Exercise walk-through

Preparation of salts ▪ 7.3

eXercise

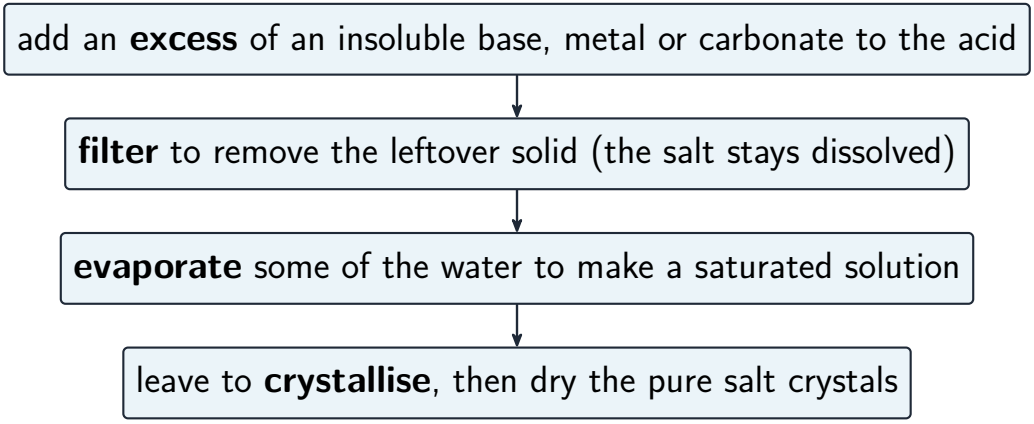
You must be able to

- use the solubility rules
- describe making a soluble salt (excess solid, filter, evaporate, crystallise)
- describe making an insoluble salt by precipitation

Method — Two salt-making routes

- **soluble:** all Na/K/ammonium and nitrates; most chlorides/sulfates.

Method — Two salt-making routes



A flowchart: excess solid → filter → evaporate → crystallise

Method — Two salt-making routes

Two solutions mixed give a solid precipitate

Method — Choosing the route, and writing the equation

Decide from the solubility rules first. **Soluble:** all sodium, potassium and ammonium salts, all nitrates, most chlorides (not silver or lead) and most sulfates (not barium, calcium or lead). **Insoluble:** most carbonates and hydroxides (except sodium, potassium and ammonium).

Route 1, a soluble salt from an insoluble base or carbonate. Warm the acid, add the solid in **excess** so all the acid is used up, **filter** off the leftover solid, **evaporate** the filtrate until crystals begin to form, then leave it to **crystallise** and dry the crystals between filter papers. Use this when one reactant is insoluble, which is what makes "add in excess and filter" possible.

Route 2, a soluble salt from a soluble base (titration). Both reactants are in solution, so nothing can be filtered off. Find the exact volume of acid that neutralises the alkali by titration with an indicator, then repeat with the same volumes **without** the indicator, and evaporate and crystallise.

Method — Choosing the route, and writing the equation

Route 3, an insoluble salt (precipitation). Mix solutions that each carry one of the needed ions, then **filter**, **wash** the residue with distilled water, and **dry** it.

Worked example. Describe how to prepare pure, dry copper(II) sulfate crystals from copper(II) oxide.

1. Warm dilute sulfuric acid in a beaker.
2. Add copper(II) oxide a little at a time, stirring, until some remains unreacted: this shows the acid has all reacted.
3. Filter to remove the excess copper(II) oxide.
4. Evaporate the blue filtrate until crystals just start to appear at the edge.
5. Leave the solution to cool and crystallise, then dry the crystals between filter papers.

The equation is $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$. For a precipitation, an **ionic equation** shows only the ions that change: $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$.

Practice 2.1 ▪ 1 mark

State whether silver chloride is soluble or insoluble.

Solution 2.1

Method: Choosing the route, and writing the equation

Worked steps

insoluble B1.

Practice 2.2 ▪ 1 mark

Name the method used to make an insoluble salt.

Solution 2.2

Method: Choosing the route, and writing the equation

Worked steps

precipitation B1.

Practice 2.3 ▪ 1 mark

Identify which of these salts is insoluble: sodium chloride, barium sulfate, potassium nitrate.

Solution 2.3

Method: Choosing the route, and writing the equation

Worked steps

Barium sulfate B1.

Practice 2.4 ▪ 2 marks

Write the ionic equation for the formation of silver chloride from silver nitrate and sodium chloride solutions.

