2.6 REACTIONS OF IONS IN AQUEOUS SOLUTION: METAL-EQUATIONS

Metal-aqua ions are formed when transition metal compounds dissolve in water

- Form six coordinate bonds with water molecules
- The following metal-aqua ions are formed in aqueous solution:
  - $[Fe(H_2O)_6]^{2+}$ (green solution)
  - $[Cu(H_2O)_6]^{2+}$ (blue solution)
  - $[Fe(H_2O)_6]^{3+}$ (yellow solution)
  - $[Al(H_2O)_6]^{3+}$ (colourless solution)

Some metal hydroxides are amphoteric

- Metal-aqua 3+ ions are more acidic than the metal-aqua 2+ ions
  - Metal 3+ ions have a greater charge density so are more polarising
    - Electrons from the oxygen atoms in water molecules are attracted more strongly to the 3+ ion
      - Weakens the O-H bond
        - More likely that H^+ ions will be released

- Metal-aqua ions form acidic solutions
  - Act as both acids and bases
    - E.g. Aluminium hydroxide

- Hydrolysis reactions
  - Further dissociation for the 3+ ions
    - E.g. $[Cu(H_2O)_6]^{2+} H_2O \rightleftharpoons [Cu(H_2O)_5(OH)]^+ + H_3O^+$
      - Hydrolysis reactions between metal-aqua ions and water
    - Metal-aqua ions form precipitates when hydrolysed further
      - E.g. $[Cu(H_2O)_5(OH)]^+ H_2O \rightleftharpoons Cu(H_2O)_4(OH)_2 + H_3O^+$

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2.6 REACTIONS OF IONS IN AQUEOUS SOLUTION: TEST TUBE REACTIONS

Reactions with bases

- Reactions with sodium carbonate
  - Due to formation of CO_2
  - Solutions of Al^{3+} and Fe^{3+} ions produce bubbles
  - Precipitates produced with each of the four metal–aqua ions
  - Metal 2+ ions react to form metal carbonates in the form MCO_3
  - Metal 3+ ions are stronger acids
  - Therefore the carbonate ions react with H_3O^+ ions
  - Produce products in the form $M(OH)_3(H_2O)_3$
  - E.g. $2[Fe(H_2O)_6]^{3+} + 3CO_3^{2-} \rightarrow 2[Fe(OH)_3(H_2O)_3] + 3CO_2 + 3H_2O$
- Reactions with ammonia
  - Copper hydroxide precipitate will dissolve in excess ammonia
  - Ligand exchange reaction takes place
  - $[Cu(H_2O)_6]^{2+} + 4NH_3 \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+} + 4H_2O$
- Reactions with sodium hydroxide
  - Precipitates produced with each of the four metal–aqua ions
  - Aluminium hydroxide precipitate will re-dissolve in excess sodium hydroxide
- Reactions with ammonia
  - Copper hydroxide precipitate will dissolve in excess ammonia
  - Ligand exchange reaction takes place
  - $[Cu(H_2O)_6]^{2+} + 4NH_3 \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+} + 4H_2O$
  - Forms a deep blue solution

Reactions to identify the metal ion present

- Compare colours of all the complex ion solutions and precipitates

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