2.9 Chemical Analysis: 1-hour Pack

AQA 8462 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Two further gases commonly tested for in the laboratory are carbon dioxide and chlorine.

(a) Describe the test for carbon dioxide gas, and state the result of a positive test. **(2)**

(b) Describe the test for chlorine gas, and state the result of a positive test. **(2)**

(Total for Question 1 is 4 marks)

2 Describe the test for sulfate ions in solution and the observation that indicates sulfate is present. Include the reagents needed.

(a) Describe the sulfate test and observation. **(2)**

(Total for Question 2 is 2 marks)

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3 Give the flame-test colours for the following metal ions.

(a) Sodium ion **(1)**

(b) Lithium ion **(1)**

(c) Copper(II) ion **(1)**

(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 Adding a few drops of sodium hydroxide solution to a solution of a metal salt can produce a coloured precipitate of the metal hydroxide, which helps to identify the metal ion present.

(a) State the colour of the precipitate formed when sodium hydroxide solution is added to a solution containing copper(II) ions, Cu^{2+}. **(1)**

(b) State the colour of the precipitate formed with iron(II) ions, Fe^{2+}, and the colour formed with iron(III) ions, Fe^{3+}. **(2)**

(c) Higher tier only. A solution contains either aluminium ions, Al^{3+}, or calcium ions, Ca^{2+}. Both ions form a white precipitate when a small volume of sodium hydroxide solution is first added. Describe a further test, using sodium hydroxide solution, that would distinguish between the two ions, including what would be observed for each. **(3)**

(Total for Question 5 is 6 marks)

6 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 6 is 3 marks)

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7 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 7 is 3 marks)

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8 Higher tier only. Flame emission spectroscopy is an instrumental method used to analyse metal ions in solution.

(a) Name the instrumental method used to identify metal ions in solution and to determine their concentration. **(1)**

(b) Give two advantages of using this instrumental method, rather than flame tests observed by eye, to identify metal ions. **(2)**

(Total for Question 8 is 3 marks)

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9 A white solid could be either sodium carbonate or sodium sulfate. Describe a test to distinguish between sodium carbonate and sodium sulfate.

(Total for Question 9 is 3 marks)

10 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 10 is 6 marks)

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11 A quality-control chemist tests a sports drink formulation by paper chromatography, comparing it against three reference food dyes, L, M and N, run on the same solvent. The solvent front travels 9.60 cm. The single dye spot from the drink travels 6.72 cm. Figure 2 shows the Rf value of each reference dye.

Figure 2: reference dye Rf values

Reference dye	Rf value
L	0.70
M	0.55
N	0.83

(a) Calculate the Rf value of the dye spot from the sports drink. **(2)**

.....

(b) Based on this result, the chemist concludes that the sports drink contains dye L, and only dye L. Evaluate this conclusion, referring to the limitations of using a single solvent in paper chromatography. **(3)**

.....

(Total for Question 11 is 5 marks)

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12 Iron(III) chloride solution reacts with sodium hydroxide solution to form the brown precipitate used to identify Fe^{3+} ions. Write the balanced symbol equation, including state symbols, for this reaction.

(Total for Question 12 is 3 marks)

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Mark scheme · 2.9 Chemical Analysis: 1-hour Pack

Question 1

(a) bubble the gas through limewater (calcium hydroxide solution) oe **B1**

(a) a positive test turns the limewater cloudy/milky (white precipitate of calcium carbonate forms) **B1**

(a) Answer: Bubble the gas through limewater; carbon dioxide turns limewater cloudy.

(b) hold a piece of damp litmus paper (or damp universal indicator paper) at the mouth of the test tube oe **B1**

(b) a positive test bleaches the litmus paper, turning it white **B1**

(b) Answer: Hold damp litmus paper at the mouth of the test tube; chlorine bleaches the paper white.

Question 2

(a) acidify with dilute hydrochloric or nitric acid to remove carbonate **B1**

(a) add barium chloride and a white precipitate of barium sulfate forms **B1**

(a) Answer: Acidify with dilute acid then add barium chloride; a white precipitate of barium sulfate indicates sulfate ions.

Question 3

(a) yellow **B1**

(a) Answer: Yellow

(b) crimson or red **B1**

(b) Answer: Crimson (red)

(c) green or blue-green **B1**

(c) Answer: Green / blue-green

Question 4

(a) substitutes: 100 - (60 + 25 + 10) **M1**

(a) 5 % cao **A1**

(b) substitutes into mass = percentage x total mass: 0.25 x 500 **M1**

(b) 125 g cao **A1**

Answer: (a) 5 % additives. (b) 125 g of pigment.

