C8aD Tests for Ions, Gases and Flame Tests: Exam Drill

AQA 8464 · Calculator allowed · about 90 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A student wants to test a solution for chloride ions.

(a) Name a reagent that the student should add to the sample to test for chloride ions (after acidifying if needed). **(1)**

(b) State the observation that indicates chloride ions are present. **(1)**

(Total for Question 1 is 2 marks)

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2 Describe a laboratory test to show that sulfate ions are present in a solution.

(a) State the reagent to add (after acidifying if needed) and the observation for a positive test. **(2)**

(Total for Question 2 is 2 marks)

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3 A student suspects a solid sample contains carbonate ions.

(a) Give a simple test and the observation that would show carbonate is present. **(1)**

(Total for Question 3 is 1 mark)

4 Give the typical flame colours for the following metal ions when tested in a clean flame.

(a) Sodium ion (Na+) **(1)**

(b) Potassium ion (K+) **(1)**

(c) Calcium ion (Ca2+) **(1)**

(Total for Question 4 is 3 marks)

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5 State the test and observation for each of the following gases.

(a) Oxygen **(1)**

(b) Hydrogen **(1)**

(c) Carbon dioxide **(1)**

(Total for Question 5 is 3 marks)

6 A required-practical style test: A student performs sodium hydroxide tests on three unknown metal ion solutions A, B and C. The observations are shown in the table below.

Observations:
- Solution A: Add NaOH, a blue precipitate forms which does not dissolve in excess NaOH.
- Solution B: Add NaOH, a white precipitate forms that dissolves in excess NaOH to give a colourless solution.
- Solution C: Add NaOH, a green precipitate forms which darkens on standing.

Use these observations to identify the likely metal ion in each solution and state the reasoning.

(a) Identify the metal ion in solution A and give the reason. **(1)**

(b) Identify the metal ion in solution B and give the reason. **(2)**

(c) Identify the metal ion in solution C and give the reason. **(1)**

(Total for Question 6 is 4 marks)

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7 Write the ionic equation for the formation of silver chloride precipitate when silver nitrate reacts with sodium chloride.

(a) Ionic equation **(2)**

(Total for Question 7 is 2 marks)

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8 Gravimetric calculation: 2.00 g of an impure sodium chloride sample is treated with excess silver nitrate. The dry silver chloride produced weighs 3.25 g. Calculate the percentage by mass of chloride in the original sample. Relative atomic masses: Ag 107.87, Cl 35.45. Mr(AgCl) = 143.32.

(a) Show the calculation and give the percentage by mass of chloride in the sample. Give units. **(3)**

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(Total for Question 8 is 3 marks)

9 A 250.0 cm3 solution contains 0.500 g of potassium chloride (KCl). Calculate the concentration of potassium ions (K+) in mol/dm3. Ar: K 39.10, Cl 35.45, Mr(KCl) = 74.55.

(a) Show the calculation and give the concentration of K+ in mol/dm3. **(3)**

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(Total for Question 9 is 3 marks)

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10 A student reports that during several flame tests they sometimes saw an orange flame when testing potassium salts instead of the expected lilac colour.

(a) Give two possible causes for the orange flame and suggest one improvement to the procedure that would reduce this error. **(3)**

(Total for Question 10 is 3 marks)

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11 A student gently heats a carbonate and collects the gas evolved. The gas turns limewater cloudy and does not relight a glowing splint. Identify the gas and give one chemical equation for the decomposition or reaction that produced it.

(a) Identify the gas. **(1)**

(b) Give one chemical equation showing how heat produces this gas from a carbonate (use CaCO3 as an example). **(1)**

(Total for Question 11 is 2 marks)

12 Explain why the sodium flame colour can make it difficult to observe the flame colours of small amounts of calcium or potassium in the same sample, and give one practical method to overcome this problem.

(a) Explain the masking effect and give one method to reduce it. **(3)**

(Total for Question 12 is 3 marks)

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13 Predict the observations when a few drops of dilute ammonia solution are added to a solution containing aluminium ions (Al3+). Include the result for initial addition and after adding excess ammonia.

(a) State the observation on initial addition and after excess ammonia is added. **(2)**

(Total for Question 13 is 2 marks)

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14 Evaluate different methods for identifying metal ions in an unknown mixture: flame tests, tests with sodium hydroxide (precipitation), and instrumental methods (such as atomic emission spectroscopy). In your answer compare accuracy, sensitivity, speed, cost and suitability for mixtures. Conclude which method you would recommend for a forensic laboratory sample and why.

