Sulfates

4.8.3.5 · Chemical analysis · revision notes

Sulfate ions give a white precipitate of barium sulfate with barium chloride solution in the presence of dilute hydrochloric acid. This is in GCSE Chemistry only (not Combined Science). The sulfate test is often combined with other ion tests to identify a compound in the required practical.

Key facts

- Test: dilute hydrochloric acid, then barium chloride solution
- Hydrochloric acid removes carbonate ions, which would also give a white precipitate
- $BaCl_2 + Na_2SO_4 \rightarrow BaSO_4 + 2NaCl$
- Halides: nitric acid + silver nitrate. Sulfates: hydrochloric acid + barium chloride.
- Result: white precipitate of barium sulfate → sulfate ions present
- Never use sulfuric acid: it adds sulfate ions
- Grade 7+ only $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

Notes

The test

- Make a solution of the sample. Add a few drops of **dilute hydrochloric acid**, then a few drops of **barium chloride solution**.
- If sulfate ions (SO_4^{2-}) are present, a **white precipitate** of barium sulfate forms.
- If no precipitate forms, there are no sulfate ions.
- Barium chloride solution is toxic: wear eye protection and avoid skin contact.

Why dilute hydrochloric acid?

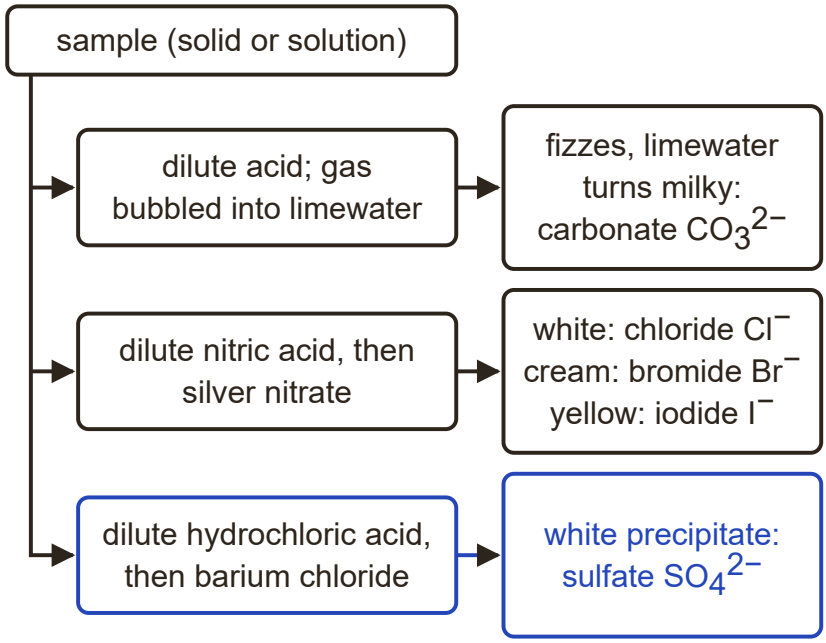
- The acid removes carbonate ions, which would otherwise form a white precipitate (barium carbonate) with barium chloride.
- Do **not** use sulfuric acid: it contains sulfate ions, so it would give a white precipitate every time.
- Compare the halide test, which uses nitric acid because hydrochloric acid would add chloride ions. In the sulfate test, extra chloride ions do not matter.

Equations

- Example: $BaCl_2(aq) + Na_2SO_4(aq) \rightarrow BaSO_4(s) + 2NaCl(aq)$
- Ionic equation: $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ Grade 7+ only

Required practical: identifying an unknown compound

- An ionic compound contains a positive ion and a negative ion, so you need a test for each.
- Dissolve the solid in deionised water and use a fresh portion of the solution for each test, so one reagent cannot affect another result.
- Positive ion: flame test, or sodium hydroxide solution.
- Negative ion: dilute acid and limewater (carbonate), nitric acid and silver nitrate (halide), or hydrochloric acid and barium chloride (sulfate).
- Record each observation (flame colour, precipitate colour, fizzing) and match it to the known results to name both ions, e.g. sodium sulfate.



One test for each negative ion; test the positive ion with a flame test or NaOH.

How to answer each type of question

Describe the test for sulfate ions and give the result

2 to 3 marks | **Grade 3**

1. Add dilute hydrochloric acid to a solution of the sample.
2. Add barium chloride solution.
3. Result: a white precipitate.

