Coloured analytical tables : showing the behaviour of the more common metals and acids to the ordinary reagents, with special reference to the colour of the various oxides, salts, precipitates, flames, borax-beads, and blowpipe reactions a class-book for students in hospitals, colleges and schools / by H. Wilson Hake.

Contributors

Hake, H. Wilson 1857-1930.

Publication/Creation

London : Philip, 1889 (London : Taylor and Francis.)

Persistent URL

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COLOURED ANALYTICAL TABLES.

H. WILSON HAKE.

COLOURED

ANALYTICAL TABLES,

SHOWING THE BEHAVIOUR OF THE MORE COMMON METALS AND ACIDS
TO THE ORDINARY REAGENTS, WITH SPECIAL REFERENCE TO THE
COLOUR OF THE VARIOUS OXIDES, SALTS, PRECIPITATES,
FLAMES, BORAX-BEADS, AND BLOWPIPE REACTIONS.

A CLASS-BOOK FOR STUDENTS
IN HOSPITALS, COLLEGES, AND SCHOOLS.

BY

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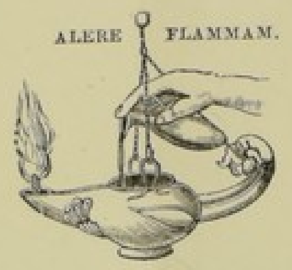
LONDON:
GEORGE PHILIP & SON, 32 FLEET STREET, E.C.
LIVERPOOL: 45-51 SOUTH CASTLE STREET.
1889.



PRINTED BY TAYLOR AND FRANCIS,
RED LION COURT, FLEET STREET.

PREFACE.

The idea of aiding the study of analytical chemistry by the use of hand-tinted imitations of the various coloured reactions originated with my brother, C. Napier Hake, F.I.C., and the form it has taken in this work was suggested to me by him.

Of the 140 ordinary reactions of the 24 more common metals (including ammonium), no less than 84 are distinguished by their colour; 6 out of the 24 form coloured salts with 12 varieties of colour; 9 out of the 24 form coloured oxides with 14 varieties of colour; 7 impart a characteristic colour to the flame, and 6 yield distinctive borax-beads. To this list may be added many blowpipe reactions, in which the colour produced is the leading feature of the test.

The Tables themselves are those which I have employed in my own classes for many years. While aiming especially at brevity, I have included all the well-recognized tests of each metal, so as to give (with the valuable aid of the colouration) such a complete picture of them as will enable the student to detect infallibly the presence of any common base in a salt or oxide.

I have not entered into the methods of separating the members of the various groups, since this would be beyond the scope of the book; and I have only briefly referred to the reactions for the detection of the more common acid-radicles and some few organic substances. My object has been to produce, without any sacrifice of scientific exactness, a work of a strictly elementary character, which may serve as a steppingstone, and perhaps even as a useful addition, to the many excellent manuals of qualitative analysis already published.

The book, I believe, should prove of service in Schools, or in large classes where individual attention from the Teacher becomes difficult or almost impracticable; and Medical Students who, under the present regulations, have a good deal of simple analysis to learn in a comparatively short space of time, will probably find their labours lightened by its use*.

The greatest care has been taken to reproduce the various colours with absolute accuracy from the reactions themselves.

My thanks are due to my pupil, Mr. F. E. Welchman, for assisting me in preparing the work for the press.

H. WILSON HAKE.

Westminster Hospital Medical School,
Caxton Street, S.W.,
May 1889.

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* It will be found that the Tables cover the Practical Chemistry required for the primary examination of the Conjoint Board of the Royal Colleges of Physicians and Surgeons; but I have, of course, included the reactions of the metals tin, cadmium, aluminium, chromium, manganese, nickel, cobalt, and strontium, which, for no very obvious reason, are omitted by the Conjoint Board.

PART I.

DETECTION OF THE METALS.

DIRECTIONS FOR PROCEDURE.

The following Tables are intended for the detection of any one of the more common metals or acids in a simple salt—that is to say, in a compound containing not more than one acid and one base. Some directions are also added for the detection of metals as such and their oxides, and such organic substances as are required in the primary examination of the Conjoint Board; insoluble substances will be detected in the examination for the acid and by the aid of the various blowpipe reactions. The directions given must be rigidly adhered to, especially as regards the *order* in which the tests are to be made.

A. The substance is a solid; note the *colour*, if any (Table IX.), and proceed to test its *solubility* or *insolubility* as follows:—

Take as much of the substance as will go on the point of a penknife-blade, hold a test-tube perpendicularly, and allow the solid (best in fine powder) to fall to the bottom without touching the sides, and try the action of various solvents upon it, in the following order, using as little of the solvent as possible.

1. *Dilute hydrochloric acid* (HCl).
2. *Strong* HCl.
3. *Dilute nitric acid* (HNO_3).
4. *Strong* HNO_3.
5. *Aqua regia* (*3 vols. strong* HCl *to* 1 *vol. strong* HNO_3).

N.B.—*If strong acids are used the solution must either be diluted or else evaporated on a water-bath to near dryness* (*best in a draught-cupboard*), *and the residue taken up in water.*

If the substance is **insoluble** in any of the above media, proceed to Part II.

B. The substance is in solution; note the *colour*, if any (see Table IX.), and proceed to Table I.

METHOD OF USING THE GENERAL TABLE.

The object of this Table is to determine the *group* to which the particular metal in solution belongs, and in this way to narrow the scope of the examination; this being done, it is comparatively easy to differentiate the various members of each group by their *special reactions*, as given in Tables II.–VIII.

