Cambridge (CIE) IGCSE Chemistry

Your notes

Preparation of Salts

Contents

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Preparing soluble salts

How to name a salt

- The name of salt has two parts:
  1. The first part comes from the **metal**, **metal** oxide or **metal** carbonate used in the reaction
  2. The second part comes from the **acid**
- The name of the salt can be determined by looking at the reactants
  - For example, hydrochloric acid always produces salts that end in chloride and contain the **chloride** ion, Cl^-
- Other examples:
  - **Sodium** hydroxide reacts with hydro**chloric** acid to produce sodium chloride
  - **Zinc** oxide reacts with **sulf**uric acid to produce **zinc sulfate**

What is a salt?

- A salt is a compound that is formed when the **hydrogen atom** in an acid is replaced by a **metal** or **ammonium ion**
  - For example, replacing H in HCl with potassium gives potassium chloride, KCl
- Salts have many uses including:
  - Fertilisers
  - Batteries
  - Cleaning products
  - Healthcare products
  - Fungicides
- The method used depends on:
  - The **solubility** of the salt being prepared
  - Whether the base is **insoluble** or **soluble (alkali)**

Preparing soluble salts

- There are two methods of preparing a soluble salt:

Method A: Acid + insoluble base / carbonate

- This is for metals, metal oxides, or carbonates that do not dissolve in water

1. Warm dilute acid gently in a beaker.
2. Add the metal, insoluble base, or carbonate slowly while stirring until no more reacts (the base is in excess).
3. Filter the mixture to remove the excess solid.
4. Transfer the filtrate (salt solution) to an evaporating basin and heat gently until the solution is concentrated.
    - Check the solution is saturated by dipping a cold, glass rod into the solution and seeing if crystals form on the end
5. Leave the basin in a warm place to crystallize.
6. Decant excess liquid and dry the crystals with filter paper.

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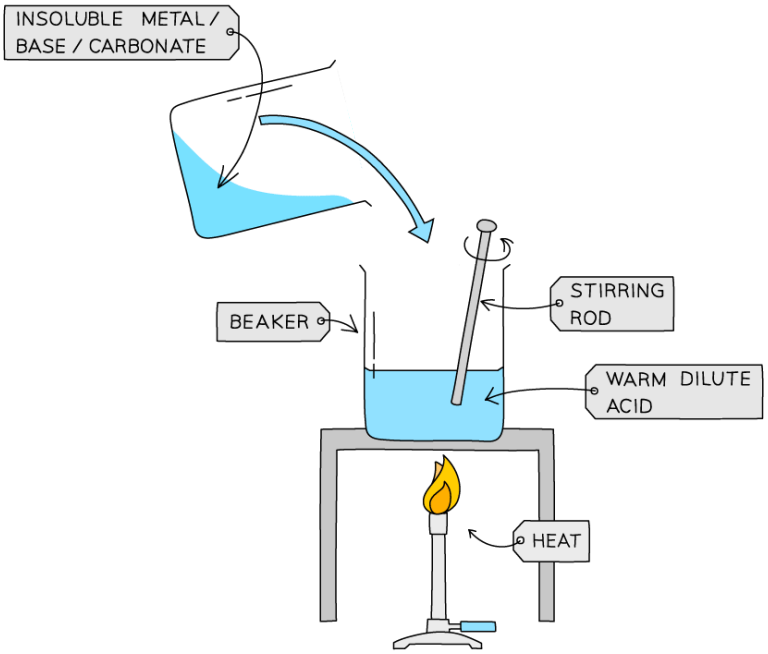
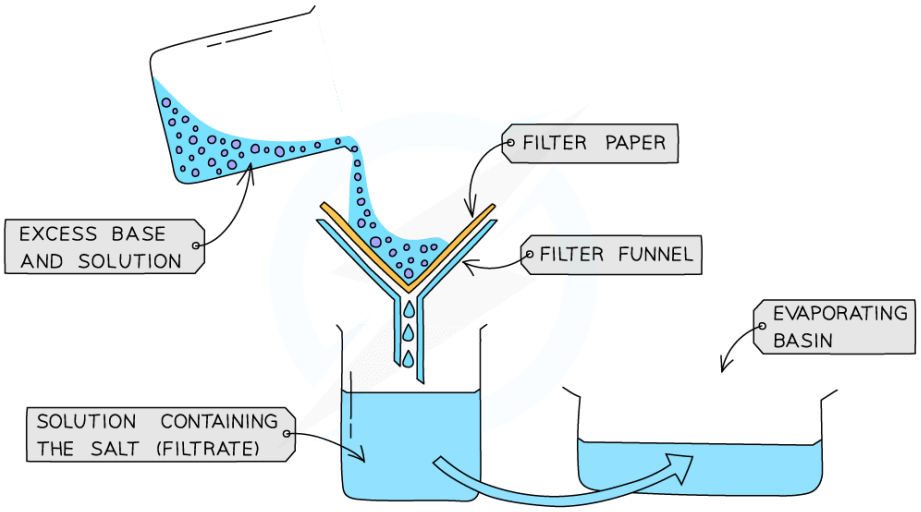
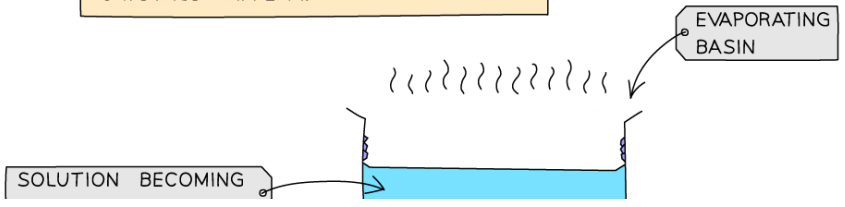
1 HEAT ACID UNTIL WARM, THEN ADD METAL / BASE / CARBONATE, STIRRING CONSTANTLY UNTIL IT STOPS DISAPPEARING



