K8E Chemical Reactions: Depth and Practice

AQA AQA KS3 Science - Chemistry · Calculator allowed · about 90 minutes

Name: ______________________________ Date: ____ / ____ / ______

Answer ALL questions. Show all your working.

1 Quickfire: circle the correct letter for each question.

(a) Which observation is the best evidence that a chemical reaction is taking place? **(1)**

- ☐ A) the substance is broken into smaller pieces
- ☐ B) a permanent colour change and a temperature rise happen together
- ☐ C) the substance changes shape when squashed
- ☐ D) the substance floats on water

(b) A white powder is heated and a colourless gas is given off that turns limewater cloudy. Which gas is most likely being produced? **(1)**

- ☐ A) oxygen
- ☐ B) hydrogen
- ☐ C) carbon dioxide
- ☐ D) nitrogen

(c) In a chemical reaction, the total mass of the products compared with the total mass of the reactants is: **(1)**

- ☐ A) always greater
- ☐ B) always less
- ☐ C) always equal (in a closed system)
- ☐ D) impossible to predict

(d) Which type of reaction always releases energy to the surroundings, shown by a temperature rise? **(1)**

- ☐ A) endothermic
- ☐ B) exothermic
- ☐ C) reversible
- ☐ D) neutral

2 Write a word equation for each reaction described.

(a) Zinc metal is added to blue copper sulfate solution. The blue colour fades and orange-brown copper metal is deposited, leaving colourless zinc sulfate solution. **(2)**

(b) Ethanol burns completely in plenty of oxygen. **(2)**

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3 Balance each symbol equation by writing the correct numbers in front of the formulae.

(a) ___Na + ___O2 -> ___Na2O **(2)**

(b) ___Ca + ___HCl -> ___CaCl2 + ___H2 **(2)**

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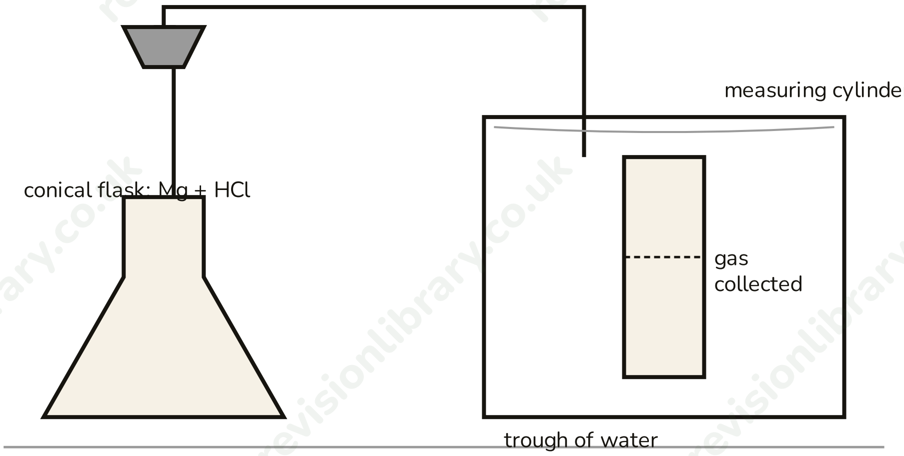
4 15.0 g of solid copper carbonate is heated strongly in an open test tube until it has fully decomposed into black copper oxide and carbon dioxide gas, which escapes. The solid remaining (copper oxide) has a mass of 9.6 g.

(a) Calculate the mass of carbon dioxide gas released during heating. **(2)**

....

(b) Explain what would happen to the reading on a balance if this same reaction were carried out in a stoppered (sealed) flask instead of an open test tube. **(2)**

5 Required practical: Yusuf reacts a coil of magnesium ribbon with excess dilute hydrochloric acid in a conical flask. The hydrogen gas produced is collected in an upside-down measuring cylinder full of water, standing in a trough of water. Results: Time (s): 0, 15, 30, 45, 60, 75. Volume of gas collected (cm3): 0, 18, 30, 38, 42, 42.



(a) Identify the independent variable and the dependent variable in this investigation. **(2)**

(b) Calculate the mean rate of reaction between 0 and 30 seconds, in cm3/s. **(2)**

....

(c) Explain why no more gas is collected after 60 seconds. **(2)**

(d) Predict and explain how using a more concentrated acid, with all other variables unchanged, would affect the shape of the graph. **(2)**

6 A student adds small pieces of different metals to solutions of different metal salts and records whether a reaction happens (shown by a colour change or a solid coating forming). Magnesium + copper sulfate solution: reaction occurs. Copper + magnesium sulfate solution: no reaction. Magnesium + zinc sulfate solution: reaction occurs. Zinc + copper sulfate solution: reaction occurs.

(4)

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7 Classify each process below as exothermic or endothermic.