Question 5

(a) blue (precipitate) **B1**

(a) Answer: Blue precipitate.

(b) Fe^{2+}: green precipitate **B1**

(b) Fe^{3+}: brown (orange-brown) precipitate **B1**

(b) Answer: Fe^{2+} gives a green precipitate; Fe^{3+} gives a brown precipitate.

(c) add an excess (large excess) of sodium hydroxide solution to each sample oe **M1**

(c) if the ion is Al^{3+}, the white precipitate dissolves (redissolves) in the excess sodium hydroxide, forming a colourless solution oe **A1**

(c) if the ion is Ca^{2+}, the white precipitate remains (does not dissolve) even in excess sodium hydroxide **A1**

(c) Answer: Add excess sodium hydroxide solution: if the ion is Al^{3+}, the white precipitate dissolves in the excess to give a colourless solution; if the ion is Ca^{2+}, the white precipitate stays undissolved even in excess sodium hydroxide.

Question 6

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 **B1**

Answer: (a) Sodium ions and potassium ions. (b) Sodium, because its line is much stronger (more intense) and line intensity increases with concentration.

Question 7

substitutes into Rf = distance travelled by substance / distance travelled by solvent: Rf = 6.0 / 8.0 **M1**

0.75 cao **A1**

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 **B1**

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 8

(a) flame emission spectroscopy **B1**

(a) Answer: Flame emission spectroscopy.

(b) it is more sensitive/accurate than judging a flame colour by eye, so it can detect and identify very small amounts of an ion, and can distinguish ions that give similar flame colours oe **B1**

(b) it can identify the concentration of the ion present, and can analyse mixtures of metal ions in a single sample, which is not reliable using a flame test observed by eye oe **B1**

(b) Answer: It is far more sensitive and accurate than judging colour by eye, so it can identify ions present in very small amounts or distinguish ions with similar flame colours; it can also measure the concentration of an ion and analyse mixtures of metal ions in one sample, which a flame test viewed by eye cannot reliably do.

Question 9

add dilute hydrochloric acid to a sample of the solid oe **M1**

if the solid is sodium carbonate, effervescence (fizzing) occurs and a gas is produced that turns limewater cloudy (carbon dioxide) oe **A1**

if the solid is sodium sulfate, no fizzing/gas is produced (sulfate does not react with dilute acid in this way) oe **A1**

Answer: Add dilute hydrochloric acid to a sample of the solid: sodium carbonate fizzes, producing carbon dioxide gas that turns limewater cloudy, whereas sodium sulfate produces no fizzing or gas.

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Question 10

Level 3 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. **5-6**

Level 2 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. **3-4**

Level 1 Simple, undeveloped statements about instrumental or chemical methods with little comparison or justification. **1-2**

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 11

(a) 6.72 / 9.60 **M1**

(a) 0.70 cao **A1**

(a) Answer: 0.70

(b) the calculated Rf value (0.70) does match dye L exactly, so this is reasonable initial evidence that dye L is present oe **M1**

(b) however, the conclusion is not fully certain from one solvent alone, because a different dye (not among L, M, N) could coincidentally share the same Rf value of 0.70 in this solvent oe **M1**

(b) also, only one spot was seen, which shows the drink's dye component is a single (pure) substance, but repeating the chromatography with a second, different solvent would be needed to confirm the match with dye L reliably oe **A1**

(b) Answer: The Rf value matching dye L exactly (0.70) is good initial evidence, but it is not fully conclusive on its own, since a different dye not in the reference table could coincidentally give the same Rf value in this one solvent; the single spot does show the drink contains only one dye, but the identification would only become reliable if the match were confirmed by repeating the chromatography using a second, different solvent.

Question 12

correct formulae for all four species: $FeCl_3$, NaOH, $Fe(OH)_3$, NaCl **M1**

correctly balanced: $FeCl_3 + 3NaOH \rightarrow Fe(OH)_3 + 3NaCl$ **M1**

correct state symbols throughout: $FeCl_3(aq) + 3NaOH(aq) \rightarrow Fe(OH)_3(s) + 3NaCl(aq)$ **A1**

Answer: $FeCl_3(aq) + 3NaOH(aq) \rightarrow Fe(OH)_3(s) + 3NaCl(aq)$

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