2 FILTER MIXTURE TO REMOVE EXCESS BASE, TRANSFER SOLUTION TO EVAPORATING BASIN.



3 EVAPORATING WATER FROM SOLUTION USING A BUNSEN BURNER UNTIL CRYSTALS APPEAR.



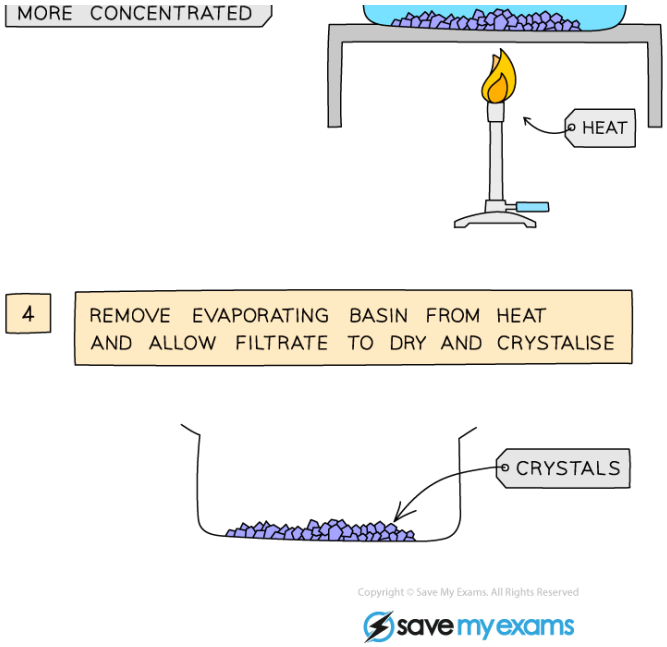


Diagram showing the preparation of soluble salts

- For example, preparing pure, hydrated copper(II) sulfate crystals using method A:

copper(II) oxide + sulfuric acid → copper(II) sulphate + water

$CuO\ (s) + H_2SO_4\ (aq) \rightarrow CuSO_4\ (aq) + H_2O\ (l)$

Method B: Acid + alkali (titration method)

- This is for soluble bases such as sodium hydroxide

1. Use a pipette to place alkali in a conical flask and add a few drops of indicator (e.g. phenolphthalein).
2. Fill a burette with the acid and record the starting volume.
3. Add the acid slowly while swirling until the indicator changes colour (end point).
    - Record the final volume.
4. Repeat the titration without indicator, using the same measured volume of acid.
5. Heat the neutral solution in an evaporating basin until concentrated.
6. Leave to crystallise, decant excess liquid, and dry the crystals.