Proceed as follows:—

1. To a portion of the solution add dilute **hydrochloric acid** (HCl).

(*a*) *A precipitate is produced*; note its behaviour to ammonia (NH_3), and proceed to Table II.

(*b*) *No precipitate is produced*:—

2. To the same solution add **sulphuretted hydrogen** (H_2S) (gas or solution).

(*a*) *A precipitate is produced*; note its solubility or otherwise in potash (KHO) or ammonium sulphide (Am_2S), and proceed to Table III. or IV. accordingly.

(*b*) *No precipitate is produced*:—

3. To a *fresh portion* of the solution add **ammonium chloride** (AmCl) in fair quantity and **ammonia** (NH_3).

(*a*) *A precipitate is produced*; proceed to Table V.

(*b*) *No precipitate is produced*:—

4. Add **ammonium sulphide** (Am_2S).

(*a*) *A precipitate is produced*; proceed to Table VI.

(*b*) *No precipitate is produced*:—

5. Add **ammonium carbonate** (Am_2CO_3).

(*a*) *A precipitate is produced*; proceed to Table VII.

(*b*) *No precipitate is produced*; proceed to Table VIII.

I.—GENERAL TABLE. Showing the Separation of the more Common Metals into Groups by Group-Reagents.

Hydrochloric Acid, HCl, precipitates.		**Sulphuretted Hydrogen,** H_2S*, precipitates.				**Ammonium Sulphide,** Am_2S, after ammonium chloride ($AmCl$) and ammonia (NH_3) †, precipitates.				**Ammonium Carbonate,** Am_2CO_3, precipitates.		**Not precipitated.**
Silver chloride, $AgCl$, *soluble in ammonia.*		Arsenic trisulphide, As_2S_3, *soluble in ammonium carbonate (Am_2CO_3), reprecipitated by HCl.*		Mercuric sulphide, HgS.		Ferrous sulphide, FeS.		Zinc sulphide, ZnS.		Barium carbonate, $BaCO_3$.		Magnesium salts.
Lead chloride ‡. $PbCl_2$, *unchanged by ammonia.*		Antimony trisulphide, Sb_2S_3.		Bismuth trisulphide, Bi_2S_3.		Alumina hydrate, $Al_2(HO)_6$.		Manganous sulphide, MnS.		Strontium carbonate, $SrCO_3$.		Potassium salts.
Mercurous chloride, Hg_2Cl_2, *blackened by ammonia.*		Stannous sulphide, SnS.		Cupric sulphide, CuS.		Chromic hydrate, $Cr_2(HO)_6$.		Nickel sulphide, NiS.		Calcium carbonate, $CaCO_3$.		Sodium salts.
		Stannic sulphide, SnS_2.		Cadmium sulphide. CdS.				Cobalt sulphide, CoS.				Ammonium salts.
		A. Soluble in ammonium sulphide (Am_2S) and in potash (KHO) §.		B. Insoluble in ammonium sulphide (Am_2S) and in potash (KHO).		A. Also precipitated as hydrates by ammonia, added after ammonium chloride.		B. Not precipitated by ammonia added after ammonium chloride.				

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* If finely divided sulphur is precipitated on addition of H_2S and the solution becomes green, a ferric salt or a chromate is present; a green or purple solution becoming colourless indicates a manganate or a permanganate.

† If an oxalate or a phosphate of barium, strontium, calcium or magnesium is present in acid solution, it will be precipitated white on addition of excess of ammonia (see oxalates and phosphates, Part II.).

‡ Very dilute solutions of lead are not precipitated by hydrochloric acid, but are precipitated black (PbS) by sulphuretted hydrogen, the precipitate being insoluble in ammonium sulphide.

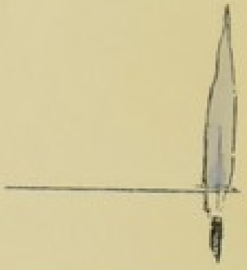
§ Gold and platinum are precipitated by H_2S as Au_2S_3 (black) and PtS_2 (dark brown); soluble in ammonium sulphide.

II.—Special Reactions of Salts of Metals precipitated by Hydrochloric Acid.

Silver.

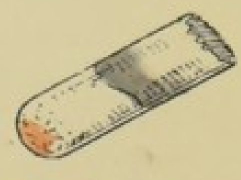
Reagent.	Precipitate.	Colour.	Blowpipe Reactions.
Pot. chromate, K_2CrO_4.	Silver chromate, Ag_2CrO_4.		*Fused with sodium carbonate*, Na_2CO_3, *on charcoal*: white malleable *globules*; no incrustation.
Potash, KHO.	Silver oxide, Ag_2O.		
Sulphuret. hydrogen, H_2S.	Silver sulphide, Ag_2S.		
Pot. iodide, KI.	Silver iodide, AgI.		

Lead.

Reagent.	Precipitate.	Colour.	Blowpipe Reactions.
Pot. chromate, K_2CrO_4.	Lead chromate, $PbCrO_4$.		*Fused with sodium carbonate*, Na_2CO_3, *on charcoal*: white very malleable *globules*; incrustation → 
Pot. iodide, KI.	Lead iodide, PbI_2.		
Sulphuric acid, H_2SO_4.	Lead sulphate, $PbSO_4$.		
Sulphuret. hydrogen, H_2S.	Lead sulphide, PbS*.		
Potash, KHO.	Lead hydrate, $Pb(HO)_2$†.		*Flame* → 

* In presence of much free HCl a red precipitate is obtained. † Sol. in xs.

