Flame photometry and calibration graphs

Pearson Edexcel 1CH0 Separate Chemistry · Foundation and Higher

Show your working where needed. Check the worked answers when you finish.

Name _____ Date _____

1. Choose a test

A correctly performed flame test shows no visible colour for a dilute sample. A chemist measures a signal from that sample using a flame photometer. What advantage has the instrument shown? Use the evidence.

2. Time two methods

A chemical test gives the correct result in 8 minutes. An instrumental test gives the same correct result in 30 seconds. Calculate how many times as long the chemical test takes and state one advantage the results show.

3. Identify an ion

Ion P has lines at 423 and 611 nm, Q at 589 and 615 nm, and R at 423 and 671 nm. A sample gives lines at 423 and 671 nm. Identify its ion and explain whether one of these two lines alone is enough.

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4. Identify two ions

Ion S has lines at 404 and 770 nm, T at 554 and 589 nm, and U at 589 and 615 nm.

A mixture of two of these ions gives lines at 404, 589, 615 and 770 nm. Identify the ions and explain how you distinguished them from the other possibility.

5. Accuracy and precision

A standard contains 8.0 mg dm^{-3} of a metal ion. Method A gives 7.7, 7.8 and 7.9 mg dm^{-3}. Method B gives 7.0, 8.0 and 9.0 mg dm^{-3}.

Which method gives the more accurate mean? Which gives the more precise results? Use the data.

6. Use calibration data

A straight calibration line passes through the points (2.0 mg dm^{-3}, 18 units) and (6.0 mg dm^{-3}, 54 units). Estimate the concentration of a sample that gives a reading of 45 units.

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7. Draw a calibration graph

Standard concentration in mg dm^{-3}: 1, 2, 4, 5

Instrument reading in the same order: 9, 16, 30, 37 units

Plot the calibration data, label the axes and draw a line of best fit. Use the line to estimate the concentration of a sample that gives a reading of 23 units.

8. Outside the calibration range

The highest standard gives a reading of 72 units. An unknown sample gives 92 units. A student wants to extend the calibration line to 92 units. Explain the weakness of this method and suggest how to obtain a result in range.

9. Extra challenge · Choose the correct reference and calibration

Ion P has lines at 488 and 680 nm. Ion Q has lines at 488 and 614 nm. An unknown gives lines at 488 and 614 nm.

For concentrations 1.0, 3.0 and 5.0 mg dm^{-3}, the signals at 488 nm are 8, 18 and 28 units for P, and 11, 27 and 43 units for Q. Each calibration is straight over this range. The unknown gives 35 units at 488 nm.

Identify the ion and find its concentration. Explain why the shared 488 nm line is insufficient for choosing a calibration.

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Worked answers

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1. Choose a test

It is more sensitive in this comparison. It can detect the metal ion at a concentration too low to produce a visible flame colour.

2. Time two methods

8 minutes = 480 seconds. The chemical test takes 480 ÷ 30 = 16 times as long. The instrument gives a result more quickly in this comparison.

3. Identify an ion

The ion is R. The 423 nm line could come from P or R. The 671 nm line matches R alone in this reference set.

4. Identify two ions

S accounts for 404 and 770 nm, and U accounts for 589 and 615 nm. The line at 589 nm alone could come from T or U. The 615 nm line identifies U and the 554 nm line for T is absent.

5. Accuracy and precision

Method B gives the more accurate mean for this standard. Its mean is 8.0 mg dm^{-3}, equal to the known value. Method A has mean 7.8 mg dm^{-3}.

Method A is more precise. Its results are closer together, with a range of 0.2 mg dm^{-3} compared with 2.0 mg dm^{-3} for B.

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Worked answers

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6. Use calibration data

45 units is three quarters of the way from 18 to 54 units. Move the same fraction of the way from 2.0 to 6.0 mg dm^{-3}. Concentration = 2.0 + 0.75 × 4.0 = 5.0 mg dm^{-3}.

7. Draw a calibration graph

Put concentration on the horizontal axis and instrument reading on the vertical axis. Plot (1, 9), (2, 16), (4, 30) and (5, 37) and draw a straight line through them. A reading of 23 units is halfway between 16 and 30 units, giving a concentration of 3 mg dm^{-3}.

8. Outside the calibration range

The standards give no evidence that the same relationship continues above 72 units. Dilute the sample by a known factor, measure it again and read the concentration of the diluted sample from the graph if it is now in range. Multiply by the dilution factor.

9. Extra challenge · Choose the correct reference and calibration

The pattern matches Q because Q has a line at 614 nm. On Q's calibration, 35 units is halfway between 27 and 43 units. The concentration is halfway between 3.0 and 5.0 mg dm^{-3}, giving 4.0 mg dm^{-3}.

Both ions give a 488 nm line, but each ion has a different response for a given concentration. The shared wavelength alone cannot tell you which calibration to use. Also, 35 units is beyond P's measured range.

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