Your notes

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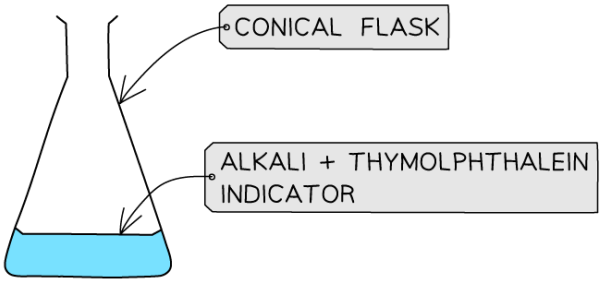
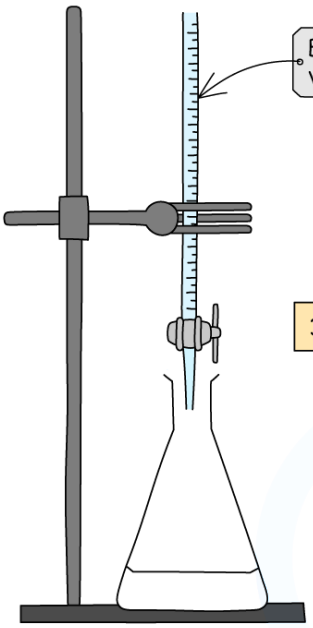
1 ADD ALKALI + INDICATOR TO CONICAL FLASK USING A PIPETTE

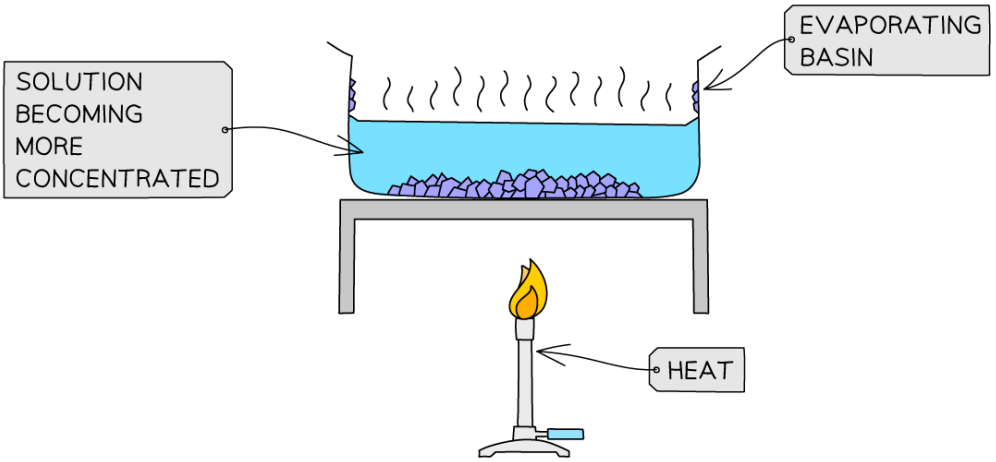


2 ADD ACID TO BURETTE, NOTING THE STARTING VOLUME



3 ADD ACID TO ALKALI SLOWLY UNTIL INDICATOR CHANGES COLOUR. CALCULATE VOLUME OF ACID ADDED. REPEAT STEPS 1–3 WITHOUT INDICATOR

4 TRANSFER SOLUTION TO AN EVAPORATING BASIN, HEAT TO PARTIALLY EVAPORATE WATER



5 REMOVE EVAPORATING BASIN FROM HEAT AND ALLOW FILTRATE TO DRY AND CRYSTALISE

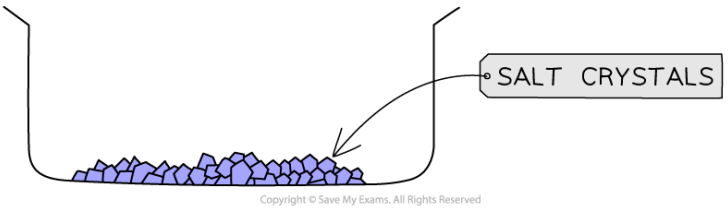


Diagram showing the apparatus needed to prepare a salt by titration

Your notes

- For example, preparing pure sodium chloride crystals using method B:

sodium hydroxide + hydrochloric acid → sodium chloride + water

$NaOH\ (aq) + HCl\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)$

Examiner Tips and Tricks

Use **Method A** if the base is insoluble (e.g. copper oxide).

