Identification Tests

Flame test colours Li, Na, K, Ca, Sr, Ba ions.

Flame test colours

Metal	Colour
lithium	magenta
sodium	yellow
potassium	lilac
calcium	brick red
strontium	blood red
barium	apple green

Gases- chemical test
H_2, O_2, Cl_2, CO_2, SO_2, HCl, NH_3

GASES

(i) **<u>Hydrogen</u> - H_2**

Burns with a yellow flame - pops in air

$$2H_2\,(g) + O_2\,(g) \longrightarrow 2H_2O\,(l)$$

(ii) **<u>Oxygen</u> - O_2**

Rekindles a glowing splint

(iii) **<u>Chlorine</u> - Cl_2**

(a) bleaches damp litmus paper

$$Cl_2\,(g) + H_2O\,(l) \longrightarrow HCl\,(aq) + \underset{\text{(bleach)}}{HOCl\,(aq)}$$

(b) bubble through potassium bromide solution colour change: colourless to brown

$$Cl_2\,(g) + \underset{\text{colourless}}{2KBr\,(aq)} \longrightarrow \underset{\text{brown}}{Br_2\,(aq)} + 2KCI\,(aq)$$

(iv) **<u>Carbon dioxide</u> - CO_2**

Bubble gas through lime water - turns milky

$$CO_2\,(g) + Ca(OH)_2\,(aq) \longrightarrow CaCO_3\,(s) + H_2O\,(1)$$

(v) **<u>Sulphur dioxide</u> - SO_2**

(a) turns damp blue litmus red
(b) bubble through potassium dichromate(VI) solution: colour change from orange to green.

$$2H^+ (aq) + 3SO_2 (g) + Cr_2O_7^{2-} (aq) \longrightarrow 2Cr^{3+} (aq) + 3SO_4^{2-} (aq) + H_2O(l)$$
(orange) (green)

(vi) **Hydrogen chloride - HCl**

(a) turns damp blue litmus red
(b) forms white fumes with conc. ammonia

$$HCl (g) + NH_3 (g) \longrightarrow NH_4Cl (s)$$
white

(vii) **Ammonia - NH_3**

(a) turns damp red litmus blue
(b) forms white fumes with conc. hydrochloric acid

$$HCl (g) + NH_3 (g) \longrightarrow NH_4Cl (s)$$

Anions

Cl^-, Br^- and I^- using Ag^+ followed by NH_3 (aq)
CO_3^{2-} and HCO_3 using dilute acid and Mg^{2+}
SO_4^{2-} using dilute acid and Ba^{2+}
SO_3^{2-} using dilute acid

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(a) **Chloride Cl^-, Bromide Br^-, and Iodide I^-**

To a solution of the ions add a solution of silver nitrate.

	Ag^+ (aq)
Chloride	White precipitate insoluble in dilute HNO_3. Soluble in dilute NH_3 (aq) Soluble in conc. NH_3
Bromide	Cream precipitate insoluble in dilute HNO_3. Insoluble in dilute NH_3 (aq). Soluble in conc. NH_3
Iodide	Yellow precipitate insoluble in dilute HNO_3. Insoluble in dilute NH_3 (aq). Insoluble in conc. NH_3.

$$Ag^+ (aq) + X^- (aq) \longrightarrow AgX(s)$$

where x is Cl^-, Br^-, I^-.

(b) **Carbonate, CO_3^{2-} and hydrogen carbonate, HCO_3^-**

(i) Add dilute acid - in each case carbon dioxide gas is evolved.
(ii) To a solution add a few drops of magnesium sulphate solution.

	CO_3^{2-} (aq)	HCO_3^- (aq)
Mg^{2+}(aq)	White precipitate of $MgCO_3$	No precipitate. $Mg(HCO_3)_2$, is soluble. On heating it decomposes forming a precipitate of $MgCO_3$

(c) **Sulphate (V1), SO_4^{2-}, and sulphate(IV), (sulphite) SO_3^{2-}**

(i) Addition of dilute acid

$$Na_2SO_3 + 2\ HCl \longrightarrow 2\ NaCl + SO_2 + H_2O$$

then test for SO_2.

(ii) To a solution add dilute HCl followed by barium chloride solution.

Sulphate (VI) SO_4^{2-} - white precipitate.

$$Ba^{2+}(aq) + SO_4^{2-}(aq) \longrightarrow BaSO_4\ (s)$$

Sulphate (IV) SO_3^{2-} - no precipitate.