Mercury (Hg').—*Mercurous Salts.*

Reagent.	Precipitate.	Colour.	Blowpipe Reactions.
Pot. chromate, K_2CrO_4.	Mercurous chromate, Hg_2CrO_4.		Volatile *on ignition*.
Potash, KHO.	Mercurous oxide, Hg_2O.		*Fused with sodium carbonate*, Na_2CO_3, *in glass tube*: metallic sublimate.
Pot. iodide, KI.	Mercurous iodide, Hg_2I_2.		
Sulphuret. hydrogen, H_2S.	Mercuric sulphide and mercury, $HgS + Hg$.		

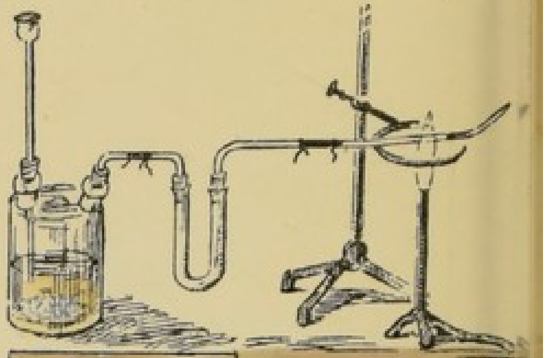
III.—Special Reactions of Salts of Metals precipitated by Sulphuretted Hydrogen

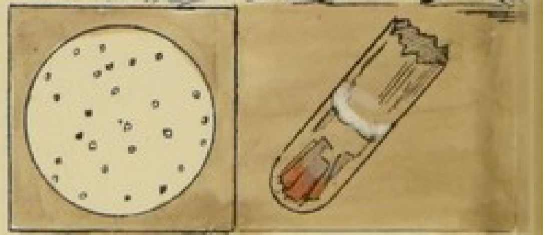
(in the presence of Hydrochloric Acid).

A. *Metals whose Sulphides are soluble in* Am_2S *or* KHO.

Arsenic.

The reactions of arsenic in the General Table are sufficient for ordinary purposes, but the following reactions may be made.





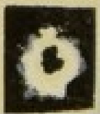
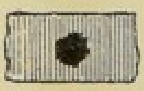
Marsh's Test[*].—This consists in the production of arseniuretted hydrogen, AsH_3, by the addition of an arsenic compound in solution to an apparatus in which hydrogen is being generated. The AsH_3 so formed is a poisonous gas of garlic-like odour; it burns with a pale blue flame, which deposits metallic arsenic in contact with a cold porcelain surface, and it is decomposed with deposition of metallic arsenic on heating a glass tube through which it is passing.

Reinsch's Test.—This consists in boiling small clean pieces of pure copper-foil in a hydrochloric acid solution of an As compound (strength of acid 1 : 6 water) for a few minutes, when, if As is present, it will be deposited as a grey coating on the copper foil; on drying and heating the foil (gently at first) in a thin perfectly dry tube closed at one end the deposit is oxidised to arsenious oxide, As_2O_3, which sublimes in octahedra recognizable with a low-power magnifying-glass.

N.B.—This production of As_2O_3 crystals is also possible with the metallic deposit in Marsh's test; absence of moisture is an essential condition.

All arsenic compounds are volatile on ignition.

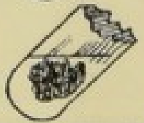
Antimony.

REAGENT.	PRECIPITATE.	COLOUR.		BLOWPIPE REACTIONS.
Potash, KHO.	Antimony hydrate[†], $Sb(HO)_6$.		Sol. in xs.	Fused with sodium carbonate (Na_2CO_3) on charcoal, white brittle globules; incrustation. 
Zinc and hydrochloric acid, Zn and HCl.	Sb.		Black stain on platinum-foil.	

[†] The solution of the hydrated oxide in hydrochloric acid (HCl) gives, with much water, a white precipitate of oxychloride of antimony (SbOCl), soluble in tartaric acid ($H_2C_4H_4O_6$) [distinction from Bismuth].

Tin.

Stannous Salts.

REAGENT.	PRECIPITATE.	COLOUR.		BLOWPIPE REACTIONS.
Potash, KHO.	Stannous hydrate, $Sn(HO)_2$.		Sol. in xs.	Fused with sodium carbonate (Na_2CO_3) on charcoal, white malleable globules; no incrustation.
Gold chloride, $AuCl_3$.	Purple of Cassius.		In presence of a drop of chlorine-water.	
Mercuric chloride, $HgCl_2$.	Mercurous chloride and mercury, Hg_2Cl_2; Hg.		Grey on boiling. The stannous salt must be in xs.	
Zinc and hydrochloric acid, Zn + HCl.	Sn.		Spongy mass.	

Stannic Salts.

These also yield metallic tin with zinc and hydrochloric acid, and are reduced to stannous salts on addition of copper and long boiling.

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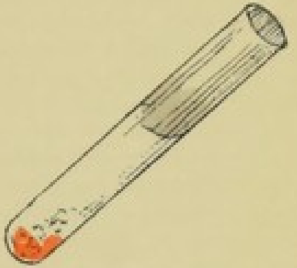
[*] Many precautions are necessary in making this test, which should be conducted in a draught cupboard, owing to the poisonous nature of the gas, and especial care should be taken to avoid lighting the issuing hydrogen before the whole of the air is driven out of the apparatus, or an explosion may easily occur. A beginner should not attempt it without skilled assistance.

IV.—Special Reactions of Salts of Metals precipitated by Sulphuretted Hydrogen

(in the presence of Hydrochloric Acid).