Solution 2.4

Method: Choosing the route, and writing the equation

Worked steps

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ **M1** **A1** *for the correct ions and product, for the state symbols.*

Practice 2.5 ▪ 2 marks

Explain why the solid is added in excess in the filtration route.

Solution 2.5

Method: Choosing the route, and writing the equation

Worked steps

So that all of the acid is used up B1; the excess solid can then be filtered off, leaving a solution containing only the salt B1.

Exam-style 3.1 ▪ 1 mark

A soluble salt is best made from an acid and an **excess** of an insoluble base by, in order:

A filter, react, crystallise

B react, filter, evaporate, crystallise

C evaporate, react, filter

D precipitate, wash, dry

Solution 3.1

Method: Choosing the route, and writing the equation

A filter, react, crystallise

B react, filter, evaporate, crystallise ✓

C evaporate, react, filter

D precipitate, wash, dry

Worked steps

B. React (excess base), filter off the excess, evaporate, then crystallise.

Exam-style 3.2 ▪ 4 marks

Describe how to make pure, dry copper(II) sulfate crystals from copper(II) oxide and dilute sulfuric acid.

Solution 3.2

Method: Choosing the route, and writing the equation

Worked steps

add excess copper(II) oxide to warm dilute sulfuric acid until no more reacts **M1**; filter to remove the excess solid **M1**; evaporate some water from the filtrate **M1**; leave to crystallise, then dry the crystals **A1**.

Exam-style 3.3 ▪ 3 marks

Barium sulfate is insoluble. Name two solutions that could be mixed to make it, and state what you would do after mixing.

Solution 3.3

Method: Choosing the route, and writing the equation

Worked steps

(a) $ZnCO_3 + H_2SO_4 \rightarrow ZnSO_4 + H_2O + CO_2$ M1 A1 *correct reactants and products, balanced.*
(b) Warm the dilute sulfuric acid B1; add zinc carbonate a little at a time, with stirring, until it is in excess B1; filter to remove the excess solid B1; evaporate the filtrate until crystals begin to form at the edge B1; leave it to cool and crystallise, then dry the crystals between filter papers B1.
(c) Solid stays at the bottom of the beaker and no more bubbles of carbon dioxide are produced B1; this shows all the acid has reacted B1.

Solution 3.3

(d) Any soluble lead salt, such as lead(II) nitrate, with any soluble iodide, such as potassium iodide B1 B1; $Pb^{2+}(aq) + 2I^{-}(aq) \rightarrow PbI_2(s)$ B1.
(e) Filter the mixture, wash the residue with distilled water and dry it B1 B1; it is washed to remove the soluble salt solution left on the crystals, which would otherwise contaminate the product B1.

Exam-style 3.3 ▪ 2 marks

A student prepares two salts: zinc sulfate crystals from zinc carbonate, and lead(II) iodide.
(a) Write the equation for the reaction of zinc carbonate with dilute sulfuric acid.
(b) Describe how the student obtains pure, dry crystals of zinc sulfate, giving the practical steps in order.
(c) Explain how the student knows when enough zinc carbonate has been added.
(d) Lead(II) iodide is insoluble. Identify two solutions that could be mixed to prepare it, and write the ionic equation.
(e) State the three steps needed to obtain the dry lead(II) iodide from the mixture, and state why the residue is washed.

Solution 3.3

Method: Choosing the route, and writing the equation

Worked steps

(a) $ZnCO_3 + H_2SO_4 \rightarrow ZnSO_4 + H_2O + CO_2$ M1 A1 *correct reactants and products, balanced.*
(b) Warm the dilute sulfuric acid B1; add zinc carbonate a little at a time, with stirring, until it is in excess B1; filter to remove the excess solid B1; evaporate the filtrate until crystals begin to form at the edge B1; leave it to cool and crystallise, then dry the crystals between filter papers B1.
(c) Solid stays at the bottom of the beaker and no more bubbles of carbon dioxide are produced B1; this shows all the acid has reacted B1.

Solution 3.3

(d) Any soluble lead salt, such as lead(II) nitrate, with any soluble iodide, such as potassium iodide B1 B1; $Pb^{2+}(aq) + 2I^{-}(aq) \rightarrow PbI_2(s)$ B1.
(e) Filter the mixture, wash the residue with distilled water and dry it B1 B1; it is washed to remove the soluble salt solution left on the crystals, which would otherwise contaminate the product B1.