C4aD Reactivity, Acids and Salts: Exam Drill

AQA 8464 · Calculator allowed · about 95 minutes

Total Marks

Name: _______________________________ Date: ____ / ____ / ______

Answer ALL questions. Show all your working.

1 This question checks three key terms used throughout this topic.

(a) Define an 'acid', in terms of the ions it produces in aqueous solution. **(1)**

(b) Define an 'alkali', in terms of the ions it produces in aqueous solution. **(1)**

(c) Define a 'salt'. **(1)**

(Total for Question 1 is 3 marks)

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2 An iron nail is placed into a test tube of blue copper sulfate solution and left for several minutes.

(a) Describe two observations you would expect to make. **(2)**

(b) Write the balanced symbol equation for the reaction taking place. **(2)**

(c) State, in terms of electrons, what happens to (i) the iron atoms and (ii) the copper ions during this reaction. **(2)**

(Total for Question 2 is 6 marks)

3 Gold is found in the Earth's crust as the native (uncombined) metal. Sodium is never found in the Earth's crust as the native metal; it is always found combined in compounds.

(a) Explain, in terms of reactivity, why gold is found as the native metal. **(2)**

(b) Explain why sodium is never found as the native metal. **(2)**

(Total for Question 3 is 4 marks)

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4 Required practical: Ibrahim prepares copper sulfate crystals by reacting excess copper oxide (an insoluble black powder) with dilute sulfuric acid, then filtering, and finally evaporating and crystallising the resulting solution.

(a) Explain why copper oxide is added in excess (until no more dissolves or reacts). **(2)**

(b) Explain why the leftover (excess) copper oxide must be removed by filtration before crystallisation. **(1)**

(c) Explain why the solution should only be heated to reduce its volume (until crystals start to appear at the edges), rather than evaporated fully to dryness. **(2)**

(Total for Question 4 is 5 marks)

5 Sulfuric acid is exactly neutralised by sodium hydroxide according to the equation: H_2SO_4 + $2NaOH \rightarrow Na_2SO_4 + 2H_2O$. Relative formula masses: H_2SO_4 = 98, NaOH = 40. 4.9 g of sulfuric acid is used.

(a) Calculate the number of moles of sulfuric acid in 4.9 g. **(1)**

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(b) Use the balanced equation and your answer to (a) to calculate the mass of sodium hydroxide needed to exactly neutralise this sulfuric acid. **(3)**

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(Total for Question 5 is 4 marks)

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6 Nitric acid and methanoic acid are both acids, at the same concentration (0.50 mol/dm3). Nitric acid is a strong acid; methanoic acid is a weak acid. Equal volumes of each acid are reacted separately with excess powdered calcium carbonate, and the volume of carbon dioxide gas produced in the first 15 seconds is measured.

(a) Higher tier only. Predict which acid would produce the greater volume of gas in the first 15 seconds, and explain your answer in terms of ion concentration. **(3)**

(b) State whether the total volume of gas produced, once both reactions are fully complete, would be the same or different for the two acids, assuming equal moles of acid are used in each case. **(1)**

(Total for Question 6 is 4 marks)

7 A student compares the reactivity of magnesium, zinc and iron by adding a piece of each metal to separate test tubes containing the same volume and concentration of dilute hydrochloric acid, and timing how long each metal takes to completely react. However, the piece of iron used was noticeably thinner than the pieces of magnesium and zinc, because of how it had been cut.

(a) Suggest why using a thinner piece of iron than the other metals would make this comparison of reactivity invalid. **(2)**

(b) Suggest one way to control this variable so that the comparison is fair. **(2)**

(Total for Question 7 is 4 marks)

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8 A student wants to prepare a pure, dry sample of potassium sulfate crystals. Two methods are suggested.

Method 1: titrate potassium hydroxide solution with dilute sulfuric acid, using a suitable indicator to find the exact volume of acid needed for complete neutralisation, then repeat using the same volumes but without the indicator, and crystallise the resulting solution.

Method 2: add excess solid potassium carbonate to the dilute sulfuric acid, then filter to remove any excess, and crystallise the filtrate.

Evaluate the two methods, and recommend which the student should use to obtain a pure sample of potassium sulfate.