	SO_4^{2-} (aq)	SO_3^{2-} (aq)
(i) dilute acid	no reaction	effervescence of SO_2
(ii) dilute HCl + $BaCl_2$ (aq)	white precipitate of $BaSO_4$	no precipitate.
(iii) $BaCl_2$ (aq) + HCl	white precipitate. Insoluble in HCl	white precipitate. Soluble in HCl

(d) **Nitrate (V) ion - NO_3^-**

Dissolve 2 or 3 small crystals in one quarter of a test tube of sodium hydroxide solution. Add a small quantity of aluminium. Warm the mixture. Ammonia gas is evolved which can be tested in the usual way.

$$5OH^- + 18H_2O + 3NO_3^- + 8A1 \longrightarrow 3NH_3 + 8Al(OH)_4^-$$

(e) **Nitrate (III) ion - NO_2^-**

To a solution add dilute hydrochloric acid. Immediate effervescence of a brown gas NO_2, is observed and a pale blue solution.

$$3NO_2^- (aq) + 2H^+ \longrightarrow 2NO (g) + NO_3^- + H_2O$$

NO_2 gas is formed when NO reacts with air

$$2NO (aq) + O_2 \longrightarrow 2NO_2 (g)$$
(brown gas)

Cations in aqueous solution

Ag^+ using halide ions
Cu^{2+}, Fe^{2+}, Al^{3+}, Zn^{2+}, Ni^{2+} using NaOH (aq) and NH_3 (aq)
Mn^{2+} using NaOH followed by H_2O_2
Fe^{3+} using SCN^-
Fe^{2+} using $[Fe(CN)_6]^{3-}$
Co^{2+} using conc. HCl

Identification of cations in solution

(i) **Silver (Ag^+) and lead (Pb^{2+})**
Similar test to that for halide ions

To a solution of the ions add a solution of sodium halide.

	Chloride	Bromide	Iodide
Ag^+ (aq)	White precipitate insoluble in dilute HNO_3. Soluble in dilute NH_3 (aq) Soluble in conc. NH_3	Cream precipitate insoluble in dilute HNO_3. Insoluble in dilute NH_3 (aq). Soluble in conc. NH_3	Yellow precipitate insoluble in dilute HNO_3. Insoluble in dilute NH_3 (aq). Insoluble in conc. NH_3.
Pb^{2+} (aq)	White precipitate. Soluble in hot water.	Cream precipitate	Yellow precipitate

$$Ag^+ (aq) + X^- (aq) \longrightarrow AgX(s)$$
$$Pb^{2+} (aq) + 2X^- (aq) \longrightarrow PbX_2 (s)$$
where x is Cl^-, Br^-, I^-.

(ii) **Cu^{2+}, Fe^{2+}, Al^{3+}, Zn^{2+}, Ni^{2+}**

	Cu^{2+}	Fe^{2+}	Al^{3+}	Zn^{2+}	Ni^{2+}
(a) add NaOH(aq)	blue ppt.	green ppt.	white ppt.	white ppt.	green ppt.
(b) add excess	insoluble	insoluble	soluble	soluble	insoluble
(c) add NH_3	blue ppt.	green ppt.	white ppt.	white ppt.	green ppt.
(d) add excess	dark blue solution	insoluble	insoluble	colourless soln.	dark blue soln.

(a) Formation of insoluble metal hydroxides using NaOH (aq)

$$M^{2+}\,(aq) + 2OH^{-}\,(aq) \longrightarrow M(OH)_2\,(s)$$

ppt.

(b) $Al(OH)_3$ (s) and $Zn(OH)_2$ (s) soluble in excess due to their amphoteric nature.

(c) Formation of insoluble metal hydroxides using NH_3

$$NH_3 + H_2O \longrightarrow NH_4^{+} + OH^{-}$$

(d) $Cu(OH)_2$, $Zn(OH)_2$, $Ni(OH)_2$ are soluble in excess due to the formation of complex ions.

$$M(OH)_2 + 4NH_3 \longrightarrow [M(NH_3)_4]^{2+} + 2OH^{-}$$

(iii) **<u>Manganese (II)</u> - Mn^{2+}**

Add excess 2M sodium hydroxide to a solution of manganese(II) - a white precipitate is formed

$$Mn^{2+}\,(aq) + 2OH^{-}\,(aq) \longrightarrow Mn(OH)_2\,(s)$$

white ppt.

Add 20 vol hydrogen peroxide - a black ppt. of manganese(IV) oxide, MnO_2 is formed and oxygen is evolved.

(iv) **<u>Iron (III)</u> - Fe^{3+}**

To a solution of Fe^{3+} add a solution of potassium thiocyanate : deep red colour.

$$[Fe(H_2O)_6]^{3+}\,(aq) + SCN\,(aq) \longrightarrow [Fe(H_2O)_5SCN]^{2+}\,(aq) + H_2O\,(l)$$

blood red soln

(v) **<u>Iron (II)</u> - Fe^{2+}**

To a solution of Fe^{2+} add a solution of potassium hexacyanoferrate (III) : dark blue precipitate.

$$Fe^{2+}\,(aq) + [Fe(CN)_6]^{3-}\,(aq) \longrightarrow Fe^{3+}\,(aq) + [Fe(CN)_6]^{4-}\,(aq)$$

followed by

$$K^+ (aq) + Fe^{3+} (aq) + [Fe(CN)_6]^{4-} (aq) \longrightarrow KFe^{III}[Fe^{II}(CN)_6] (s)$$

dark blue ppt.

(vi) **<u>Cobalt(II)</u> - Co^{2+}**

To a pink solution of cobalt (II) add a few drops of conc. hydrochloric acid. Colour changes from pink to blue.

$$\underset{\text{pink}}{[Co(H_2O)_6]^{2+} (aq)} + 4Cl^- (aq) \Leftrightarrow \underset{\text{blue}}{[CoCl_4]^{2-} (aq)} + 6H_2O (l)$$