2.14 Reactivity, Acids and Salts: 1-hour Pack

AQA 8464 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 The position of a metal in the reactivity series determines how it is extracted from its ore.

(a) Explain why gold is found in the Earth's crust as the uncombined element, rather than as a compound. **(2)**

(b) Iron oxide is reduced by carbon in a blast furnace. Write a word equation for this reaction and state which substance is reduced. **(2)**

(Total for Question 1 is 4 marks)

2 Neutralisation reactions occur between acids and bases, including alkalis.

(a) Write the general word equation for the reaction between an acid and an alkali. **(2)**

(b) Hydrochloric acid reacts with sodium hydroxide solution. Name the salt and the other product formed. **(2)**

(c) Give one everyday use of a neutralisation reaction. **(1)**

(Total for Question 2 is 5 marks)

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3 Acids and alkalis can be defined in terms of the ions they produce in aqueous solution.

(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) Using your answers to (a) and (b), write the overall ionic equation that occurs in any neutralisation reaction. **(1)**

(Total for Question 3 is 3 marks)

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4 Oxidation and reduction can be defined in terms of oxygen or, at a more advanced level, in terms of electrons.

(a) Define reduction in terms of oxygen. **(1)**

(b) Define reduction in terms of electrons. **(1)**

(c) Zinc metal is added to a solution of silver nitrate: $Zn + 2AgNO_3 \rightarrow Zn(NO_3)_2 + 2Ag$. In this reaction, silver ions gain electrons. Write a half equation for this process. **(2)**

(Total for Question 4 is 4 marks)

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5 The table below lists four metals and their position relative to carbon in the reactivity series.

Metal	Position relative to carbon	Method of extraction
Sodium	more reactive than carbon	?
Iron	less reactive than carbon	?
Zinc	less reactive than carbon	?
Gold	far less reactive than carbon (very unreactive)	?

(a) Complete the table to give the method used to extract each metal (reduction with carbon, electrolysis, or found native/uncombined). **(3)**

(b) Explain, in terms of reactivity, why zinc can be extracted using carbon but sodium cannot. **(3)**

(Total for Question 5 is 6 marks)

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6 Required practical: a student prepared pure, dry magnesium sulfate crystals from magnesium oxide (an insoluble base) and dilute sulfuric acid using this method:

1. Measure about 25 cm^3 of dilute sulfuric acid into a beaker and warm it gently.
2. Add magnesium oxide powder to the acid a little at a time, stirring after each addition, until no more of the white powder dissolves and a little excess remains at the bottom.
3. Filter the mixture to remove the unreacted magnesium oxide.
4. Gently heat the filtrate in an evaporating basin until a hot, saturated solution forms, then leave it to cool undisturbed.
5. Filter off the crystals that form and dry them between sheets of filter paper.

(a) Explain why the dilute sulfuric acid is warmed in step 1. **(1)**

(b) Explain why magnesium oxide is added until a little excess remains undissolved. **(1)**

(c) Name the technique used in step 3 to remove the excess, unreacted magnesium oxide. **(1)**

(d) Explain why the solution in step 4 is only heated to the point of forming a hot saturated solution, rather than heated until it is completely dry. **(2)**

(e) Write a balanced symbol equation, with state symbols, for the reaction between magnesium oxide and sulfuric acid. **(2)**

(f) 4.0 g of magnesium oxide is reacted with excess dilute sulfuric acid. Calculate the maximum mass of hydrated magnesium sulfate crystals, $MgSO_4.7H_2O$, that could be obtained. [Relative atomic masses: Mg = 24, S = 32, O = 16, H = 1] **(3)**

(Total for Question 6 is 10 marks)

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7 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 7 is 4 marks)

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8 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 8 is 4 marks)

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9 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 9 is 6 marks)

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Mark scheme · 2.14 Reactivity, Acids and Salts: 1-hour Pack

Question 1

(a) gold is very unreactive / very low down the reactivity series **B1**

(a) it does not readily react with oxygen or other elements to form compounds, so it stays as the metal (oe) **B1**

(a) Answer: Gold is very unreactive, so it does not react with other elements to form compounds and is found naturally as the metal itself.

(b) correct word equation: iron oxide + carbon -> iron + carbon dioxide **M1**

(b) iron oxide is reduced (cao) **A1**

(b) Answer: iron oxide + carbon -> iron + carbon dioxide; iron oxide is reduced.

Question 2

(a) acid + alkali -> salt (oe) **B1**

(a) + water (cao) **B1**

(a) Answer: acid + alkali -> salt + water

(b) sodium chloride **B1**

(b) water **B1**

(b) Answer: Sodium chloride and water.