(Total for Question 8 is 6 marks)

9 When magnesium is heated with copper oxide, a reaction occurs: Mg + CuO -> MgO + Cu.

(a) State, in terms of oxygen, which substance is oxidised and which is reduced in this reaction. **(2)**

(b) Write the balanced half equation for the oxidation of magnesium in this reaction. **(2)**

(Total for Question 9 is 4 marks)

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10 The table shows the pH of five solutions.

Solution 1: pH 1
Solution 2: pH 4
Solution 3: pH 7
Solution 4: pH 10
Solution 5: pH 13

For every whole pH unit decrease, the hydrogen ion concentration increases by a factor of 10.

(a) Higher tier only. Calculate how many times greater the hydrogen ion concentration of Solution 1 (pH 1) is compared with Solution 2 (pH 4). **(2)**

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(b) State whether Solution 5 (pH 13) is acidic, neutral or alkaline, and name the ion that is in excess in this solution. **(2)**

(Total for Question 10 is 4 marks)

Mark scheme · C4aD Reactivity, Acids and Salts: Exam Drill

Question 1

- (a) **B1** a substance that releases (forms) hydrogen ions, H^+, when dissolved in water, oe
- **(a) Answer: A substance that releases hydrogen ions, H^+, when dissolved in water.**
- (b) **B1** a soluble base that releases (forms) hydroxide ions, OH^-, when dissolved in water, oe
- **(b) Answer: A soluble base that releases hydroxide ions, OH^-, when dissolved in water.**
- (c) **B1** a compound formed when the hydrogen ion(s) of an acid are replaced by a metal ion (or ammonium ion), oe
- **(c) Answer: A compound formed when the hydrogen ions of an acid are replaced by a metal (or ammonium) ion.**

Question 2

- (a) **B1** the blue colour of the solution fades (becomes paler), oe
- (a) **B1** an orange-brown (pinkish-brown) coating of copper forms on the surface of the iron nail, oe
- **(a) Answer: The blue solution fades in colour, and an orange-brown coating of copper forms on the nail.**
- (b) **M1** correct formulae: $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$
- (b) **A1** equation is already balanced (1 Fe, 1 Cu, 1 S, 4 O on each side) cao
- **(b) Answer: $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$**
- (c) **B1** iron atoms lose electrons (are oxidised) to form Fe^{2+} ions, oe
- (c) **B1** copper ions gain electrons (are reduced) to form copper atoms, oe
- **(c) Answer: Iron atoms lose electrons and are oxidised to Fe^{2+} ions; copper ions gain electrons and are reduced to copper atoms.**

Question 3

- (a) **M1** gold is very unreactive (it is below carbon and hydrogen in the reactivity series), oe
- (a) **A1** so it does not readily react with other substances (e.g. oxygen) in the environment to form compounds, and remains as the free element, oe
- **(a) Answer: Gold is very unreactive, so it does not readily react with substances such as oxygen in the environment and remains as the free metal.**
- (b) **M1** sodium is very reactive (it is near the top of the reactivity series), oe
- (b) **A1** so it reacts readily (rapidly) with other substances in the environment, such as oxygen and water, to form stable compounds, oe
- **(b) Answer: Sodium is very reactive, so it reacts rapidly with substances such as oxygen and water in the environment, forming stable compounds.**

Question 4

- (a) **M1** to make sure that all of the sulfuric acid has fully reacted (is used up), oe
- (a) **A1** so the final product/solution is not contaminated with unreacted (excess) acid, oe
- **(a) Answer: Using excess copper oxide ensures all the sulfuric acid is used up, so the product is not contaminated with unreacted acid.**
- (b) **B1** to leave a clear, pure solution of copper sulfate, so the excess solid copper oxide does not contaminate the crystals that form, oe
- **(b) Answer: Filtering removes the excess solid copper oxide, so it does not contaminate the copper sulfate crystals.**
- (c) **M1** heating fully to dryness/too strongly could decompose the copper sulfate or drive off all the water too quickly, oe
- (c) **A1** instead this would cause small, poorly-formed crystals to form quickly, rather than allowing larger, well-formed pure crystals to grow slowly as the remaining hot saturated solution cools, oe
- **(c) Answer: Evaporating fully to dryness could decompose the product and gives small, poorly-formed crystals; reducing the volume and allowing the hot solution to cool slowly lets larger, well-formed crystals grow.**

