Soluble salts

4.4.2.3 · Chemical changes · revision notes

How to make a pure, dry sample of a soluble salt from an acid and an insoluble solid (a metal, metal oxide, hydroxide or carbonate). This is required practical 1, so expect 4 to 6 mark method questions and questions on why each step is done.

Key facts

- insoluble solid (metal, oxide, hydroxide, carbonate) + acid → soluble salt solution
- Filter → removes the excess solid
- Dry the crystals between filter paper or in a warm place
- $ZnCO_3 + 2HCl \rightarrow ZnCl_2 + H_2O + CO_2$
- Add the solid in excess → all the acid reacts
- Evaporate some water (water bath) → cool → crystals form
- $CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$ (black solid → blue solution)

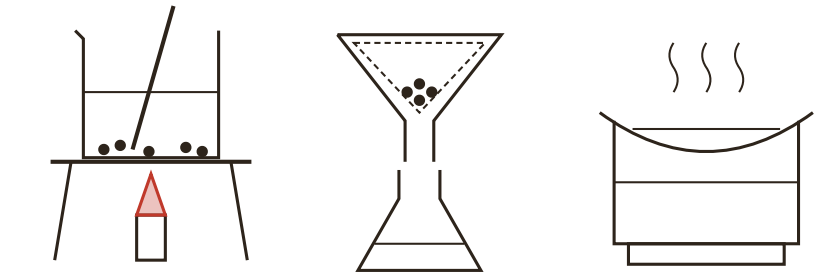
Notes

The idea

- A soluble salt can be made by reacting an acid with a **solid, insoluble** substance: a metal, metal oxide, metal hydroxide or metal carbonate.
- Choose the acid for the salt you want: sulfuric acid for a sulfate, hydrochloric acid for a chloride, nitric acid for a nitrate.
- Example: copper(II) oxide + sulfuric acid → copper(II) sulfate + water.
- The solid is added in **excess** (more than is needed) so that all the acid reacts. The leftover solid is easy to remove by filtering.

Method (required practical 1)

- 1. Measure dilute acid (e.g. 40 cm^3 of sulfuric acid) into a beaker and warm it gently with a Bunsen burner. Do not boil it.
- 2. Add the insoluble solid a little at a time, stirring, until some solid is left over and will not dissolve. With a carbonate, the fizzing stops.
- 3. Filter the mixture to remove the excess solid. The filtrate is the salt solution.
- 4. Heat the filtrate in an evaporating basin, using a water bath or electric heater, until about half of the water has evaporated or crystals start to form.
- 5. Leave the solution to cool so that crystals form.
- 6. Filter off the crystals and dry them between sheets of filter paper or in a warm place.



React, filter, crystallise. The filtrate in step 2 is the salt solution; in step 3 the evaporating basin sits on a water bath.

Why each step matters

- Warming the acid speeds up the reaction.
- Excess solid makes sure no acid is left, so the salt is not contaminated with acid.
- Filtering removes the unreacted solid, leaving only the salt solution.
- Heating gently and not to dryness gives crystals; boiling it dry can make the solution spit and leaves a powder.
- Wear eye protection: the acid and the hot solutions are hazards.

How to answer each type of question

Explain why a step is done

1 mark each | Grade 5

1. Link each step to its purpose: warming (faster), excess (all acid reacts), filtering (remove excess solid).
2. Give the specific reason, not just 'to make it work'.

Example. A student makes copper(II) chloride from copper(II) carbonate and dilute hydrochloric acid.
(a) Why is excess copper(II) carbonate added?
(b) How can the student tell that the copper(II) carbonate is in excess?
(c) Why is the mixture then filtered?

Model answer.

(a) To make sure all the acid has reacted / is used up (1)
(b) Solid is left over / no more dissolves / the fizzing stops (1)
(c) To remove the excess (unreacted) copper(II) carbonate (1)

6-mark: describe how to make a pure, dry sample of a named salt

4 to 6 marks | Grade 5

1. Name the reactants: the acid and the insoluble solid.
2. Warm the acid, then add the solid until it is in excess.
3. Filter to remove the excess solid.
4. Heat to evaporate some water, then leave to cool and crystallise.
5. Filter off the crystals and dry them.

Example. Describe how you would make a pure, dry sample of zinc sulfate crystals from zinc oxide and dilute sulfuric acid. [6 marks]

Model answer.

Marked in levels. A top-level answer is a complete method in a logical order, such as:
Warm some dilute sulfuric acid in a beaker (1)
Add zinc oxide a little at a time, stirring (1)
until no more dissolves / zinc oxide is in excess (1)
Filter to remove the excess zinc oxide (1)
Heat the filtrate (on a water bath) until crystals start to form, then leave it to cool so crystals form (1)
Filter off the crystals and dry them between filter papers (1)

Choose reactants for a named salt

2 to 3 marks | **Grade 5**

1. The acid gives the second part of the name.
2. The solid must contain the metal: an oxide, hydroxide or carbonate, or a metal that reacts safely with acid.
3. Metals below hydrogen (e.g. copper) do not react with dilute hydrochloric or sulfuric acid; very reactive metals (e.g. sodium) react dangerously.

Example. (a) Suggest two substances that could be reacted together to make magnesium chloride. (b) Explain why copper metal cannot be used to make copper(II) sulfate by reacting it with dilute sulfuric acid.

Model answer.

(a) Magnesium oxide / magnesium carbonate / magnesium hydroxide / magnesium (1) and hydrochloric acid (1)

(b) Copper is less reactive than hydrogen, so it does not react with dilute sulfuric acid (1)

Don't lose marks

- Adding excess acid instead of excess solid: the salt would then be contaminated with acid.
- Writing 'evaporate all the water' or 'boil until dry'.
- Forgetting to filter off the excess solid before crystallising.
- Missing the final drying step, so the salt is not dry.
- Choosing a very reactive metal such as sodium, which reacts dangerously with acid.

More tips

Memory tricks

- Order of steps: We Eat Fresh Eggs, Cooked Daily (Warm, Excess, Filter, Evaporate, Crystallise, Dry).
- Two filterings: the first removes excess solid (keep the filtrate); the second collects the crystals (keep what is in the filter paper).
- Colour clue with copper(II) oxide: black solid left in a blue solution means the oxide is in excess.

Exam technique

- In 6-mark method questions, write the steps in order and name the equipment: beaker, filter funnel and paper, evaporating basin, water bath.
- Use the key words 'excess', 'filter', 'filtrate' and 'crystallise'.
- A sensible volume of acid is fine to include, but the key steps and the reason for each matter most.

What each grade needs

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

Grade 3 **Name reactants needed to make a salt**

For example, copper(II) oxide and sulfuric acid make copper(II) sulfate.

Grade 4

Describe filtering and crystallising

Filter off the excess solid, heat to evaporate some water, then leave the solution to cool and crystallise.

Grade 5

Explain why excess solid is added

Excess solid makes sure all the acid reacts, so the salt solution contains no leftover acid.

Grade 5

Tell when the solid is in excess

Solid stays undissolved at the bottom, and for a carbonate the fizzing stops.

Grade 5

Describe the full method for a salt

Warm acid, add solid until in excess, filter, evaporate some water, crystallise, then dry the crystals.

Grade 5

Choose suitable reactants for a named salt

Pick the acid with the right negative ion and an insoluble compound of the metal (or a metal that is safe to use).

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