Use **Method B (titration)** if the base is soluble (alkali).

Your notes

Preparing insoluble salts

Extended tier only

- Insoluble salts can be prepared using a **precipitation reaction**
- The solid salt obtained is the precipitate, thus in order to successfully use this method the solid salt being formed must be insoluble in water, and the reactants must be soluble

Using two soluble reactants

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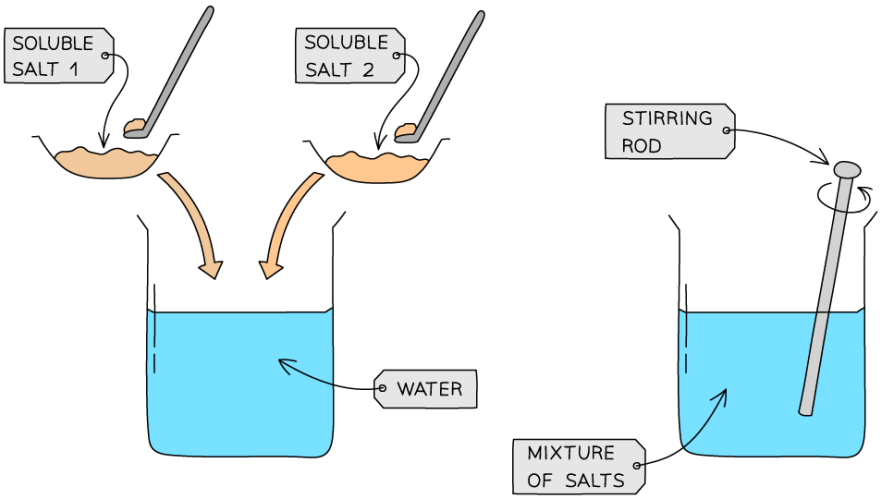
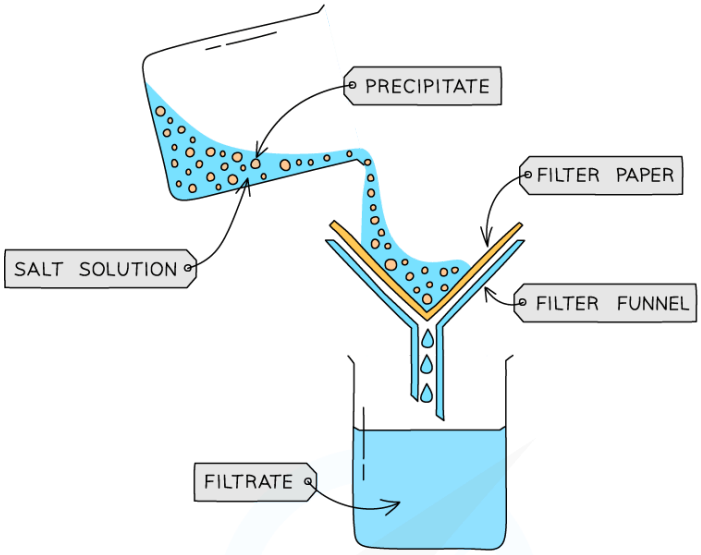
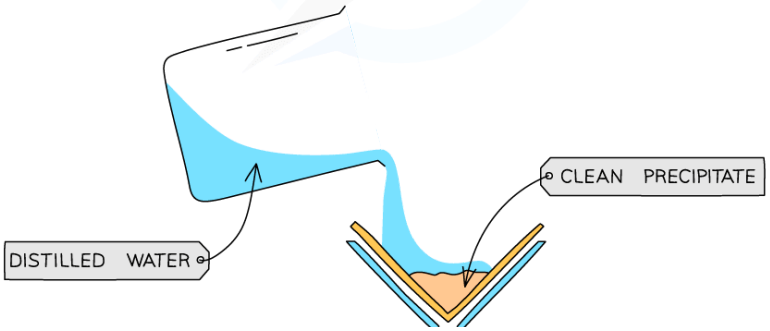
1 ADD SOLUBLE SALTS TO WATER AND MIX

