Instrumental methods

4.8.3.6 · Chemical analysis · revision notes

Instrumental methods use machines to detect and identify elements and compounds. This is in GCSE Chemistry only (not Combined Science). You need to state their advantages (accurate, sensitive and rapid) and compare them with the chemical tests in the specification.

Key facts

- Instrumental method = uses an instrument to detect and identify substances
- Accurate = close to the true value
- Rapid = gives results quickly
- Chemical tests: cheap and simple, but less sensitive and unclear with mixtures
- Advantages: accurate, sensitive, rapid
- Sensitive = detects very small amounts
- Can analyse mixtures and measure amounts
- Instruments: expensive, need trained staff

Notes

What they are

- **Instrumental methods** use instruments (machines, often computer-controlled) to detect and identify elements and compounds.
- They are used, for example, in medicine, forensic science, environmental monitoring and checking the quality of products in industry.
- The one you study in detail is flame emission spectroscopy.

Advantages

- **Accurate**: the results are close to the true value.
- **Sensitive**: they can detect and measure very small amounts of a substance, so only a tiny sample is needed.
- **Rapid**: they give results quickly, and many samples can be analysed automatically.
- Many can analyse **mixtures** and measure **how much** of each substance is present.

Compared with chemical tests

- Chemical tests (gas tests, flame tests, precipitate tests) are cheap, use simple equipment and can be done almost anywhere.
- But chemical tests need more of the sample, can give unclear results with mixtures (e.g. masked flame colours), rely on judging colours by eye, and usually show only which ion is present, not how much.
- Instruments are expensive to buy and run, need trained operators, and their results must be compared with reference data for known substances.

How to answer each type of question

State advantages of instrumental methods

1 to 3 marks | **Grade 4**

1. Use the three spec words: accurate, sensitive, rapid.
2. If the question says 'compared with chemical tests', make each point a comparison: 'more sensitive', 'faster'.
3. If there are more marks, explain each point, e.g. 'sensitive, so it detects very small amounts'.

Example. Give **two** advantages of using instrumental methods rather than chemical tests to identify the metal ions in a sample of river water.

Model answer. Any two, 1 mark each: more sensitive / detects very small amounts (1); more accurate (1); faster / more rapid (1); can identify the ions in a mixture (1); can measure how much of each ion is present (1). Maximum 2 marks.

Explain why an instrumental method suits a situation

2 to 3 marks | **Grade 5**

1. Find the clue in the question: a tiny sample, a mixture, a need to know how much, or lots of samples.
2. Match each clue to an advantage: sensitive, analyses mixtures, measures amounts, rapid.
3. Link each point back to the situation.

Example. A forensic scientist has only a tiny speck of paint from a crime scene. The paint contains several different metal compounds.
Suggest why an instrumental method is used to analyse the paint instead of chemical tests.

Model answer. Instrumental methods are sensitive, so they can analyse such a tiny sample (1). They can identify each metal ion in a mixture, where chemical tests (e.g. flame colours) could be masked or unclear (1). They are accurate, which matters when the results are used as evidence (1).

6-mark: evaluate chemical tests and instrumental methods

6 marks **Grade 7**

1. Give advantages AND disadvantages of both approaches.
2. Apply each point to the situation: cost, time, sample size, number of samples, mixtures, amounts.
3. Finish with a justified judgement: which method suits this job, and why.

Example. A water company tests hundreds of drinking water samples every day for very low concentrations of harmful metal ions.
Evaluate the use of chemical tests and instrumental methods for this job. [6 marks]

Model answer.

Chemical tests are cheap and need only simple equipment. However, the metal ions are at very low concentrations, which chemical tests may not detect, and the results depend on judging colours. Chemical tests also do not show how much of each ion is present, and they are slow for hundreds of samples. Instrumental methods are sensitive, so they detect very low concentrations; they are rapid and can be automated for large numbers of samples; they are accurate and measure concentrations; and they can analyse mixtures of ions. Their disadvantages are that the equipment is expensive and needs trained staff. Judgement: instrumental methods are better here, because detecting low concentrations quickly in many samples matters more than the cost.
Marked by levels. Level 3 (5–6 marks): advantages and disadvantages of both, applied to this situation, with a justified conclusion. Level 2 (3–4 marks): some advantages and disadvantages, with limited application or no conclusion. Level 1 (1–2 marks): simple statements, e.g. 'instruments are more accurate'.

Don’t lose marks

- Writing vague answers like 'easier' or 'better'. Use the spec words accurate, sensitive, rapid.
- Confusing sensitive with accurate: sensitive means it detects small amounts; accurate means close to the true value.
- Giving only advantages in an 'evaluate' question. Include disadvantages (cost, trained staff) and a conclusion.
- Saying chemical tests are useless. They work well for single ions in reasonable amounts, cheaply and quickly.

More tips

Memory tricks

- The three advantages, A S R: Accurate, Sensitive, Rapid ('Always Super Rapid').
- Sensitive = small: tiny samples, tiny amounts.
- For evaluate questions, score both methods on a quick grid: cost, speed, sample size, mixtures, amounts.

Exam technique

- In comparisons, use comparative words: 'more sensitive', 'faster', 'cheaper'.
- Tie each point to the context, e.g. 'sensitive, so the tiny speck of paint can be analysed'.
- Evaluate = pros and cons of each method, then a justified judgement at the end.

What each grade needs

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

Grade 3

State what instrumental methods are

Methods that use instruments (machines) to detect and identify elements and compounds.

Grade 4

State the three advantages of instrumental methods

They are accurate, sensitive and rapid.

Grade 5

Explain accurate, sensitive and rapid

Accurate: close to the true value. Sensitive: detects very small amounts. Rapid: gives results quickly.

Grade 5

Compare instrumental methods with chemical tests

Instruments handle tiny samples and mixtures and measure amounts; chemical tests are cheap and simple.

Grade 6

Give disadvantages of instrumental methods

The equipment is expensive, needs trained operators, and results must be compared with reference data.

Grade 7

Evaluate methods for a given situation

Weigh up cost, speed, sample size, number of samples, mixtures and whether amounts are needed, then reach a judgement.

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