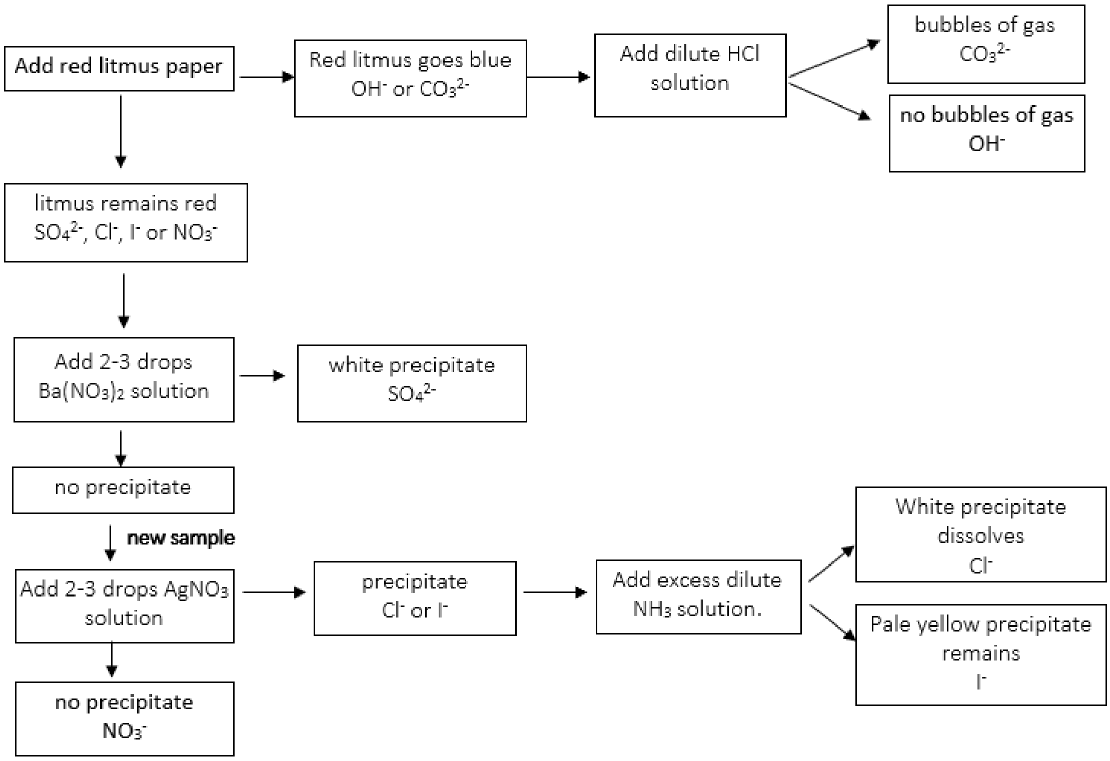
Equations

There might seem a lot to learn but in reality they fall into several general patterns, plus there are a few exceptions just to be memorised.

Anion equations



Addition of a few drops of **barium nitrate solution** (which contains $Ba^{2+}(aq)$ and $NO_3^-(aq)$) is needed to identify the sulfate ion, $SO_4^{2-}(aq)$

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow \boxed{BaSO_4(s)}$ barium sulfate is white

Addition of a few drops of **silver nitrate solution** (which contains $Ag^+(aq)$ and $NO_3^-(aq)$) is needed to identify the chloride ion, $Cl^-(aq)$ and the iodide ion, $I^-(aq)$

$Ag^+(aq) + Cl^-(aq) \rightarrow \boxed{AgCl(s)}$ silver chloride is white

$Ag^+(aq) + I^-(aq) \rightarrow \boxed{AgI(s)}$ silver iodide is (very) pale yellow