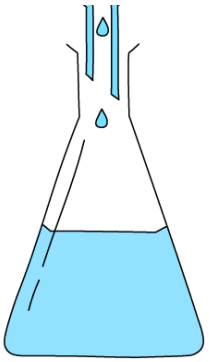


2 FILTER TO REMOVE PRECIPITATE FROM THE MIXTURE



3 WASH THE PRECIPITATE WITH DISTILLED WATER TO REMOVE TRACES OF SOLUTION





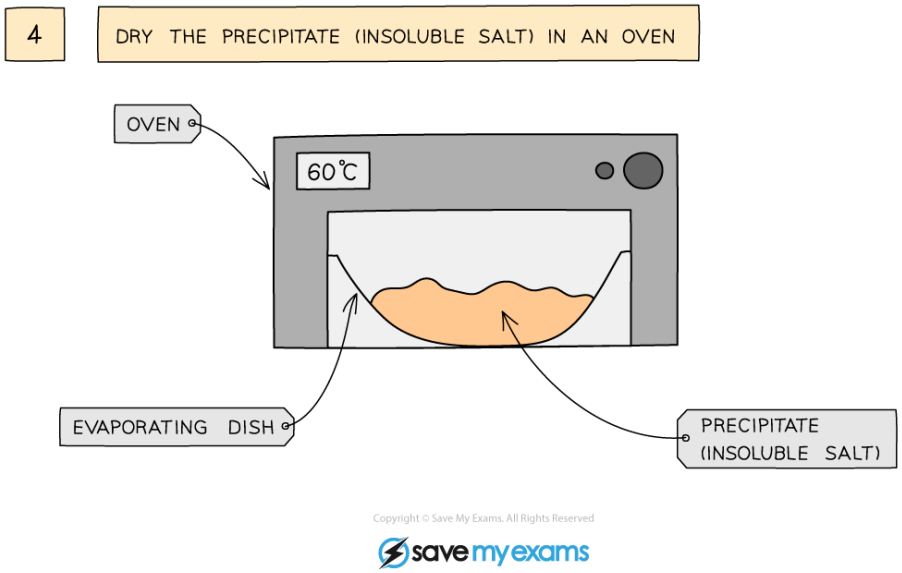


Diagram showing the filtration of the mixture to remove the precipitate

Method

- Dissolve soluble salts in water and mix together using a stirring rod in a beaker
- Filter to remove precipitate from mixture
- Wash the residue with distilled water to remove traces of other solutions
- Leave in an oven to dry

Example: Preparation of pure, dry lead(II) sulfate crystals using a precipitation reaction

- Dissolve lead(II) nitrate and potassium sulfate in water and mix together using a stirring rod in a beaker
- Filter to remove precipitate from mixture
- Wash precipitate with distilled water to remove traces of potassium nitrate solution
- Leave in an oven to dry

lead(II) nitrate + potassium sulfate → lead(II) sulfate + potassium nitrate

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$$Pb(NO_3)_2\,(aq) + K_2SO_4\,(aq) \rightarrow PbSO_4\,(s) + 2KNO_3\,(aq)$$

Your notes

Solubility rules

- Salts are prepared by different methods, depending on whether the salt is soluble or insoluble so it is important to know the solubility of salts

Solubility of the common salts

Salts	Soluble	Insoluble
Sodium, potassium and ammonium	All	None
Nitrates	All	None
Chlorides	Most are soluble	Silver and lead(II)
Sulfates	Most are soluble	Barium, calcium and lead(II)
Carbonates	Carbonates of sodium, potassium and ammonium	Most are insoluble
Hydroxides	Hydroxides of sodium potassium and ammonium (calcium hydroxide is sparingly soluble)	Most are insoluble

