"No bell-fitter should be without it."—*Building News.*

Electro-Motors: How Made and How Used. A Handbook for Amateurs and Practical Men. With 64 Illustrations. *Second Edition*, revised and enlarged. 3s.

LONDON: WHITTAKER & CO., PATERNOSTER SQUARE.

WORKS BY W. PERREN MAYCOCK, M.I.E.E.

First Book of Electricity and Magnetism.

84 Illustrations. 2s. 6d.

"Students who purchase a copy, and carefully study it, will obtain an excellent groundwork of the science."—*Electrical Review*.

"As a first book for such students as have to pass examinations, it is admirable."—*Electrical Engineer*.

An Elementary Manual of Electric Lighting and Power Distribution.

For Students preparing for the Ordinary Grade Examination of the City and Guilds of London Institute, and General Readers. With 280 Illustrations. *Second Edition*. In One Vol., 6s. ; or in Three Parts, Crown 8vo, price 2s. 6d. each.

"We can congratulate Mr. Maycock upon having produced a book which cannot fail to be useful to all who are genuine students of electricity and its methods."—*Electrical Review*.

WORKS BY A FOREMAN PATTERN MAKER.

Practical Ironfounding. Illustrated with over 100 Engravings. *Second Edition*. 4s.

"Every pupil and apprentice would find it, we think, an assistance to obtaining a thorough knowledge of his work. The book, however, is not intended merely for the student, but contains much useful information for practical men."—*Industries*.

The Principles of Fitting. For Engineer Students. Illustrated with 250 Engravings, and containing an Appendix of Useful Shop Notes and Memoranda. Crown 8vo. 5s.

"A practical manual for practical people."—*English Mechanic*.

"Calculated to aid and encourage the most useful set of handicraftsmen we have amongst us."—*Daily Chronicle*.

The Principles of Pattern-Making. Written specially for Apprentices, and for Students in Technical Schools. Illustrated with 101 Engravings, and containing a Glossary of the Common Terms employed in Pattern-Making and Moulding. 3s. 6d.

"We have no hesitation in recommending the book to technical students and apprentices."—*Mechanical World*.

"This is one of those works which have a more than ordinary value."—*Steamship*.

Metal Turning. With 81 Illustrations. 4s.

"A handy little work."—*Ironmonger*.

"An exceedingly useful publication to have at hand."

Machinery.

LONDON: WHITTAKER & CO., PATERNOSTER SQUARE.

By J. TRAILL TAYLOR, Editor of *The British Journal of Photography*.

The Optics of Photography and Photographic Lenses. With 68 Illustrations. 3s. 6d.

"An excellent guide, of great practical use."—*Nature*.

"Personally we look upon this book as a most valuable labour-saving invention, for no questions are so frequent, or take so long to answer, as those about lenses."—*Practical Photographer*.

"Written so plainly and clearly that we do not think the merest tyro will have any difficulty in mastering its contents."
Amateur Photographer.

By H. ORFORD.

Lens Work for Amateurs. With Numerous Illustrations. Small crown 8vo. 3s.

By JOSEPH POOLE, A.I.E.E. (Wh. Sc. 1875), Chief Electrician to the late Lancashire and Cheshire Telephone Exchange Co., Manchester.

The Practical Telephone Handbook. With 227 Illustrations. 3s. 6d.

"It contains readable accounts of all the best known and most widely-used instruments, together with a considerable amount of information not hitherto published in book form."—*Electrician*.

The Specialists' Series.

By GISBERT KAPP, C.E., Member of the Institution of Civil Engineers, Member of Institution of Electrical Engineers.

Electric Transmission of Energy, and its Transformation, Sub-division, and Distribution. A Practical Handbook. With 166 Illustrations. *Fourth Edition*, mostly re-written, 455 pp., xii. pp. Crown 8vo. 10s. 6d.

* * * The work has been brought up to date both as regards theory and practice.

By J. O. ARNOLD, Professor of Metallurgy, Sheffield Technical School.

Steel Works Analysis. With 22 Illustrations and Diagrams. 350 pp. Crown 8vo. 10s. 6d.

LONDON: WHITTAKER & CO., PATERNOSTER SQUARE.

By G. W. SUTCLIFFE, M.Inst.C.E. (Whitworth Scholar).

Steam Power and Mill Work: Modern Practice in. With numerous Tables, Illustrations, &c.
About 800 pp. Crown 8vo.