Example. Describe a test to show that a solution contains sulfate ions. Give the result.

Model answer. Add dilute hydrochloric acid (1), then barium chloride solution (1). A white precipitate forms (1).

Describe tests to confirm both ions in a compound

4 marks | Grade 5

1. Dissolve the solid in water.
2. Test one portion for the positive ion (flame test or sodium hydroxide solution) and give the result.
3. Test another portion for the negative ion and give the result.

Example. A solid is thought to be iron(III) sulfate.
Describe tests to show that it contains iron(III) ions and sulfate ions. Give the results.

Model answer. Dissolve the solid in water and add sodium hydroxide solution to one portion (1). A brown precipitate shows iron(III) ions (1). To another portion, add dilute hydrochloric acid and then barium chloride solution (1). A white precipitate shows sulfate ions (1).

Explain why sulfuric acid must not be used

2 marks | Grade 6

1. Say that sulfuric acid contains sulfate ions.
2. So a white precipitate would form even if the sample had no sulfate ions.

Example. In the test for sulfate ions, explain why dilute sulfuric acid must **not** be used to acidify the solution.

Model answer. Sulfuric acid contains sulfate ions (1), so a white precipitate would form even if the sample contained no sulfate ions (1).

6-mark: plan tests to identify unknown compounds

6 marks | Grade 5

1. List the ions in each compound, then choose one test for each ion.
2. For every test, give the reagents and the result for each compound.
3. Make sure your results tell every compound apart, and write them in a logical order.

Example. A technician has three unlabelled white solids: lithium carbonate, sodium sulfate and magnesium chloride.
Describe tests the technician could use to identify each solid. Give the results for each solid. [6 marks]

Model answer.

Flame test: dip a clean wire loop into each solid and hold it in a blue Bunsen flame. Lithium carbonate gives a crimson flame, sodium sulfate a yellow flame, and magnesium chloride no distinctive colour. Add dilute hydrochloric acid to each solid: only lithium carbonate fizzes, and the gas turns limewater milky. Dissolve the other two solids in water. Add dilute hydrochloric acid then barium chloride solution: only sodium sulfate gives a white precipitate. Add dilute nitric acid then silver nitrate solution: only magnesium chloride gives a white precipitate. (Sodium hydroxide solution also gives a white precipitate with magnesium chloride that does not dissolve in excess.)
Marked by levels. Level 3 (5–6 marks): tests for the positive and negative ions, with correct reagents and results that identify all three solids. Level 2 (3–4 marks): correct tests and results that identify at least two solids. Level 1 (1–2 marks): one or two relevant tests or results.

Don’t lose marks

- Using sulfuric acid, which adds sulfate ions, instead of hydrochloric acid.
- Mixing up the reagents: silver nitrate is for halides; barium chloride is for sulfates.
- Writing 'goes cloudy' without saying that a white precipitate forms.
- Writing the sulfate ion wrongly. It is SO_4^{2-}.

More tips

Memory tricks

- Barium for sulfate, silver for halides.
- The acid matches the reagent's negative ion: barium chloride with hydrochloric acid; silver nitrate with nitric acid.
- Both tests: acid first (to remove carbonate ions), then the reagent.

Exam technique

- Name both reagents (dilute hydrochloric acid and barium chloride solution) and the result (white precipitate).
- In 6-mark 'identify' questions, go test by test and give the result for every substance.
- Say 'dissolve the solid in water' first: the halide and sulfate tests are done on solutions.

What each grade needs

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

Grade 3

Describe the test for sulfate ions

Add dilute hydrochloric acid, then barium chloride solution, to a solution of the sample.

Grade 3

State the positive result for sulfates

A white precipitate of barium sulfate forms.

Grade 5

Identify a compound using two ion tests

e.g. a blue precipitate with sodium hydroxide and a white precipitate with barium chloride → copper(II) sulfate.

Grade 5

Plan tests to identify several unknown compounds

Choose a test for each positive ion and each negative ion, and give the result for each compound.

Grade 6

Explain why hydrochloric acid is added

It removes carbonate ions, which would also give a white precipitate with barium chloride.

Grade 6

Explain why sulfuric acid cannot be used

It contains sulfate ions, so it would always give a white precipitate.

Grade 7

Write the ionic equation for barium sulfate

$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$.

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