HIGHER

C8H Chemical Analysis: Higher Tier Practice

AQA 8462 · Calculator allowed · about 90 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Flame emission spectroscopy is an instrumental method used to identify metal ions in solution and measure their concentration.

State two advantages of using flame emission spectroscopy instead of a simple flame test to identify a metal ion.

(Total for Question 1 is 2 marks)

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2 A student runs a sample through a flame emission spectrometer. The output line spectrum shows sharp lines at wavelengths of 589 nm and a faint line at 767 nm.

Reference data: sodium ions give a strong line at 589 nm; potassium ions give a line at 767 nm; lithium ions give a line at 671 nm.

(a) Identify the two metal ions present in the sample.
(b) State which ion is present in the greater concentration, and explain your reasoning.

(Total for Question 2 is 3 marks)

3 In flame emission spectroscopy, the intensity of the emission line can be compared against a calibration curve produced using solutions of known concentration.

A calibration curve gives the following points for a sodium ion solution: 1.0 mg/dm3 gives an intensity reading of 20 units; 2.0 mg/dm3 gives 40 units; 3.0 mg/dm3 gives 60 units; 4.0 mg/dm3 gives 80 units.

A sample of unknown concentration gives an intensity reading of 68 units. Use the pattern in the calibration data to calculate the concentration of sodium ions in the unknown sample.

(Total for Question 3 is 3 marks)

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4 A formulation is a mixture designed and made to have specific, useful properties, made by combining components in carefully measured quantities.

A 500 g tin of white gloss paint is a formulation containing: 60 % solvent, 25 % pigment (titanium dioxide), 10 % resin (binder), and the remainder is additives.

(a) Calculate the percentage of the paint that is additives.
(b) Calculate the mass, in g, of pigment in the tin.

(Total for Question 4 is 4 marks)

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5 State two reasons why a manufacturer might need to know the exact formulation (recipe) of a product such as a paint or a fuel.

(Total for Question 5 is 2 marks)

6 A student runs thin-layer chromatography (TLC) to test whether a food colouring, sample X, is the same substance as a known reference dye, sample R. Both are run on the same TLC plate using the same solvent.

The solvent front travels 8.0 cm from the baseline. Sample X travels 6.0 cm from the baseline. Sample R travels 6.0 cm from the baseline.

(a) Calculate the Rf value of sample X.
(b) State, giving a reason, whether this evidence alone is enough to conclude that X and R are the same substance.

(Total for Question 6 is 3 marks)

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7 A white solid is suspected to be one of the following: sodium carbonate, potassium carbonate, or calcium sulfate.

A student carries out these tests:

Test 1: adds dilute hydrochloric acid to a sample. Vigorous effervescence is observed and the gas produced turns limewater cloudy.
Test 2: performs a flame test on a fresh sample. A lilac (pale purple) flame colour is observed.

Identify the white solid, using evidence from both tests to justify your answer.

(Total for Question 7 is 4 marks)

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8 Explain why the sample in question 7 should be acidified with dilute nitric acid before testing it with silver nitrate solution to check for a halide ion, rather than testing with silver nitrate straight away.

(Total for Question 8 is 2 marks)

9 Extended response (6 marks).

A water company needs to identify and measure the concentration of metal ion contamination in a river sample. They could use either simple chemical (wet) test-tube methods, such as flame tests and precipitate tests, or an instrumental method, such as flame emission spectroscopy.

Evaluate the use of instrumental methods compared with chemical test-tube methods for this purpose, and recommend which the water company should use.

(Total for Question 9 is 6 marks)

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10 A student wants to check the purity of a sample of aspirin by measuring its melting point.

State what result would indicate the aspirin sample is impure, and explain why an impurity has this effect on melting point.

(Total for Question 10 is 2 marks)

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11 A 2.50 g sample of impure calcium carbonate is reacted with excess dilute hydrochloric acid. The mass of carbon dioxide gas released is measured to be 0.968 g, using the equation $CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$. Relative formula mass of $CaCO_3 = 100$; relative formula mass of $CO_2 = 44$.

Calculate the percentage by mass of calcium carbonate in the impure sample.

(Total for Question 11 is 4 marks)

Mark scheme · C8H Chemical Analysis: Higher Tier Practice

Question 1

- **B1** it is more sensitive and accurate, so it can detect and identify ions correctly even when more than one ion is present in a mixed sample, oe
- **B1** it can be used to measure the concentration of the metal ion in the sample (quantitative data), which a simple flame test cannot do, oe
- **Answer: It is more accurate and can identify ions correctly even in mixtures; it can also give the concentration of the ion, not just its identity.**

Question 2

- **B1** sodium ions (Na+) cao
- **B1** potassium ions (K+) cao
- **B1** (b) sodium is present in the greater concentration, because the line at 589 nm is sharp/strong (more intense) while the line at 767 nm is faint, and line intensity increases with concentration, oe
- **Answer: (a) Sodium ions and potassium ions. (b) Sodium, because its line is much stronger (more intense) and line intensity increases with concentration.**

