Metal hydroxides

4.8.3.2 · Chemical analysis · revision notes

Adding sodium hydroxide solution identifies some metal ions from the colour of the hydroxide precipitate. This is in GCSE Chemistry only (not Combined Science). Expect colour recall, how to tell the white precipitates apart, and balanced or ionic equations.

Key facts

- Cu^{2+} → blue precipitate
- Fe^{3+} → brown precipitate
- Only $Al(OH)_3$ dissolves in excess sodium hydroxide solution
- $CuSO_4 + 2NaOH \rightarrow Cu(OH)_2 + Na_2SO_4$
- Fe^{2+} → green precipitate
- Al^{3+}, Ca^{2+}, Mg^{2+} → white precipitate
- Ca^{2+} or Mg^{2+}? Flame test: calcium gives orange-red
- Grade 7+ only $Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$

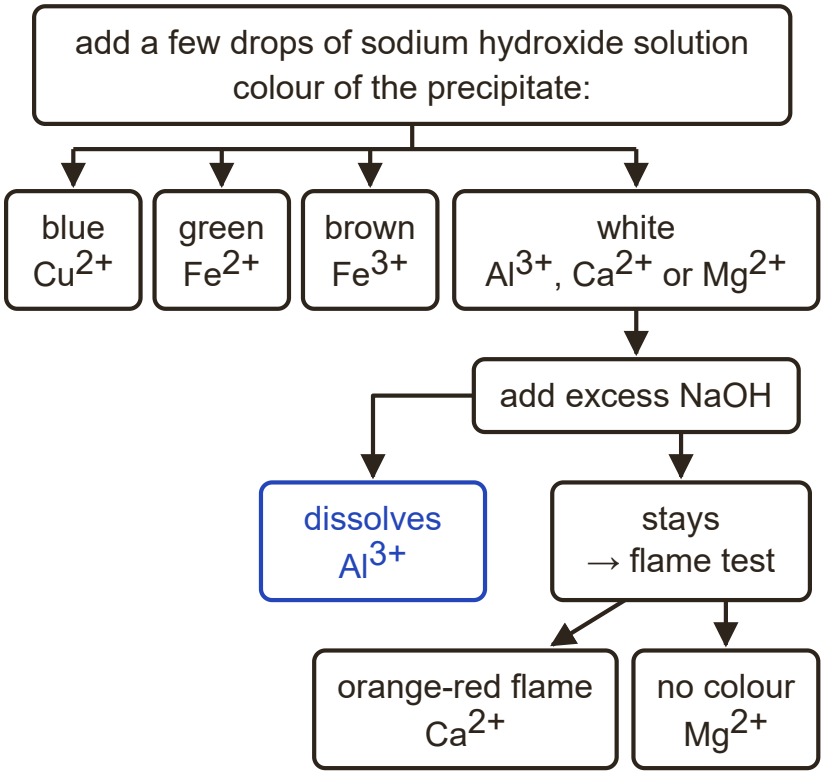
Notes

The test

- Add a few drops of **sodium hydroxide solution** to a solution of the compound. Many metal ions form an insoluble metal hydroxide, seen as a **precipitate**.
- Then add **excess** sodium hydroxide solution and see whether the precipitate dissolves.

Results

- **Copper(II)**, Cu^{2+}: **blue** precipitate.
- **Iron(II)**, Fe^{2+}: **green** precipitate.
- **Iron(III)**, Fe^{3+}: **brown** precipitate.
- **Aluminium** Al^{3+}, **calcium** Ca^{2+} and **magnesium** Mg^{2+}: **white** precipitates.
- Only the **aluminium hydroxide** precipitate dissolves in excess sodium hydroxide solution, giving a colourless solution.
- To tell calcium from magnesium, do a flame test: calcium ions give an orange-red flame; magnesium ions give no distinctive colour.
- A green iron(II) hydroxide precipitate slowly turns brown in air as it is oxidised, so record the colour as soon as it forms.



Colour of the hydroxide precipitate first; for white, add excess, then a flame test.

Equations

- The hydroxide has one OH^- for each positive charge on the metal ion: $Cu(OH)_2$, $Fe(OH)_2$, $Fe(OH)_3$, $Al(OH)_3$, $Mg(OH)_2$, $Ca(OH)_2$.
- Example: $FeCl_3(aq) + 3NaOH(aq) \rightarrow Fe(OH)_3(s) + 3NaCl(aq)$.
- Ionic equation: leave out the spectator ions (here Na^+ and Cl^-), which stay in solution: $Fe^{3+}(aq) + 3OH^-(aq) \rightarrow Fe(OH)_3(s)$. Grade 7+ only
- You do not need an equation for aluminium hydroxide dissolving in excess.