B. *Metals whose Sulphides are not soluble in* Am_2S *or* KHO*.

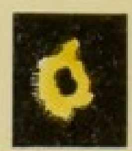
Mercury (Hg″).—*Mercuric Salts.*

Reagent.	Precipitate.	Colour.	Blowpipe Reactions.
Potash, KHO.	Mercuric oxide, HgO.		Volatile *on ignition.*
Ammonia, NH_3.	Mercuri-ammonic chloride, NH_2HgCl.		*Fused with sodium carbonate,* Na_2CO_3, *in glass tube*: metallic sublimate. 
Pot. iodide, KI.	Mercuric iodide†, HgI_2.		
Stannous chloride, $SnCl_2$.	Mercurous chloride and mercury, Hg_2Cl_2 : Hg.		
Copper or Gold, Cu or Au‡.	Mercury, Hg.		

† Sol. in xs.

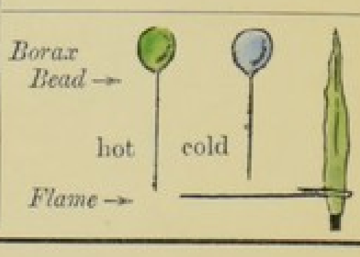
‡ When touched through the acid solution with iron.

Bismuth.

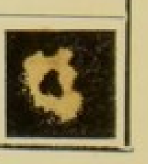
Reagent.	Precipitate.	Colour.	Blowpipe Reactions.
Potash or Ammonia, KHO or NH_3.	Bismuthic hydrate, $Bi(HO)_3$§.		*Fused with sodium carbonate,* Na_2CO_3, *on charcoal*: white brittle globules; incrustation → 
Pot. chromate, K_2CrO_4.	Bismuth chromate, $Bi_2(CrO_4)_3$.		

§ If this precipitate is dissolved in hydrochloric acid, HCl, and the solution added to much water bismuth oxychloride, BiOCl, is precipitated.

Copper.

Reagent.	Precipitate.	Colour.			Blowpipe Reactions.
Potash, KHO.	Cupric hydrate, $Cu(HO)_2$.		Slightly sol. in xs.		*Fused with sodium carbonate,* Na_2CO_3, *on charcoal*: *red scales*; no incrustation.
Ammonia, NH_3.	Cupric hydrate, $Cu(HO)_2$.		Sol. in xs.		
Pot. ferrocyanide, K_4FeCy_6.	Cupric ferrocyanide, Cu_2FeCy_6.				
Iron, Fe.	Copper, Cu.				

Cadmium.

Reagent.	Precipitate.	Colour.	Blowpipe Reactions.
Ammonia, NH_3.	Cadmium hydrate, $Cd(HO)_2$. Sol. in xs.		*Fused with sodium carbonate,* Na_2CO_3, *on charcoal*: incrustation → 

* For reactions of *Lead*, if precipitated in this group (*note* Table I.), see Table II.

V.—Special Reactions of Salts of Metals which are precipitated by Ammonium Sulphide

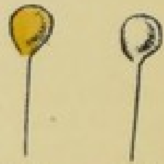
(in the presence of Ammonium Chloride and Ammonia).

A. *Also precipitated by Ammonia in presence of Ammonium Chloride.*

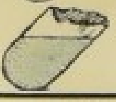
Iron (Fe'').—*Ferrous Salts.*

REAGENT.	PRECIPITATE.	COLOUR.	BLOWPIPE REACTIONS.
Ammonium sulphide, Am_2S.	Ferrous sulphide, FeS.		*Fused with sodium carbonate,* Na_2CO_3, *on charcoal*: grey scales; no incrustation.
Potash or Ammonia, KHO or NH_3.	Ferrous hydrate, $Fe(HO)_2$.		*Borax Bead* → 
Pot. ferrocyanide, K_4FeCy_6.	Soluble Prussian blue, $K_2Fe_5Cy_{12}$.		
Pot. ferricyanide, $K_6Fe_2Cy_{12}$.	Turnbull's blue, Fe_5Cy_{12}.		

Iron (Fe^{iv}).—*Ferric Salts.*

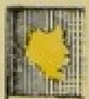
REAGENT.	PRECIPITATE.	COLOUR.	BLOWPIPE REACTIONS.
Ammonium sulphide, Am_2S.	Ferrous sulphide and sulphur, $FeS+S$.		*Fused with sodium carbonate,* Na_2CO_3, *on charcoal*: grey scales; no incrustation.
Potash or Ammonia, KHO or NH_3.	Ferric hydrate, $Fe_2(HO)_6$.		*Borax Bead* → 
Pot. ferrocyanide, K_4FeCy_6.	Insol. Prussian blue, Fe_7Cy_{18}.		
Pot. ferricyanide, $K_6Fe_2Cy_{12}$.	Colouration.		
Pot. sulphocyanide, $KCNS$.	Colouration. Ferric sulphocyanide, $Fe(CNS)_3$.		

Aluminium.

REAGENT.	PRECIPITATE.	COLOUR.	BLOWPIPE REACTIONS.
Ammonium sulphide, Am_2S.	Aluminium hydrate, $Al_2(HO)_6$*.		*Heated on charcoal*: glows brightly; *moistened with cobalt nitrate,* $Co(NO_3)_2$, *and again heated* → 
Potash or Ammonia, KHO or NH_3.	Aluminium hydrate, $Al_2(HO)_6$†.		

† Soluble in excess of KHO, reprecipitated by ammonium carbonate, not by SH_2 (distinction from zinc).

Chromium.