(Total for Question 14 is 6 marks)

15 A student investigates the carbonate content of a marble chip sample. A 0.500 g sample of powdered marble is reacted completely with excess dilute hydrochloric acid and the gas collected. The volume of CO2 collected at room temperature and pressure is 22.4 cm3. Using 24.0 dm3 per mole as the molar volume at room temperature and pressure, calculate the percentage by mass of calcium carbonate (CaCO3) in the sample. Ar: Ca 40.08, C 12.01, O 16.00, Mr(CaCO3) = 100.09.

(a) Show the calculation and give the percentage by mass of CaCO3 in the sample. Include units. **(4)**

(Total for Question 15 is 4 marks)

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16 A 25.0 cm3 sample of an unknown solution was titrated with 0.100 mol/dm3 silver nitrate to determine chloride concentration. The titre required was 18.6 cm3 of AgNO3. Using the reaction Ag+ + Cl- -> AgCl, calculate the concentration of chloride ions in the unknown solution in g/dm3. Ar: Cl 35.45.

(a) Show the calculation and give the concentration of chloride in g/dm3. **(4)**

(Total for Question 16 is 4 marks)

Mark scheme · C8aD Tests for Ions, Gases and Flame Tests: Exam Drill

Question 1

- (a) **B1** silver nitrate (AgNO3) added after acidification with dilute nitric acid, oe
- **(a) Answer: Silver nitrate (AgNO3) after acidifying with dilute nitric acid.**
- (b) **B1** a white precipitate of silver chloride (AgCl) forms, oe
- **(b) Answer: A white precipitate (silver chloride) forms.**

Question 2

- (a) **B1** add barium chloride solution (BaCl2) after acidifying with dilute hydrochloric or nitric acid, oe
- (a) **B1** a white precipitate of barium sulfate (BaSO4) forms, oe
- **(a) Answer: Add barium chloride after acidifying; a white precipitate of barium sulfate forms.**

Question 3

- (a) **B1** add dilute acid and observe effervescence; gas turns limewater cloudy (carbon dioxide), oe
- **(a) Answer: Add dilute acid and collect gas; effervescence and limewater turns cloudy (CO2).**

Question 4

- (a) **B1** bright yellow flame (sodium), cao
- **(a) Answer: Bright yellow flame.**
- (b) **B1** lilac (pale violet) flame, oe
- **(b) Answer: Lilac flame.**
- (c) **B1** orange-red or brick-red flame, oe
- **(c) Answer: Orange-red flame.**

Question 5

- (a) **B1** glowing splint relights in oxygen, oe
- **(a) Answer: A glowing splint relights.**
- (b) **B1** popping sound with lighted splint (hydrogen), oe
- **(b) Answer: Produces a popping sound with a lighted splint.**
- (c) **B1** turns limewater cloudy (white precipitate of calcium carbonate), oe
- **(c) Answer: Turns limewater cloudy.**

Question 6

- (a) **B1** copper(II) ion, Cu2+ (forms a blue precipitate of Cu(OH)2 that is insoluble in excess NaOH), oe
- **(a) Answer: Copper(II) ion, Cu2+, because it gives an insoluble blue precipitate with NaOH.**
- (b) **M1** identifies aluminium ion, Al3+, which gives a white precipitate with NaOH and dissolves in excess NaOH (amphoteric behaviour), oe
- (b) **A1** states that the white precipitate dissolves in excess to give a colourless solution (Al(OH)3 dissolves), cao
- **(b) Answer: Aluminium ion, Al3+, because the white precipitate dissolves in excess NaOH.**
- (c) **B1** iron(II) ion, Fe2+, which gives a green precipitate that darkens on standing due to oxidation to iron(III), oe
- **(c) Answer: Iron(II) ion, Fe2+, because a green precipitate forms and darkens on standing.**

Question 7

- (a) **M1** shows Ag+ and Cl- combining to form AgCl(s): Ag+ + Cl- -> AgCl(s), oe
- (a) **A1** ionic equation correct and state symbol included: Ag+ + Cl- -> AgCl(s) cao
- **(a) Answer: Ag+ + Cl- -> AgCl(s)**

Question 8

- (a) **M1** calculates moles AgCl = 3.25 / 143.32 = 0.02267 mol (or 2.267 x 10^{-2} mol), oe
- (a) **M1** calculates mass of chloride = moles x Ar(Cl) = 0.02267 x 35.45 = 0.8039 g (ecf from previous), oe
- (a) **A1** calculates percentage = (0.8039 / 2.00) x 100 = 40.2% (to three significant figures) cao
- **(a) Answer: 40.2 %**

Question 9

- (a) **M1** calculates moles KCl = 0.500 / 74.55 = 0.006704 mol, oe
- (a) **M1** calculates concentration = moles / volume (dm3) = 0.006704 / 0.250 = 0.02682 mol/dm3, oe
- (a) **A1** gives final value 0.0268 mol/dm3 (to three significant figures) cao
- **(a) Answer: 0.0268 mol/dm3**

