Flame emission spectroscopy

4.8.3.7 · Chemical analysis · revision notes

Flame emission spectroscopy is an instrumental method that identifies the metal ions in a solution from their line spectra and measures their concentrations. This is in GCSE Chemistry only (not Combined Science). You interpret spectra or data by comparing them with reference spectra.

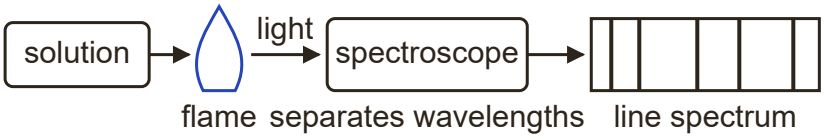
Key facts

- Sample solution in flame → light → spectroscope → line spectrum
- A metal ion is present only if ALL its reference lines appear
- More intense lines = higher concentration
- Better than flame tests: no masking, gives concentrations, more sensitive
- Each metal ion has its own pattern of lines
- Mixture: the spectrum shows the lines of every metal ion present
- Grade 7+ only Calibration graph: intensity against known concentration → read off the unknown

Notes

How it works

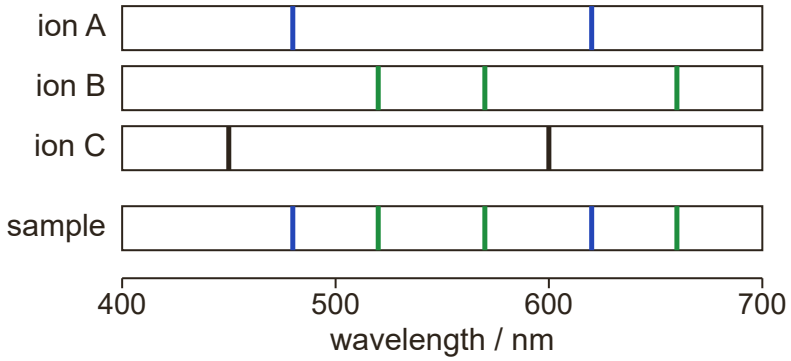
- Flame emission spectroscopy is an instrumental method used to analyse **metal ions in solutions**.
- The sample solution is put into a flame, and the metal ions give out light.
- The light given out is passed through a **spectroscope**, which separates it into different wavelengths.
- The output is a **line spectrum**: a pattern of lines at particular wavelengths.



Each metal ion gives its own pattern of lines.

Identifying metal ions

- Each metal ion gives its own pattern of lines, like a fingerprint.
- Compare the sample's spectrum with **reference spectra** of known metal ions. A metal ion is present only if **all** of its lines appear in the sample's spectrum.

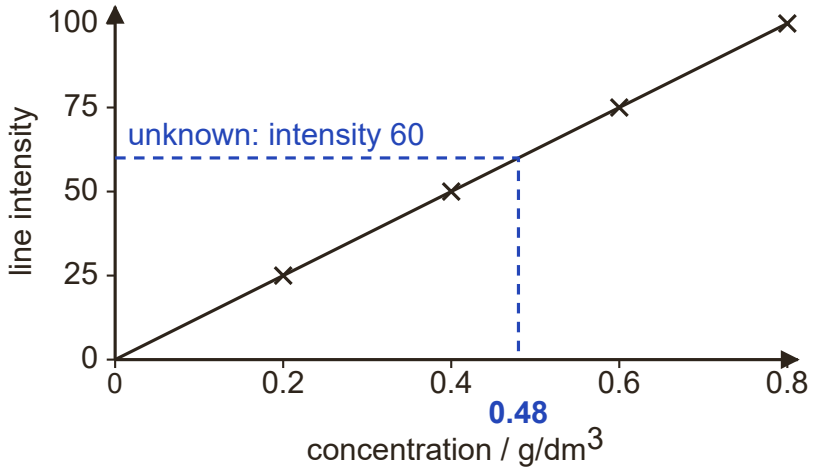


Sample contains A and B: all their lines appear. C is absent: its 450 nm line is missing.

- A mixture gives a spectrum containing the lines of every metal ion present, so each ion can still be identified. With flame tests, one colour can mask another.

Measuring concentration

- The **intensity** (brightness) of the lines depends on the concentration of the metal ion: the higher the concentration, the more intense the lines.
- To find a concentration, measure solutions of known concentration, plot a calibration graph of intensity against concentration, then read off the concentration that matches the unknown's intensity. Grade 7+ only



Plot the standards, draw the line, then read across and down from the unknown.

Grade 7+ only

- Compared with flame tests, it is more sensitive and accurate, works with mixtures and gives concentrations, but the equipment is expensive.