REAGENT.	PRECIPITATE.	COLOUR.			BLOWPIPE REACTIONS.
Ammonium sulphide, Am_2S.	Chromium hydrate, $Cr_2(HO)_6$*.				Heated on platinum foil with sodium carbonate, Na_2CO_3, and potassium nitrate, KNO_3, forms potassium chromate, K_2CrO_4 → 
Potash, KHO.	Chromium hydrate, $Cr_2(HO)_6$.		Sol. in xs.		
Ammonia, NH_3.	Chromium hydrate, $Cr_2(HO)_6$.		Sol. in xs.		Borax bead → 

* SH_2 given off.

VI.—Special Reactions of Salts of Metals precipitated by Ammonium Sulphide

(in the presence of Ammonium Chloride and Ammonia).

B. *Not precipitated by Ammonia in the presence of Ammonium Chloride.*

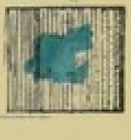
Zinc.

Reagent.	Precipitate.	Colour.	Blowpipe Reactions.
Potash or Ammonia, KHO or NH_3.	Zinc hydrate, $Zn(HO)_2$. Sol. in xs.†		Heated on charcoal, hot → , *cold* → 
Sulphuret. hydrogen, SH_2*.	Zinc sulphide, ZnS.		After moistening with cobalt nitrate, $Co(NO_3)_2$, and again heating → 

* In neutral or alkaline solutions, or in the presence of acetic acid.

† From this solution SH_2 precipitates ZnS, but Am_2CO_3 produces no precipitate (distinction from Al).

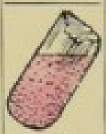
Manganese.

Reagent.	Precipitate.	Colour.	Blowpipe Reactions.
Potash, KHO.	Manganese hydrate, $Mn(HO)_2$.		Fused with sodium carbonate, Na_2CO_3, and potassium nitrate, KNO_3, on platinum-foil yields sodium manganate, Na_2MnO_4 → 
Nitric Acid and Peroxide of Lead, HNO_3 and PbO_2.	Permanganic acid, $H_2Mn_2O_8$, solution.		*Borax Bead* → 

Nickel.

Reagent.	Precipitate.	Colour.			Blowpipe Reactions.
Potash, KHO.	Nickel hydrate, $Ni(HO)_2$.				*Fused with sodium carbonate,* Na_2CO_3, *on charcoal* ‡; white scales.
Ammonia, NH_3.	Nickel hydrate, $Ni(HO)_2$.		Sol. in xs.		*Borax Bead* → 

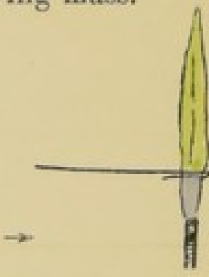
Cobalt.

Reagent.	Precipitate.	Colour.			Blowpipe Reactions.
Potash, KHO.	Cobalt hydrate, $Co(HO)_2$.		On boiling →		*Fused with sodium carbonate,* Na_2CO_3, *on charcoal* ‡; *white scales.*
Ammonia, NH_3.	Cobalt hydrate, $Co(HO)_2$.		Sol. in xs., reppd. on standing.		*Borax Bead* → 

‡ Bunsen's Reaction.

VII.—Special Reactions of Salts of Metals precipitated by Ammonium Carbonate.

Barium.

Reagent.	Precipitate.	Colour.		Blowpipe Reactions.
Calcium sulphate, $CaSO_4$.	Barium sulphate, $BaSO_4$.		Immediately.	*Heated on charcoal* white glowing mass.  *Flame* →
Sulphuric acid, H_2SO_4.	Barium sulphate, $BaSO_4$.		Immediately.	
Potassium chromate, K_2CrO_4.	Barium chromate, $BaCrO_4$.		Immediately; insol. in acetic acid.	

Strontium.

Reagent.	Precipitate.	Colour.		Blowpipe Reactions.
Calcium sulphate, $CaSO_4$.	Strontium sulphate, $SrSO_4$.		On standing or boiling.	*Heated on charcoal* white glowing mass.  *Flame* →
Sulphuric acid, H_2SO_4.	Strontium sulphate, $SrSO_4$.		On standing or boiling.	
Potassium chromate, K_2CrO_4.	Strontium chromate, $SrCrO_4$.		On standing. Sol. in acetic acid.	

Calcium *.

Reagent.	Precipitate.	Colour.	Blowpipe Reactions.
Calcium sulphate, $CaSO_4$.	None.		*Heated on charcoal* white glowing mass.  *Flame* →
Sulphuric acid, H_2SO_4.	Calcium sulphate, $CaSO_4$.		
Potassium chromate, K_2CrO_7.	None.		

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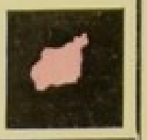
* Oxalate of ammonium ($Am_2C_2O_4$) in the presence of ammonia gives, with calcium salts, a white precipitate (CaC_2O_4), and is often used for their detection; but it is not a distinctive test, except in the proved absence of barium and strontium salts, which behave similarly.

VIII.—Special Reactions of Salts of Metals *not* precipitated by Hydrochloric Acid, Sulphuretted Hydrogen, Ammonium Sulphide, or Ammonium Carbonate.

Magnesium.

REAGENT.	PRECIPITATE.	COLOUR.	BLOWPIPE REACTIONS.
Potash, KHO.	Magnesia hydrate, $Mg(HO)_2$†.		*Heated on charcoal* white glowing mass; *moistened with cobalt nitrate*, $Co(NO_3)_2$, *and again heated* → 
Sodium phosphate, Na_2HPO_4*, in presence of $AmCl$ and NH_3.	$AmMgPO_4$.		

* Or Am_2HPO_4.

† In strong solutions.

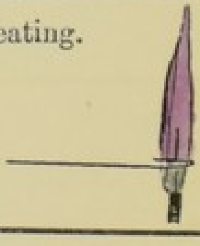
Ammonium ‡.