Question 3

- **M1** identifies the calibration relationship: intensity = 20 x concentration (in mg/dm3), oe
- **M1** substitutes and rearranges: concentration = 68 / 20
- **A1** 3.4 mg/dm3 cao
- **Answer: 3.4 mg/dm3**

Question 4

- **M1** (a) substitutes: 100 - (60 + 25 + 10)
- **A1** (a) 5 % cao
- **M1** (b) substitutes into mass = percentage x total mass: 0.25 x 500
- **A1** (b) 125 g cao
- **Answer: (a) 5 % additives. (b) 125 g of pigment.**

Question 5

- **B1** to make sure the product performs consistently and has the intended properties every time it is made (quality control), oe
- **B1** to control cost/safety, or to comply with legal or industry standards/regulations, oe
- **Answer: For example: to ensure the product performs consistently every time it is made, and to control cost, safety and meet legal standards.**

Question 6

- **M1** substitutes into Rf = distance travelled by substance / distance travelled by solvent: Rf = 6.0 / 8.0
- **A1** 0.75 cao
- **B1** no, matching Rf values in one solvent is good evidence but not conclusive proof, because different substances can coincidentally have the same Rf value in a single solvent; running the plate in a second, different solvent (or comparing directly on the same plate) would give stronger evidence, oe
- **Answer: (a) Rf of X = 0.75. (b) Not conclusive on its own: different substances can share an Rf value by coincidence, so repeating in a second solvent (or running side by side) gives stronger evidence.**

Question 7

- **B1** identifies potassium carbonate cao (accept only if both reasons given)
- **B1** Test 1: effervescence with acid and gas turning limewater cloudy shows the presence of a carbonate ion (carbon dioxide gas is produced), oe
- **B1** Test 2: a lilac flame colour is characteristic of potassium ions, K+, oe
- **B1** combining both results identifies the compound as potassium carbonate (not sodium carbonate, since sodium gives a yellow flame, and not the other two candidates, which do not fizz with acid or do not give a lilac flame), oe
- **Answer: Potassium carbonate. The fizzing and cloudy limewater confirm a carbonate ion; the lilac flame confirms a potassium ion, so together they identify potassium carbonate.**

Question 8

- **B1** if a carbonate ion is present, it would also react with silver nitrate/nitric acid and could form a precipitate, which could be mistaken for a positive halide test, oe
- **B1** adding dilute nitric acid first reacts with (removes) any carbonate ions present, releasing them as carbon dioxide gas, so any precipitate seen afterwards with silver nitrate is a reliable (unambiguous) test for a halide ion, oe
- **Answer: Carbonate ions can also react to give a misleading precipitate. Adding nitric acid first removes any carbonate (as carbon dioxide gas), so a later precipitate with silver nitrate reliably confirms a halide ion.**

Question 9

- **Level 3** (5-6): A balanced, well-reasoned evaluation covering accuracy, sensitivity, speed and quantitative capability of instrumental methods against the simplicity, cost and equipment needs of chemical tests, ending in a justified recommendation.
- **Level 2** (3-4): Some valid points made on both instrumental and chemical methods, but the evaluation is one-sided or the recommendation is not clearly justified by the points made.
- **Level 1** (1-2): Simple, undeveloped statements about instrumental or chemical methods with little comparison or justification.
- **Indicative content:**
  - Instrumental methods (e.g. flame emission spectroscopy) are more sensitive, so they can detect very low (trace) concentrations of contamination that chemical tests might miss.
  - Instrumental methods are quantitative, giving an exact concentration value using a calibration curve, whereas chemical tests are usually only qualitative (they show presence/absence, or give a rough estimate at best).
  - Instrumental methods are generally faster and can be automated, allowing many samples to be tested quickly and consistently, and results are less open to human error/interpretation.
  - Instrumental methods require expensive equipment and trained staff/laboratory facilities, whereas chemical tests use cheap, simple, widely available apparatus and reagents.
  - Chemical tests can still be useful as a quick, low-cost first screening step to check whether a metal ion is present at all before sending a sample for more detailed instrumental analysis.
  - A justified recommendation: for monitoring drinking/river water where accurate, low-level, legally reportable concentrations are needed, instrumental analysis is more appropriate despite the higher cost, because water safety limits depend on precise concentration data.

Question 10

- **B1** an impure sample melts over a range of temperatures and starts melting below the true (sharp) melting point of pure aspirin, oe
- **B1** an impurity disrupts the regular arrangement of particles in the crystal lattice, which lowers the melting point and widens the temperature range over which melting occurs, oe
- **Answer: An impure sample melts below the true melting point and over a range of temperatures, because the impurity disrupts the regular crystal lattice structure, weakening it.**

Question 11

- **M1** calculates moles of CO_2 produced: 0.968 / 44 = 0.022 mol
- **M1** uses 1:1 mole ratio $CaCO_3$: CO_2 to find moles $CaCO_3$ = 0.022 mol, then mass $CaCO_3$ = 0.022 x 100
- **M1** mass of pure $CaCO_3$ = 2.2 g
- **A1** 88 % cao