(c) any valid example, e.g. indigestion remedies neutralising excess stomach acid, or farmers adding lime to neutralise acidic soil (oe, any one) **B1**

(c) Answer: Indigestion remedies contain a base (e.g. magnesium hydroxide) that neutralises excess hydrochloric acid in the stomach.

Question 3

(a) produces H^+ (hydrogen) ions in aqueous solution (cao) **B1**

(a) Answer: An acid produces H^+ ions in aqueous solution.

(b) produces OH^- (hydroxide) ions in aqueous solution (cao) **B1**

(b) Answer: An alkali produces OH^- ions in aqueous solution.

(c) $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ (cao, state symbols not essential) **B1**

(c) Answer: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

Question 4

(a) loss of oxygen (cao) **B1**

(a) Answer: Reduction is the loss of oxygen.

(b) gain of electrons (cao) **B1**

(b) Answer: Reduction is the gain of electrons.

(c) correct species and charge shown: Ag^+ and e- and Ag **M1**

(c) Ag^+ + e- -> Ag correctly balanced (cao) **A1**

(c) Answer: Ag^+ + e- -> Ag

Question 5

(a) sodium: electrolysis **B1**

(a) iron and zinc: reduction with carbon (both needed for this mark) **B1**

(a) gold: found native / as the element (no extraction needed) **B1**

(a) Answer: Sodium: electrolysis. Iron: reduction with carbon. Zinc: reduction with carbon. Gold: found native.

(b) zinc is less reactive than carbon, so carbon can remove the oxygen from (reduce) zinc oxide (oe) **B1**

(b) sodium is more reactive than carbon, so carbon cannot remove the oxygen from sodium oxide (oe) **B1**

(b) therefore sodium must be extracted by a different method (electrolysis) that does not rely on carbon (oe) **B1**

(b) Answer: Zinc is less reactive than carbon so carbon can reduce zinc oxide; sodium is more reactive than carbon so carbon cannot reduce sodium oxide, meaning electrolysis must be used instead.

Question 6

(a) warming increases the rate of reaction, so the magnesium oxide reacts/dissolves faster (oe) **B1**

(a) Answer: Warming increases the rate of reaction between the acid and magnesium oxide.

(b) to make sure all the acid has reacted, so the final salt solution is not contaminated with unreacted (excess) acid (oe) **B1**

(b) Answer: Adding excess magnesium oxide ensures all the sulfuric acid has reacted, leaving no acid in the final product.

(c) filtration **B1**

(c) Answer: Filtration.

(d) heating to complete dryness could decompose the crystals or drive off the water of crystallisation, leaving a powder instead of crystals (oe) **B1**

(d) cooling a hot saturated solution slowly allows larger, well-formed pure crystals to grow (oe) **B1**

(d) Answer: Heating to dryness could decompose the salt or drive off its water of crystallisation; cooling a saturated solution slowly instead allows large, well-formed crystals to grow.

(e) correct formulae shown: $MgO + H_2SO_4 \rightarrow MgSO_4 + H_2O$ **M1**

(e) correctly balanced with state symbols: $MgO(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2O(l)$ (cao) **A1**

(e) Answer: $MgO(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2O(l)$

(f) Mr(MgO) = 24 + 16 = 40, so moles MgO = 4.0/40 = 0.10 mol **M1**

(f) mole ratio MgO : $MgSO_4.7H_2O$ is 1:1, so moles $MgSO_4.7H_2O$ = 0.10 mol (ecf); Mr($MgSO_4.7H_2O$) = 24+32+(4x16)+7x(2x1+16) = 246 **M1**

(f) mass = 0.10 x 246 = 24.6 g (awrt 24.6 g, ecf, cao) **A1**

(f) Answer: 24.6 g

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Question 7

(a) gold is very unreactive (it is below carbon and hydrogen in the reactivity series), oe **M1**

(a) 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 **A1**

(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) sodium is very reactive (it is near the top of the reactivity series), oe **M1**

(b) so it reacts readily (rapidly) with other substances in the environment, such as oxygen and water, to form stable compounds, oe **A1**

(b) Answer: Sodium is very reactive, so it reacts rapidly with substances such as oxygen and water in the environment, forming stable compounds.

Question 8

(a) a thinner piece of metal has a smaller surface area exposed to the acid, oe **M1**

(a) 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 **A1**

(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) 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) **M1**

(b) this ensures any difference observed in reaction time is due only to differences in metal reactivity, not surface area, oe **A1**

(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 9

Level 3 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. **5-6**

Level 2 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. **3-4**

Level 1 Simple, undeveloped statements about one method, with little or no reference to solubility or purity. **1-2**

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 both reactants in Method 2 are soluble, so the student should be recommended to use Method 1 (titration)

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