CONTENTS:—Heat and Work—Fuel and Combustion—Calorimeters—Storage and Manipulation of Coal—Coal Washing for the Removal of Solid Waste—Connection, Circulation, Evaporation, and Priming in Boilers—Forced Draft—Gas Firing—Use of Liquid Fuel—Analysis of Gases produced in Combustion—Water for Use in Boilers—Boilers—Boiler Houses and Boiler Setting—Chimneys—Economisers—Crossheads and Connecting Rods—Crank Shafts—Gearing, &c., &c. [In the press.]

By OSCAR GUTTMANN, Assoc.M.Inst.C.E., F.I.C., Member of the Societies of Civil Engineers and Architects of Vienna and Budapest, Corresponding Member of the Imp. Roy. Geological Inst. of Austria, &c.

Modern Explosives: The Manufacture of.
A Theoretical and Practical Treatise on the History, the Physical and Chemical Properties, and the Manufacture of Explosives.

* * The work will extend to about 1,000 pp., Crown 8vo, with about 300 Illustrations, and will contain the most recent information on Gunpowder, Guncotton, Dynamite, Smokeless Powders, Fulminates, &c.

By C. C. HAWKINS, M.A., A.I.E.E.; and F. WALLIS, A.I.E.E.
The Dynamo: Its Theory, Design, and Manufacture. With 190 Illustrations, mostly from original drawings. 530 pp. 10s. 6d.

“We welcome this book as a thoroughly trustworthy and useful work.”—*Electrician*.

“A work of no mean ability. One valuable feature throughout the book is the excellence and number of the illustrations.”
Electrical Engineer.

By W. H. PREECE, C.B., F.R.S., President of the Institution of Electrical Engineers, Engineer-in-Chief and Electrician at the General Post Office; and A. J. STUBBS, Technical Officer General Post Office, A.I.E.E.

A Manual of Telephony. With upwards of 300 Illustrations, mostly from original drawings. Appendix, Tables, and a full Index. 520 pp. Crown 8vo. 15s.

“The most complete epitome of present-day telephonic practice.”—*Electrical Engineer.*

LONDON: WHITTAKER & CO., PATERNOSTER SQUARE.

By Sir D. SALOMONS, Vice-President of the Institution of Electrical Engineers, A.I.C.E., M.Amer.I.E.E., M.P.S., F.R.A.S., F.C.S., &c., &c.

Electric Light Installations. *Seventh Edition,* revised.

Vol. I.—ACCUMULATORS. With 33 Illustrations. 5s.

“A capital practical handbook.”—*Mechanical World.*

“The best work on the Subject.”—*English Mechanic.*

Vol. II.—APPARATUS. 7s. 6d.

Vol. III.—APPLICATION. With 32 Illustrations. 5s.

By STUART A. RUSSELL, Assoc.M.Inst.C.E., M.I.E.E.

Electric Light Cables and the Distribution of Electricity. With 107 Illustrations. 7s. 6d.

“The various systems of main distribution, heating, losses, jointing, cost of distribution, testing, safety devices &c., are dealt with. . . . A book of very great value.”—*Electrical Review.*

“A more thorough book could not have been written.”

Electrician.

By THOMAS H. BLAKESLEY, M.A., M.Inst.C.E., Hon. Sec. Physical Society.

Alternating Currents of Electricity. *Third Edition,* enlarged. 5s.

“It is written with great clearness and compactness of statement, and well maintains the character of the series of books with which it is now associated.”—*Electrician.*

By OLIVER J. LODGE, LL.D., D.Sc., F.R.S., M.I.E.E., Lyon Jones Professor of Experimental Physics in the University College, Liverpool.

Lightning Conductors & Lightning Guards.

A Treatise on the Protection of Buildings, of Telegraphic Instruments and Submarine Cables, and of Electric Installations generally, from damage by Atmospheric Discharges. In one volume, with numerous Illustrations. Crown 8vo. 550 pp. 15s.

“A comprehensive and most instructive treatise, which is the work of one of our best authorities on modern theories of electricity and their practical application.”—*Times.*

LONDON: WHITTAKER & CO., PATERNOSTER SQUARE.

By WILLIAM ANDERSON, F.R.S., D.C.L., Member of the Council of the Institution of Civil Engineers, M.I.M.E., and Director General of Ordnance Factories, Royal Arsenal, Woolwich.

On the Conversion of Heat into Work.
A Practical Handbook on Heat-Engines. With 62 Illustrations. *Third Edition.* 6s.