Question 5

- (a) **B1** 0.05 mol (4.9 / 98) cao
- **(a) Answer: 0.05 mol**
- (b) **M1** uses the 1:2 mole ratio: moles NaOH = 0.05 x 2 = 0.1 mol, ecf from (a)
- (b) **M1** substitutes: mass = 0.1 x 40
- (b) **A1** 4.0 g cao
- **(b) Answer: 4.0 g**

Question 6

- (a) **M1** predicts nitric acid produces more gas in the first 15 seconds (a faster initial rate), oe
- (a) **M1** explains that nitric acid, as a strong acid, fully ionises (dissociates) in water, producing a higher concentration of H+ ions than the same concentration of the weak methanoic acid, which only partially ionises, oe
- (a) **A1** the higher concentration of H+ ions in the nitric acid causes more frequent successful collisions with the calcium carbonate per second, increasing the initial rate of reaction, oe
- **(a) Answer: Nitric acid produces more gas in the first 15 seconds, because as a strong acid it fully ionises, giving a higher H+ ion concentration than the partially-ionised methanoic acid, so collisions with the calcium carbonate are more frequent.**
- (b) **B1** the same total volume, because the total amount of gas produced depends on the total number of moles of acid (H+ ions) available overall, not on how quickly the acid ionises, oe
- **(b) Answer: The same total volume, because the total gas produced depends on the total moles of acid available, not on how fast it ionises.**

Question 7

- (a) **M1** a thinner piece of metal has a smaller surface area exposed to the acid, oe
- (a) **A1** this would make the iron react more slowly for that reason alone, not necessarily because it is less reactive, giving a misleading (invalid) comparison of reactivity, oe
- **(a) Answer: A thinner piece has a smaller surface area, so it could react more slowly simply because of its size, not its reactivity, making the comparison invalid.**
- (b) **M1** use pieces of metal with the same mass and the same dimensions (surface area) for each metal tested, oe (accept using metal powder of the same, controlled particle size for all three metals)
- (b) **A1** this ensures any difference observed in reaction time is due only to differences in metal reactivity, not surface area, oe
- **(b) Answer: Use pieces of metal with the same mass and surface area for each metal, so any difference in reaction time is due to reactivity alone.**

Question 8

- **Level 3** (5-6): A well-reasoned evaluation that correctly identifies why Method 2 could not work (both reactants are soluble), explains why Method 1 is the appropriate approach for two soluble reactants, and reaches a fully justified recommendation.
- **Level 2** (3-4): Some correct evaluation of at least one method, with a partial explanation of solubility or the role of the indicator, but the comparison is not fully developed or the recommendation not fully justified.
- **Level 1** (1-2): Simple, undeveloped statements about one method, with little or no reference to solubility or purity.
- **Indicative content:**
  - Potassium hydroxide and potassium carbonate are both soluble in water, so 'add excess and filter' cannot work for either of them, because any excess added would simply dissolve rather than remain as a filterable solid
  - This means Method 2 would leave unreacted potassium carbonate dissolved in the filtrate, contaminating the final potassium sulfate crystals; it would not produce a pure sample
  - Method 1 (titration) is the correct approach when both reactants are soluble, because it allows the exact volumes needed for complete neutralisation, with no excess of either reactant, to be found
  - The titration must be repeated without the indicator (using the volumes already found) because the indicator itself is an impurity that would contaminate the crystals if left in the final crystallising solution
  - Method 1 requires more practical skill and careful, repeated volume measurement (titration technique) than simply adding excess and filtering, so it takes longer and is more technically demanding
  - Overall conclusion: Method 1 is the only one of the two that would actually produce pure potassium sulfate, because

Question 9

- (a) **B1** magnesium is oxidised, because it gains oxygen to form magnesium oxide, oe
- (a) **B1** copper oxide is reduced, because it loses oxygen to form copper, oe
- **(a) Answer: Magnesium is oxidised (gains oxygen to form MgO); copper oxide is reduced (loses oxygen to form copper).**
- (b) **M1** correct species: Mg -> Mg2+
- (b) **A1** correctly balanced with electrons: Mg -> Mg2+ + 2e- cao
- **(b) Answer: Mg -> Mg2+ + 2e-**

Question 10

- (a) **B1** identifies the difference in pH as 3 units
- (a) **B1** 1000 times greater (10 x 10 x 10), cao
- **(a) Answer: 1000 times greater**
- (b) **B1** alkaline
- (b) **B1** hydroxide ions, OH-, cao
- **(b) Answer: Alkaline; hydroxide ions (OH-) are in excess.**