REAGENT.	PRECIPITATE.	COLOUR.	BLOWPIPE REACTIONS.
Potash, KHO.	Evolution of NH_3.		Volatile *on ignition.*
Platinic chloride, $PtCl_4$.	Ammonium platinochloride, Am_2PtCl_6 §.		
Acid sodium tartrate, $NaH\bar{T}$.	Acid ammonium tartrate, $AmHC_4H_4O_6$.		

‡ The original solution must always be used.

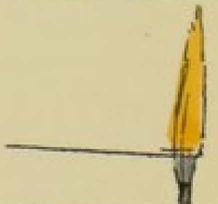
§ Insoluble in alcohol; yields NH_3 on boiling with KHO.

Potassium.

REAGENT.	PRECIPITATE.	COLOUR.	BLOWPIPE REACTIONS.
Platinic chloride, $PtCl_4$.	Potassium platinochloride, K_2PtCl_6 ‖.		Fuse easily on heating. 
Acid sodium tartrate, $NaH\bar{T}$.	Acid potassium tartrate, $KHC_4H_4O_6$.		*Flame* →

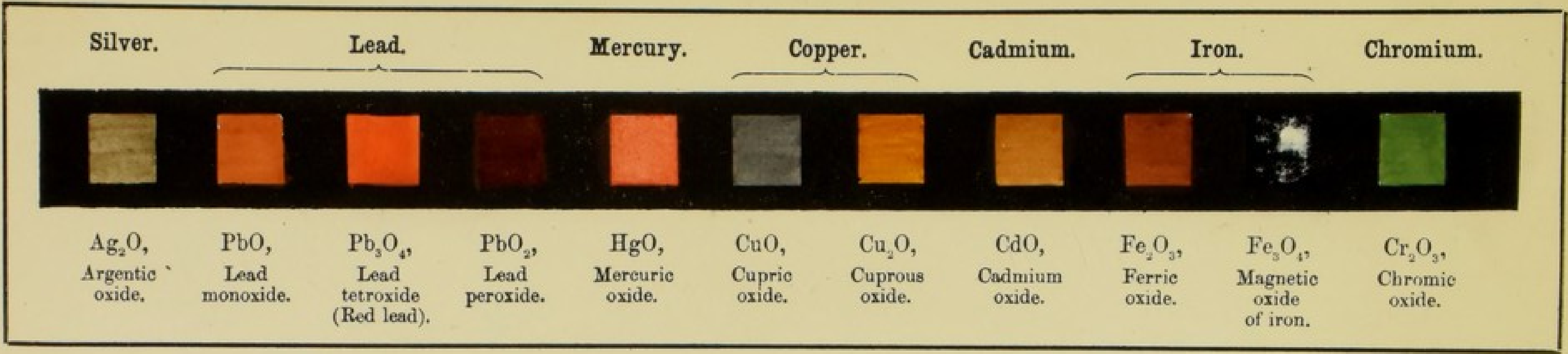
‖ Insoluble in alcohol.

Sodium.

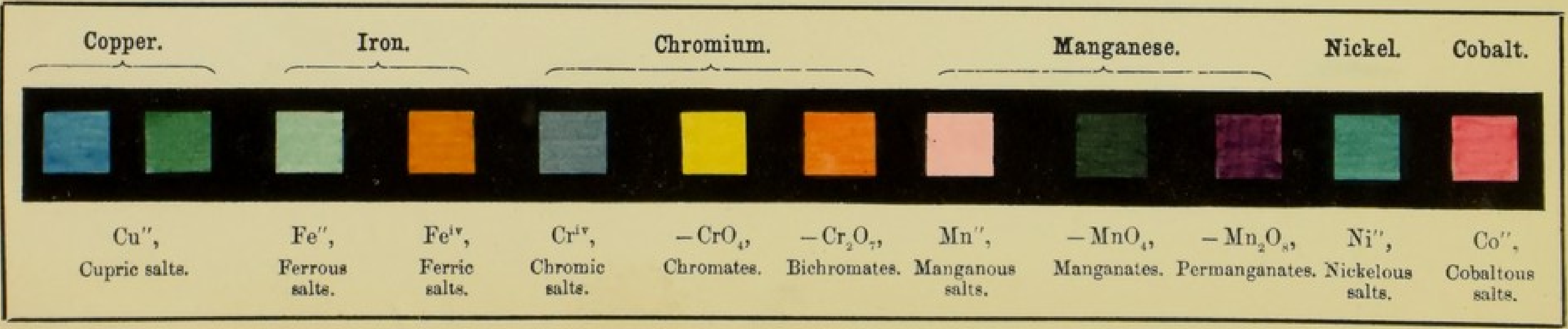
REAGENT.	PRECIPITATE.	COLOUR.	BLOWPIPE REACTIONS.
Potassium metantimonate, $K_2Sb_2O_7$.	Sodium metantimonate, $Na_2Sb_2O_7$.		Fuse easily. *Flame* → 

IX.

Coloured Oxides (anhydrous).



Coloured Salts (solid, or in solution).



PART II.*

DETECTION OF SOME SIMPLE ACID-RADICLES, OXIDES, AND SOME ORGANIC SUBSTANCES.

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* The statements made in this section refer strictly to compounds of the preceding 24 metals.

PART II.—Detection of some simple Acid-Radicles, Oxides, and some Organic Substances.

The following tests must be made in the order here laid down, and a fresh portion taken for each test. If the substance is insoluble, test for the various acids in the same order, using the special tests mentioned where practicable.

Ignite a portion of the solid substance (if a solution evaporate a few drops to obtain the solid).