"We have no hesitation in saying there are young engineers—and a good many old engineers too—who can read this book, not only with profit but pleasure, and this is more than can be said of most works on heat."—*The Engineer.*

By GEORGE LUNGE, Ph.D., Professor of Technical Chemistry, Zurich; and FERDINAND HURTER, Ph.D., Consulting Chemist to the United Alkali Co., Limited.

The Alkali Makers' Handbook. Tables and Analytical Methods for Manufacturers of Sulphuric Acid, Nitric Acid, Soda, Potash, and Ammonia. *Second Edition*, enlarged and thoroughly revised. Revised. In crown 8vo, with illustrations, 10s. 6d.; strongly bound in half leather, 12s.

"The present edition gives abundant evidence that care is being taken to make the book a faithful record of the condition of contemporary quantitative analysis."

Professor T. E. Thorpe in "Nature."

"That excellent book."—*The late Professor W. Dittmar.*

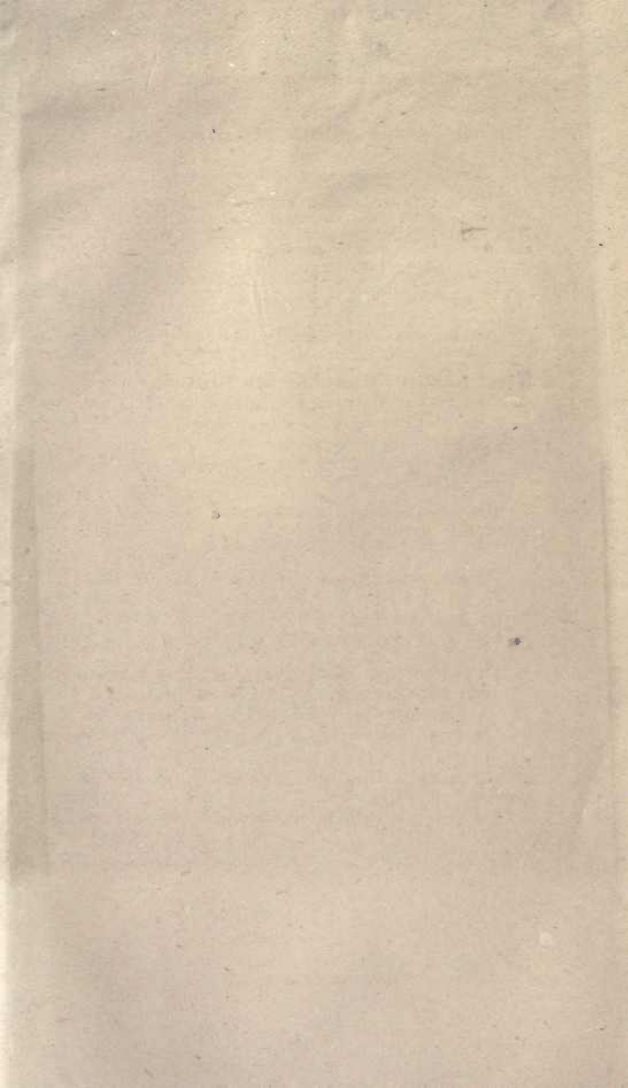
By A. B. GRIFFITHS, Ph.D., F.R.S. (Edin.), F.C.S.

A Treatise on Manures; or, the Philosophy of Manuring. With Illustrations and Index. A Practical Handbook for the Agriculturist, Manufacturer, and Student. *Second Edition*, revised and enlarged. Crown 8vo. 7s. 6d.

"The book is very full of matter, and may be recommended."—*Engineer.*

"The book is brimful of highly useful information."

Live Stock Journal.



THIS BOOK IS DUE ON THE LAST DATE
STAMPED BELOW

JUL 28 1914

SEP 12 1920

FEB 8 1924

FEB 9 1924

APR 21 1931

5 Sep '57 MF

REC'D LD

SEP 5 1957

REC'D LD
27 Oct '61 DT

OCT 19 1961

NOV 8 1974 1 2

REC'D CIRC DEPT

5743

LIBRARY USE

RETURN TO DESK FROM WHICH BORROWED

LOAN DEPT.

THIS BOOK IS DUE BEFORE CLOSING TIME
ON LAST DATE STAMPED BELOW

LIBRARY USE

NOV 10 1968

RECEIVED

NOV 10 '68 - 7 PM

LOAN DEPT.

REC'D

JUN 3 '74 35