Question 10

- (a) **M1** identifies contamination by sodium (or other metal) as a cause which can mask potassium's lilac with intense sodium yellow, oe
- (a) **M1** identifies use of impure wire/loop or residue from previous tests as cause, oe
- (a) **A1** suggests improvement such as cleaning the wire loop thoroughly in acid and a clean flame between tests or using a platinum wire or using cobalt glass to filter sodium yellow, cao
- **(a) Answer: Possible causes: contamination by sodium giving an orange/yellow colour; dirty wire loop or residue from previous tests. Improvement: clean the loop in acid and heat to a clean flame between tests or use cobalt glass to see the lilac colour.**

Question 11

- (a) **B1** carbon dioxide (CO2) cao
- **(a) Answer: Carbon dioxide (CO2).**
- (b) **B1** CaCO3 -> CaO + CO2, cao
- **(b) Answer: CaCO3 -> CaO + CO2**

Question 12

- (a) **M1** states that sodium emits a very intense yellow emission which can overwhelm weaker emissions from calcium or potassium, masking their colours, oe
- (a) **M1** explains that even trace sodium contamination produces a strong yellow that hides other colours, oe
- (a) **A1** gives a practical method such as using cobalt glass to filter out sodium yellow, using a clean platinum wire, or performing a precipitate test to separate ions before testing, cao
- **(a) Answer: Sodium's very intense yellow emission can mask weaker colours from calcium or potassium even at trace levels. Use cobalt glass to filter the yellow, ensure rigorous cleaning of the wire loop, or separate ions by precipitation before flame testing.**

Question 13

- (a) **M1** white precipitate forms on initial addition (Al(OH)3), oe
- (a) **A1** the white precipitate dissolves in excess ammonia to give a colourless solution (complex ion), cao
- **(a) Answer: White precipitate forms initially; the white precipitate dissolves in excess ammonia to give a colourless solution.**

Question 14

- **Level 3** (5-6): Detailed evaluation that compares methods across several criteria (accuracy, sensitivity, speed, cost, suitability for mixtures). Gives justified recommendation and deals with limitations and trade-offs.
- **Level 2** (3-4): Some comparison of methods with limited justification. Makes a recommendation with partial reasoning and mentions at least one advantage and one limitation for two methods.
- **Level 1** (0-2): Simple statements about methods with little or no comparison. Recommendation, if present, is not justified.
- **Indicative content:**
  - Flame tests: quick and cheap, good for identifying dominant alkali metals, low sensitivity, masked by sodium, not suitable for mixtures, qualitative only.
  - Sodium hydroxide tests: useful for distinguishing some metal ions by precipitate colour and solubility in excess, relatively cheap, requires separate tests and pure samples for clarity, some ions give similar colours, provides limited quantification.
  - Instrumental methods (atomic emission / atomic absorption / ICP-OES): high sensitivity and accuracy, can quantify and detect low concentrations and mixtures, fast for many samples once set up, high equipment cost and need for trained operator, destructive sample preparation may be required.
  - Recommendation for forensic laboratory: instrumental methods (ICP-OES or AAS) because of sensitivity, ability to analyse mixtures and provide quantitative results; mention confirmatory role for precipitation or separation methods; note trade-off with cost and time to set up.

Question 15

- (a) **M1** convert volume to moles: moles CO_2 = 22.4 cm^3 = 0.0224 dm^3; moles = 0.0224 / 24.0 = 9.333×10^{-4} mol, oe
- (a) **M1** use 1:1 ratio $CaCO_3$: CO_2 so moles $CaCO_3$ = 9.333×10^{-4} mol, oe
- (a) **M1** mass $CaCO_3$ = moles x Mr = $9.333 \times 10^{-4} \times 100.09$ = 0.0934 g (ecf), oe
- (a) **A1** percentage = (0.0934 / 0.500) x 100 = 18.7% (to three sf) cao
- **(a) Answer: 18.7 %**

Question 16

- (a) **M1** calculates moles Ag^+ used = 0.0186 dm^3 x 0.100 mol/dm^3 = 0.00186 mol, oe
- (a) **M1** uses 1:1 stoichiometry so moles Cl^- in 25.0 cm^3 = 0.00186 mol and concentration = 0.00186 / 0.0250 = 0.0744 mol/dm^3, oe
- (a) **M1** mass concentration = 0.0744 mol/dm^3 x 35.45 g/mol = 2.635 g/dm^3, oe
- (a) **A1** gives final answer 2.64 g/dm^3 (to three significant figures) cao
- **(a) Answer: 2.64 g/dm3**