Salts of inorganic acids do not blacken on ignition (**A, B, C**).

Salts of organic acids blacken on ignition (except oxalates and cyanides) and leave a residue (except ammonium salts); free organic acids and purely organic substances blacken on ignition and finally burn away entirely (**D, E**).

To the solution add,

A. Barium chloride ($BaCl_2$) *, a precipitate indicates :—

1. *Sulphates.*—SO_4; *white precipitate* ($BaSO_4$), insoluble in hydrochloric acid, even on boiling.

   N.B.—*Insoluble sulphates.* $BaSO_4$ and $PbSO_4$ are insoluble, and may be detected by conversion into their corresponding sulphides (BaS and PbS) by heating with sodium carbonate ($NaCO_3$) on charcoal. (See Sulphides.) The metals may be detected by their blowpipe reactions.

2. *Carbonates.*—CO_3; *white precipitate* ($BaCO_3$), soluble in hydrochloric acid and acetic acid with effervescence, due to evolution of carbonic anhydride (CO_2), which gas turns lime-water milky.

   N.B.—*Insoluble carbonates.* All the carbonates, except K_2CO_3, Na_2CO_3, and Am_2CO_3, are insoluble in water; they are dissolved by acids, with effervescence (see above).

3. *Phosphates.*—PO_4; *white precipitate* [$BaHPO_4$ or $Ba_3(PO_4)_2$], soluble in hydrochloric acid and in acetic acid.

   N.B.—A solution of a phosphate also yields, when added to a solution of ammonium molybdate strongly acidified with nitric acid, a yellow precipitate of ammonic molybdo-phosphate on heating; or if to a solution of a phosphate be added a clear mixture of magnesium sulphate, ammonium chloride and ammonia, a white precipitate ($AmMgPO_4$) results.

   Insoluble phosphates. All the phosphates, except those of the alkalies, are insoluble in water but easily soluble in an acid. The phosphates of Ba, Sr, Ca, and Mg are, when dissolved in an acid, precipitated white by ammonia in the ammonium sulphide group. In the case of the first three, the flames may be used to detect the metals, or the acid solution may be made neutral with ammonia, and then acid with acetic acid, ferric chloride added, and the solution boiled, whereupon ferric phosphate ($FePO_4$) is precipitated; this may be separated by filtration; the metals, remaining in solution as chlorides, may be tested for in the ordinary way, and the phosphoric acid may be detected in the original acid solution by means of the molybdate test.

4. *Oxalates.*—C_2O_4; *white precipitate* (BaC_2O_4), soluble in hydrochloric acid, insoluble in acetic acid.

   N.B.—Oxalates and free oxalic acid do not always blacken on heating. A solution of an oxalate or free oxalic acid, or a solid or insoluble oxalate, evolves carbonic anhydride (CO_2) with pure dioxide of manganese (MnO_2) and dilute sulphuric acid, indicated by a brisk effervescence; the gas evolved turns lime-water milky. Solid oxalates and free oxalic acid yield with strong sulphuric acid on heating a mixture of carbonic oxide (CO), which may be ignited at the top of the test-tube and burns with a blue flame, and carbonic anhydride (CO_2), which turns lime-water milky.

   Insoluble oxalates. Most of the oxalates are insoluble in water except those of the alkalies; the rest are soluble in mineral acids. The oxalates of Ba, Sr, Ca, and Mg are insoluble in water and are precipitated white from an acid solution by ammonia in the ammonium-sulphide group. The first three metals may be detected by their flames and the Mg by the blowpipe test; the dioxide of manganese test will detect the oxalic acid; or dissolve the ammonia precipitate in dilute hydrochloric acid and add acetate of soda in excess, a white precipitate indicates oxalic acid.

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* Or if Ag, Pb, or Hg′ are present add barium nitrate [$Ba(NO_3)_2$].

To a fresh solution add,

B. Silver nitrate, a precipitate indicates:—

1. *Chlorides.*—Cl; *white precipitate* ($AgCl$), soluble in ammonia, insoluble in nitric acid; the precipitate fuses on heating.

    N.B.—Solid chlorides yield colourless pungent fumes (HCl) when treated with strong sulphuric acid, which render a drop of silver nitrate, on the end of a glass rod, milky; or when heated with strong sulphuric acid and dioxide of manganese (MnO_2) yield chlorine gas (green when in quantity), which bleaches moist litmus paper.

    Insoluble chlorides. These are $PbCl_2$, $AgCl$, and Hg_2Cl_2. They are easily recognized by their behaviour to ammonia (see Table I.); the last is soluble in aqua regia, and is then converted into mercuric chloride, $HgCl_2$ (see Table IV.).

2. *Cyanides.*—CN; *white precipitate* ($AgCN$), soluble in strong ammonia and in strong boiling nitric acid; the precipitate yields metallic silver on heating, and evolves prussic acid when warmed with dilute hydrochloric acid (see below).

    N.B.—Solutions of cyanides yield poisonous vapours of hydrocyanic acid (prussic acid, HCN) on heating with dilute hydrochloric acid; the vapours have an odour of bitter almonds; and if boiled with ferrous sulphate ($FeSO_4$) and a very little ferric chloride (Fe_2Cl_6) and excess of potash (KHO), and, finally, made acid with hydrochloric acid, yield *insoluble Prussian blue* (Fe_7Cy_{18}).

    Insoluble cyanides. Most of the cyanides, except those of the alkalies and mercury, are insoluble; but most yield prussic acid as above.

3. *Bromides.*—Br; *pale yellow precipitate* ($AgBr$), soluble in ammonia with difficulty; insoluble in nitric acid. The precipitate or any solid bromide yields red-brown pungent vapours of bromine with strong sulphuric acid, which colour starch-paste orange.