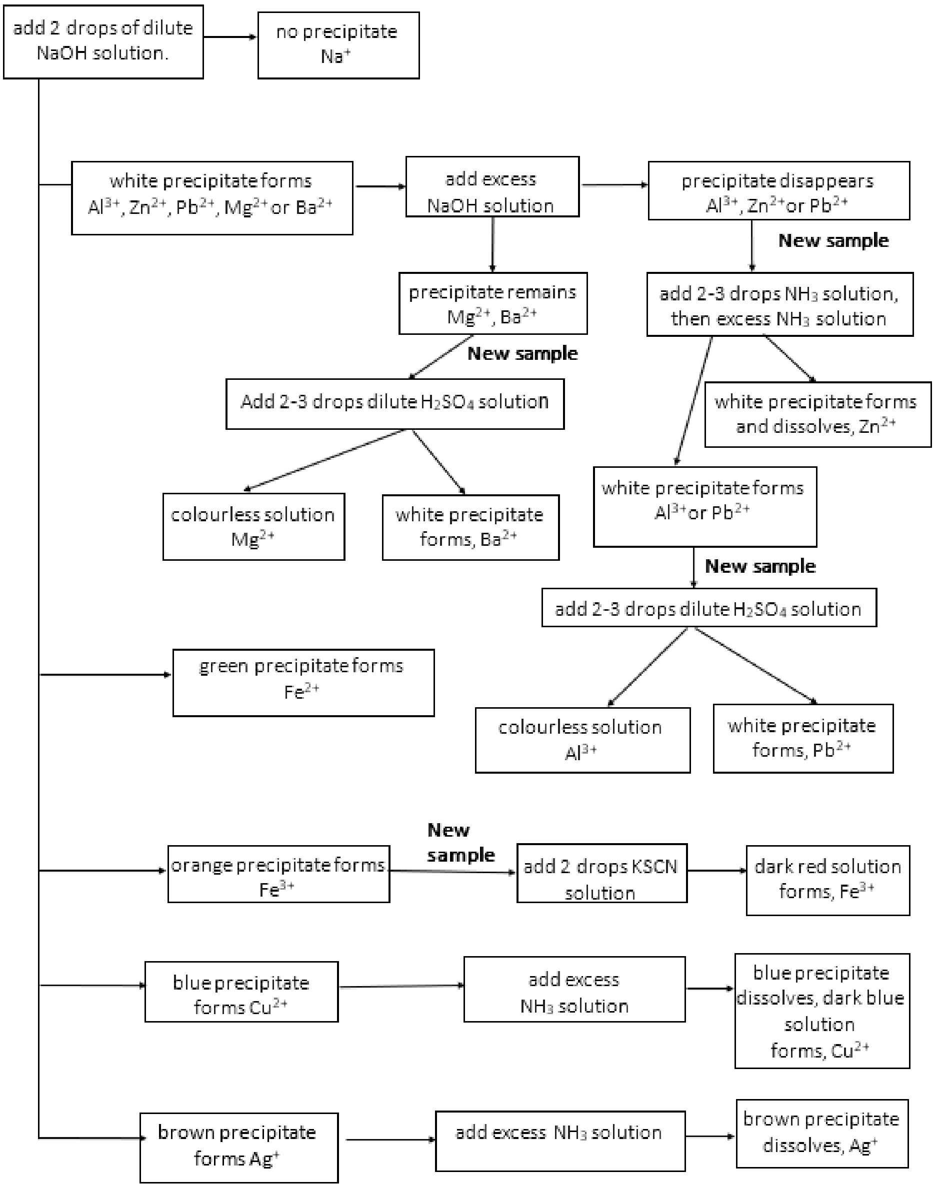
Excess **dilute ammonia solution, $NH_3(aq)$** is added to confirm whether the precipitate is AgCl(s) or AgI(s).

ONLY the AgCl(s) forms a soluble complex ion with the excess dilute ammonia solution, $NH_3(aq)$ and the white AgCl(s) precipitate dissolves to form a colourless solution.

*$AgCl(s) + 2NH_3(aq) \rightarrow [Ag(NH_3)_2]^+(aq) + Cl^-(aq)$ or $Ag^+(aq) + 2NH_3(aq) \rightarrow [Ag(NH_3)_2]^+(aq)$

*Equations involving Ag^+ just need to be memorised!

Cation equations



When a few drops of **sodium hydroxide solution**, $NaOH(aq)$ (or a few drops of dilute ammonia solution, $NH_3(aq)$) are added to a metal cation, a precipitate is formed (except for with Na^+).