Your notes

Hydrated & anhydrous salts

- When salts are being prepared, some water can be retained within the structure of the salt during the crystallisation process
- Salts that contain water within their structure are called **hydrated** salts
- **Anhydrous** salts are those that contain no water in their structure
- A common example is copper(II) sulfate which crystallises forming the salt hydrated copper(II) sulfate, which is blue
- When it is heated, the water from its structure is removed, forming anhydrous copper(II) sulfate, which is white
- The hydrated salt has been **dehydrated** to form the anhydrous salt
- This reaction can be reversed by adding water to anhydrous copper(II) sulfate

hydrated copper(II) sulfate ⇌ anhydrous copper(II) sulfate + water

Water of crystallisation

Extended tier only

- Water molecules included in the structure of some salts during the crystallisation process are known as **water of crystallisation**
- A compound that contains water of crystallisation is called a **hydrated compound**
- When writing the chemical formula of hydrated compounds, the water of crystallisation is separated from the main formula by a **dot**:
  - Hydrated copper(II) sulfate is $CuSO_4 \cdot 5H_2O$
  - Hydrated cobalt(II) chloride is $CoCl_2 \cdot 6H_2O$
- The formula shows the number of moles of water contained within one mole of the hydrated salt:
  - Hydrated copper(II) sulfate, $CuSO_4 \cdot 5H_2O$, contains 5 moles of water in 1 mole of hydrated salt
- A compound which doesn't contain water of crystallisation is called an **anhydrous compound**:
  - Anhydrous copper(II) sulfate is $CuSO_4$
  - Anhydrous cobalt(II) chloride is $CoCl_2$
- The conversion of anhydrous compounds to hydrated compounds is **reversible** by heating the hydrated salt:
  - Anhydrous to hydrated salt:

- $CuSO_4 + 5H_2O \rightarrow CuSO_4 \cdot 5H_2O$

- Hydrated to anhydrous salt (by heating):
  - $CuSO_4 \cdot 5H_2O \rightarrow CuSO_4 + 5H_2O$

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Hydrated copper(II) sulfate and anhydrous copper(II) sulfate

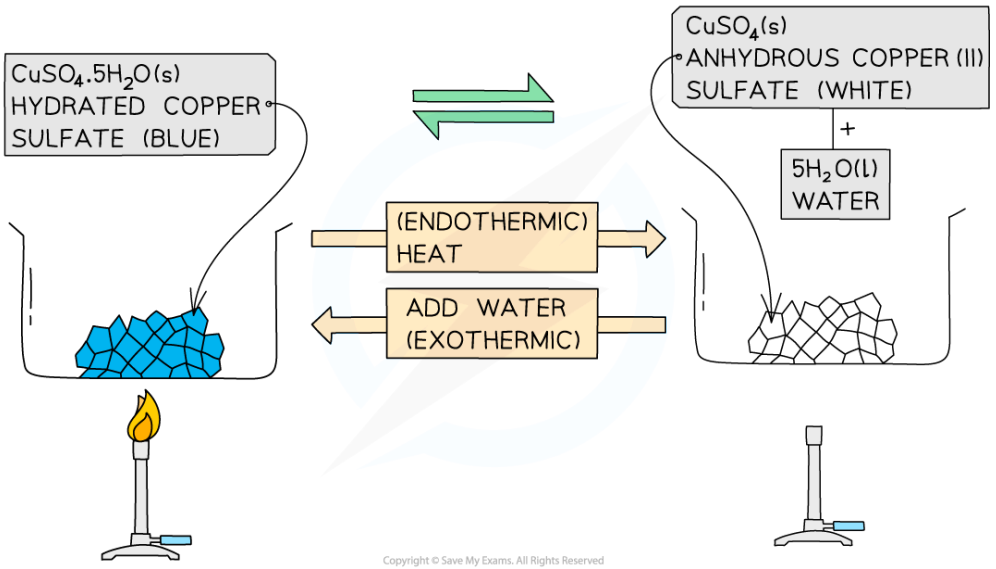

Diagram showing the dehydration of hydrated copper(II) sulfate