4. *Iodides.*—I; pale yellow (AgI), insoluble in, but whitened by, ammonia, insoluble in nitric acid; the precipitate or any solid iodide yields violet vapours of iodine with strong sulphuric acid, which colour starch-paste blue.

C. Test specially for the following inorganic acids:—

1. *Nitrates.*—NO_3.

    N.B.—All nitrates (except a few basic nitrates) are soluble in water. Solid nitrates yield (1) colourless pungent fumes (HNO_3) with strong sulphuric acid, which do not affect silver nitrate, and (2) red fumes, with strong sulphuric acid and metallic copper. A solution of a nitrate, mixed with a solution of ferrous sulphate, yields, in the cold, an amethyst or brown ring at the point of junction with strong sulphuric acid, when carefully poured on to it so as to form an upper layer.

2. *Sulphides.*—S. In solution or solid, sulphides yield sulphuretted hydrogen (SH_2) on heating with dilute sulphuric or strong hydrochloric acid. The gas may be detected by its smell and by its blackening paper moistened with lead acetate [$Pb(C_2H_3O_2)_2$].

    Solid sulphides placed on a bright silver coin render it black after moistening with dilute sulphuric acid.

D. Test specially for the following organic acids :—

1. *Acetates.*—$C_2H_3O_2$. In solution or solid, acetates yield on heating with dilute sulphuric acid, free acetic acid, recognized by its vinegar-like smell; or, on heating with alcohol and strong sulphuric acid, yield acetic ether, recognized by its fragrant odour.

2. *Tartrates.*—$C_4H_4O_6$. Solid tartrates or strong solutions of tartrates or free tartaric acid blacken almost immediately when heated with strong sulphuric acid, giving off a smell of burnt sugar and of sulphurous anhydride (SO_2). Neutral tartrates yield a white precipitate with $AgNO_3$, which, if *nearly* dissolved in ammonia, yields a brilliant silver mirror on the sides of the test-tube when gradually and gently heated. Calcium chloride gives a white precipitate ($CaC_4H_4O_6$), soluble, after washing, in KHO.

3. *Citrates.*—$C_6H_5O_7$. Solid citrates or strong solutions of citrates or free citric acid darken slowly, and yield pungent irritating fumes, with strong sulphuric acid. Calcium chloride in neutral solutions yields a white precipitate [$Ca_3(C_6H_5O_7)_2$] only on heating.

E. Test specially for the following organic substances :—

1. *Cane Sugar* ($C_{12}H_{22}O_{11}$). Tastes sweet, and blackens on addition of strong sulphuric acid. Its solution does not reduce copper sulphate ($CuSO_4$), except after boiling for some time with two or three drops of dilute hydrochloric acid (see Grape Sugar).

2. *Grape Sugar* ($C_6H_{12}O_6$). Tastes sweet, and, when pure, does not blacken, but becomes of a pale straw-colour on addition of strong sulphuric acid. Its solution reduces copper sulphate. (To make this test, add to a very dilute solution of cupric sulphate an excess of potash, and pour a little of the slightly turbid solution, so obtained, into a boiling solution of the grape sugar : a yellow-red precipitate of suboxide of copper (Cu_2O) indicates the reduction.)

3. *Starch* ($C_6H_{10}O_5$). With a little water it forms a gelatinous mass on boiling; with much water a turbid solution, which, on addition of a solution of iodine, yields a fine blue colour.

4. *Urea.*—$CO(NH_2)_2$. White and crystalline, readily soluble in water and in alcohol. The aqueous solution, which is neutral to litmus, yields ammonia when boiled with potash, and, when concentrated, gives, with nitric acid, a highly crystalline precipitate of urea nitrate, $CO(NH_2)_2$, HNO_3. Addition of sodium hypobromite, NaBrO (made by dissolving a few drops of bromine in concentrated solution of caustic soda), causes a brisk evolution of nitrogen gas. Solid urea, heated on platinum foil, first melts and finally volatilizes, giving off ammonia at the same time.

   Urea nitrate and oxalate behave somewhat similarly, and the acids may be discovered in the ordinary way.

F. Oxides.

These give no reactions for acids; some darken, but do not burn away, on heating. All are insoluble in water, except the oxides of Ba, Sr, Ca, Na, and K. The solutions of these are strongly alkaline, and those of the first three become turbid in contact with carbonic anhydride; they are white, as are also the oxides of As, Sb, Sn, Bi, Al, and Zn. All the rest are coloured (see Table IX.). The various blowpipe tests are among the most useful for their detection. Stannic oxide (SnO_2) is insoluble in acids; and ferric, chromic, and aluminic oxides, after ignition, are also insoluble.

G. Metals.

The metals are easily recognizable by their physical properties, especially Ag, Pb, Hg, Sn, Cu, Fe, Al, and Zn, and when dissolved in an acid give all the characteristic reactions. Nitric acid must be used to dissolve Pb, Hg, and Cu; the rest are for the most part soluble in hydrochloric acid with evolution of hydrogen.

H. Preliminary Examination of Substances.

As the student becomes more familiar with his subject, he may sometimes detect a substance more rapidly by a preliminary examination, such as colour, effect of heating, flame, borax-bead, reaction on charcoal, &c., but this requires a practised hand and an adequate knowledge of the various tests. I would advise a student to make such a preliminary-test table for himself, but to beware of false conclusions; always to go though the ordinary tests, and *never* to rely on one test alone unless this is unique, which is seldom the case, but to learn *all* the reactions he can possibly remember, and make constant use of them.