White precipitates:

$Mg^{2+}(aq) + 2OH^-(aq) \rightarrow \boxed{Mg(OH)_2(s)}$ magnesium hydroxide is white

$Ba^{2+}(aq) + 2OH^-(aq) \rightarrow \boxed{Ba(OH)_2(s)}$ barium hydroxide is white

$Al^{3+}(aq) + 3OH^-(aq) \rightarrow \boxed{Al(OH)_3(s)}$ aluminium hydroxide is white

$Pb^{2+}(aq) + 2OH^-(aq) \rightarrow \boxed{Pb(OH)_2(s)}$ lead hydroxide is white

$Zn^{2+}(aq) + 2OH^-(aq) \rightarrow \boxed{Zn(OH)_2(s)}$ zinc hydroxide is white

Coloured precipitates:

$Fe^{2+}(aq) + 2OH^-(aq) \rightarrow \boxed{Fe(OH)_2(s)}$ iron(II) hydroxide is green

$Fe^{3+}(aq) + 3OH^-(aq) \rightarrow \boxed{Fe(OH)_3(s)}$ iron(III) hydroxide is orange

$Cu^{2+}(aq) + 2OH^-(aq) \rightarrow \boxed{Cu(OH)_2(s)}$ copper hydroxide is blue

$2Ag^+(aq) + 2OH^-(aq) \rightarrow \boxed{Ag_2O(s)} + H_2O(l)$ silver oxide is brown *

Addition of a few drops of **dilute sulfuric acid solution** (which contains $H^+(aq)$ and $SO_4^{2-}(aq)$) is needed to distinguish between Mg^{2+} and Ba^{2+}

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow \boxed{BaSO_4(s)}$ barium sulfate is white

Addition of a few drops of **dilute sulfuric acid solution** (which contains $H^+(aq)$ and $SO_4^{2-}(aq)$) is needed to distinguish between Al^{3+} and Pb^{2+}

$Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow \boxed{PbSO_4(s)}$ lead sulfate is white

Cation complex ion equations

Some hydrated ions will react with other species in solution to form other ions, called complex ions. Note that the complex ions here are all (aq) – meaning they are soluble.

$[FeSCN]^{2+}(aq)$ is dark red	$Fe^{3+}(aq) + SCN^-(aq) \rightarrow [FeSCN]^{2+}(aq)$
$[Zn(OH)_4]^{2-}(aq)$ is colourless	$Zn(OH)_2(s) + 2OH^-(aq) \rightarrow [Zn(OH)_4]^{2-}(aq)$ or $Zn^{2+}(aq) + 4OH^-(aq) \rightarrow [Zn(OH)_4]^{2-}(aq)$
$[Pb(OH)_4]^{2-}(aq)$ is colourless	$Pb(OH)_2(s) + 2OH^-(aq) \rightarrow [Pb(OH)_4]^{2-}(aq)$ or $Pb^{2+}(aq) + 4OH^-(aq) \rightarrow [Pb(OH)_4]^{2-}(aq)$
$[Al(OH)_4]^-(aq)$ is colourless	$Al(OH)_3(s) + OH^-(aq) \rightarrow [Al(OH)_4]^-(aq)$ or $Al^{3+}(aq) + 4OH^-(aq) \rightarrow [Al(OH)_4]^-(aq)$
$[Ag(NH_3)_2]^+(aq)$ is colourless	*$Ag_2O(s) + 4NH_3(aq) + H_2O(l) \rightarrow 2[Ag(NH_3)_2]^+(aq) + 2OH^-(aq)$ or $Ag^+(aq) + 2NH_3(aq) \rightarrow [Ag(NH_3)_2]^+(aq)$
$[Zn(NH_3)_4]^{2+}(aq)$ is colourless	$Zn(OH)_2(s) + 4NH_3(aq) \rightarrow [Zn(NH_3)_4]^{2+}(aq) + 2OH^-(aq)$ or $Zn^{2+}(aq) + 4NH_3(aq) \rightarrow [Zn(NH_3)_4]^{2+}(aq)$
$[Cu(NH_3)_4]^{2+}(aq)$ is dark blue	$Cu(OH)_2(s) + 4NH_3(aq) \rightarrow [Cu(NH_3)_4]^{2+}(aq) + 2OH^-(aq)$ or $Cu^{2+}(aq) + 4NH_3(aq) \rightarrow [Cu(NH_3)_4]^{2+}(aq)$

*Equations involving Ag^+ just need to be memorised!