How to answer each type of question

Identify the metal ion from the precipitate colour

1 to 3 marks | Grade 3

1. Learn the three coloured precipitates: blue Cu^{2+}, green Fe^{2+}, brown Fe^{3+}.
2. A white precipitate means aluminium, calcium or magnesium: look at what happens in excess.
3. Name the ion, including (II) or (III) for iron.

Example. Sodium hydroxide solution was added to three solutions.

Solution	Result
A	brown precipitate
B	blue precipitate
C	green precipitate

Name the metal ion in each solution.

Model answer.

A: iron(III) / Fe^{3+} (1)

B: copper(II) / Cu^{2+} (1)

C: iron(II) / Fe^{2+} (1)

Distinguish ions that all give white precipitates

3 to 4 marks | Grade 5

1. Add sodium hydroxide solution a few drops at a time, then in excess.
2. If the white precipitate dissolves in excess, the ion is aluminium.
3. If it does not dissolve, do a flame test: orange-red means calcium; no colour suggests magnesium.

Example. Three unlabelled solutions contain aluminium chloride, calcium chloride and magnesium chloride. All three give a white precipitate with a few drops of sodium hydroxide solution.
Describe how you could identify each solution. Give the results.

Model answer. Add excess sodium hydroxide solution to each precipitate (1). The precipitate that dissolves is from aluminium chloride (1). Do a flame test on the other two solutions (1). Calcium chloride gives an orange-red flame; magnesium chloride gives no distinctive colour (1).

Write a balanced or ionic equation for forming the precipitate 2 to 4 marks **Grade 7**

1. Work out the hydroxide formula from the charge on the metal ion.
2. Balance the full equation with the number of NaOH needed.
3. For an ionic equation, leave out the spectator ions: Na^+ and the negative ion from the metal compound.
4. State symbols: ions in solution (aq); the precipitate (s).

Example. Iron(II) sulfate solution reacts with sodium hydroxide solution to form a green precipitate.
(a) Complete the balanced equation:
$FeSO_4$ + ...NaOH → ..... + Na_2SO_4
(b) Write the ionic equation for the reaction. Include state symbols.

Model answer.

(a) 2 in front of NaOH (1); $Fe(OH)_2$ (1)

(b) Fe^{2+} + $2OH^-$ → $Fe(OH)_2$ (1); state symbols (aq) + (aq) → (s) (1)

Don't lose marks

- Writing just 'iron'. Say iron(II) or iron(III), because they give different colours.
- Saying calcium or magnesium hydroxide dissolves in excess. Only aluminium hydroxide does.
- Writing 'turns blue' instead of 'blue precipitate'. Say that a precipitate (a solid) forms.
- Wrong formulae such as $FeOH_3$ or $Al(OH)_2$. Use brackets, with the number of OH equal to the charge.
- Including spectator ions (Na^+, Cl^-, SO_4^{2-}) in an ionic equation.

More tips

Memory tricks

- Rust is brown and contains iron(III), so iron(III) hydroxide is brown; iron(II) is the green one.
- Copper(II) sulfate solution is blue, and so is copper(II) hydroxide.
- 'Aluminium Always dissolves' in excess; calcium and magnesium don't.
- Number of OH in the formula = charge on the metal ion.

Exam technique

- Always use the word 'precipitate' and give its colour.
- To tell all three white precipitates apart you need BOTH excess sodium hydroxide AND a flame test.
- Put (s) after the metal hydroxide in equations: it is an insoluble solid.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 **Recall the coloured hydroxide precipitates**
Copper(II) blue, iron(II) green, iron(III) brown.

Grade 4

Name the ions giving white precipitates

Aluminium, calcium and magnesium ions all give a white precipitate.

Grade 5

Use excess sodium hydroxide to identify aluminium

Only aluminium hydroxide dissolves in excess sodium hydroxide solution.

Grade 5

Distinguish calcium ions from magnesium ions

Both precipitates stay in excess, so do a flame test: calcium gives orange-red.

Grade 6

Work out hydroxide formulae from ion charges

One OH^- for each positive charge on the metal ion, e.g. $Al(OH)_3$.

Grade 6

Write balanced equations for forming precipitates

e.g. $CuSO_4 + 2NaOH \rightarrow Cu(OH)_2 + Na_2SO_4$.

Grade 7

Write ionic equations with state symbols

e.g. $Fe^{3+}(aq) + 3OH^-(aq) \rightarrow Fe(OH)_3(s)$.

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