How to answer each type of question

Describe how flame emission spectroscopy is used

2 to 3 marks | Grade 4

1. The sample solution is put into a flame.
2. The light given out is passed through a spectroscope to give a line spectrum.
3. The spectrum is compared with reference spectra of known metal ions.

Example. Describe how flame emission spectroscopy is used to identify the metal ion in a solution.

Model answer. The solution is put into a flame (1). The light given out is passed through a spectroscope to give a line spectrum (1). The spectrum is compared with reference spectra of known metal ions to find the ion whose lines match (1).

Explain why it is better than a flame test

2 to 3 marks | Grade 6

1. Masking: in a flame test one colour can hide another; the line spectrum shows the lines of every ion.
2. Concentration: flame emission spectroscopy measures how much of each ion is present; a flame test does not.
3. Sensitivity: it detects very small amounts and does not rely on judging a colour by eye.

Example. A solution contains sodium ions and lithium ions.
Explain why flame emission spectroscopy is better than a flame test for identifying the metal ions in this solution.

Model answer. In a flame test, the strong yellow colour of sodium ions can mask the crimson colour of lithium ions (1). The line spectrum contains the lines of both ions, so each can be identified by comparing it with reference spectra (1). Flame emission spectroscopy can also measure the concentration of each ion / is more sensitive (1).

Identify metal ions from spectra

2 to 3 marks | **Grade 6**

1. List the wavelengths of all the lines in the sample's spectrum.
2. For each reference ion, check that ALL its lines are in the sample. If any are missing, that ion is not present.
3. Check that every line in the sample is explained by the ions you chose.

Example. The table gives the wavelengths of the lines in the reference spectra of four metal ions, and in the spectrum of solution S.

Spectrum	Wavelengths of lines in nm
Ion P	450, 610
Ion Q	500, 560, 690
Ion R	470, 610, 650
Ion T	560, 590
Solution S	470, 560, 590, 610, 650

Which metal ions are in solution S? Explain your answer.

Model answer. R and T (1). All the lines of R (470, 610, 650 nm) and of T (560, 590 nm) appear in the spectrum of S, and together they account for every line (1). P and Q are not present, because some of their lines (450 nm for P; 500 and 690 nm for Q) are missing (1).

Find a concentration from line intensity

2 to 3 marks | **Grade 7**

1. Use the data for solutions of known concentration (a calibration graph or table).
2. Find the intensity of the unknown, then read across and down to its concentration (or use the proportion).
3. Give the unit.

Example. Solutions of known lithium ion concentration gave these intensities for one line in their spectra.

Concentration in g/dm^3	0.10	0.20	0.30	0.40
Intensity in units	16	32	48	64

A sample of waste water gave an intensity of 40 units for the same line.
Determine the concentration of lithium ions in the sample.

Model answer.

The intensity is proportional to the concentration: 16 units for every 0.10 g/dm^3 (1).

$40 \div 16 \times 0.10 = 0.25$ g/dm^3 (1)

Don’t lose marks

- Saying a metal ion is present when only some of its lines match.
- Forgetting that a mixture's spectrum contains the lines of every ion present.
- Describing a flame test (a colour judged by eye) instead of a line spectrum from a spectroscope.
- Reading a calibration graph the wrong way: start from the intensity, then read off the concentration.

More tips

Memory tricks

- A line spectrum is a fingerprint: a metal ion is only there if every one of its lines is there.
- Tick off the lines: cross out each sample line as you match it. Any line left over means another ion is present.
- Brighter lines = more ions = higher concentration.

Exam technique

- Quote the wavelengths when you explain a match, e.g. 'lines at 470, 610 and 650 nm all appear'.
- For 'describe', use three steps: flame → spectroscope → line spectrum compared with reference spectra.
- If asked for an advantage over flame tests, mention mixtures (no masking) and measuring concentration.

What each grade needs

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

Grade 4 — **Describe how flame emission spectroscopy works**
The sample is put into a flame and the light given out passes through a spectroscope, giving a line spectrum.

Grade 5 — **Identify a metal ion from reference spectra**
Each metal ion gives its own pattern of lines; the ion is present if all its lines appear.

Grade 6 — **Identify every metal ion in a mixture**
A mixture's spectrum contains all the lines of each metal ion present.

Grade 6 — **Explain advantages over flame tests**
It works with mixtures (no masking), measures concentrations and is more sensitive.

Grade 7 — **Relate line intensity to concentration**
The more concentrated the metal ion, the more intense (brighter) its lines.

Grade 7 — **Use calibration data to find concentration**
Use intensities for solutions of known concentration to read off the concentration of the unknown.

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