(a) Natural gas burning in a household boiler. (1)

(b) Copper carbonate thermally decomposing on strong heating. (1)

(c) Neutralisation of an acid with an alkali. (1)

(d) Dissolving solid ammonium chloride in water. (1)

8 Required practical: Amelia adds 5 cm3 portions of sodium hydroxide solution to 20 cm3 of dilute hydrochloric acid in a polystyrene cup, stirring and recording the temperature after each addition. Volume of NaOH added (cm3): 0, 5, 10, 15, 20, 25. Temperature (degrees C): 20.0, 22.5, 25.0, 27.5, 25.0, 23.0.

(a) Identify the volume of sodium hydroxide at which the temperature is highest. **(1)**

(b) Calculate the temperature rise from the start of the experiment to the highest temperature reached. **(1)**

....

(c) Explain why the temperature is highest at this volume of sodium hydroxide. **(2)**

(d) Explain why the temperature falls again after 15 cm3 has been added, even though more sodium hydroxide is still being added. **(2)**

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9 Iron rusts slowly when it is exposed to both water and oxygen at the same time, forming a flaky orange-brown solid called hydrated iron oxide. Iron kept perfectly dry, or kept underwater with no dissolved oxygen, does not rust.

(a) State the two substances that must both be present for iron to rust. **(2)**

(b) Suggest and explain one method used to protect an iron gate from rusting. **(2)**

10 A technician needs to add exactly 23.5 cm3 of dilute acid, drop by drop, to a flask of alkali until it is neutralised, and needs to read the volume added precisely.

(2)

11 Hydrogen peroxide solution decomposes very slowly at room temperature into water and oxygen gas. Adding a small amount of manganese dioxide powder makes it decompose rapidly, with lots of bubbling, but the mass of manganese dioxide is unchanged at the end of the reaction.

(3)

12 Two students each react 2.0 g of calcium carbonate with 20 cm3 of the same dilute hydrochloric acid. Student A uses calcium carbonate as a single large lump. Student B uses the same mass of calcium carbonate crushed into a fine powder.

(3)

13 Explain, in terms of particles and collisions, why increasing the temperature of a reaction mixture increases the rate of reaction.

(3)

14 A colourless solution of lead nitrate is mixed with a colourless solution of potassium iodide. A bright yellow solid immediately forms and settles at the bottom of the test tube.

(3)

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15 State whether each sentence about reaction rates is true or false.

(a) A reaction is always fastest at the very start, when the concentration of reactants is highest. **(1)**

(b) On a graph of volume of gas produced against time, a horizontal (flat) section shows the reaction is still speeding up. **(1)**

(c) A catalyst is used up and needs replacing after every reaction. **(1)**

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16 In an exothermic reaction, the reacting chemicals end up with less stored chemical energy than they started with.

(2)

17 A student wants to find out how the concentration of hydrochloric acid affects the rate of its reaction with magnesium ribbon. She plans to measure the volume of hydrogen gas produced every 10 seconds using a gas syringe, for several different acid concentrations. Describe a method she could use, state at least two variables she should control and why, and explain how her results would show whether increasing concentration increases the rate of reaction. Mention how she should present her results.

(6)

Mark scheme · K8E Chemical Reactions: Depth and Practice

Question 1

- (a) **B1** B cao
- (a) Answer: **B) a permanent colour change and a temperature rise happen together**
- (b) **B1** C cao
- (b) Answer: **C) carbon dioxide**
- (c) **B1** C cao
- (c) Answer: **C) always equal (in a closed system)**
- (d) **B1** B cao
- (d) Answer: **B) exothermic**

Question 2

- (a) **B1** zinc + copper sulfate ->
- (a) **B1** -> zinc sulfate + copper
- (a) Answer: **zinc + copper sulfate -> zinc sulfate + copper**
- (b) **B1** ethanol + oxygen ->
- (b) **B1** -> carbon dioxide + water
- (b) Answer: **ethanol + oxygen -> carbon dioxide + water**

Question 3

- (a) **B1** 4 in front of Na on the left
- (a) **B1** 2 in front of Na2O on the right, fully balanced: 4Na + O2 -> 2Na2O, oe cao
- (a) Answer: **4Na + O2 -> 2Na2O**
- (b) **B1** 2 in front of HCl on the left
- (b) **B1** Ca + 2HCl -> CaCl2 + H2 fully balanced, oe cao
- (b) Answer: **Ca + 2HCl -> CaCl2 + H2**

Question 4

- (a) **M1** 15.0 - 9.6
- (a) **A1** 5.4 (g) cao
- (a) Answer: **5.4 g**
- (b) **B1** the total mass on the balance would stay the same (would not decrease), oe
- (b) **B1** because the carbon dioxide gas cannot escape and is still weighed as part of the sealed system, so no atoms are lost, oe
- (b) Answer: **The total mass would stay the same, because the carbon dioxide produced could not escape and would still be weighed inside the sealed flask.**

Question 5

- (a) **B1** independent variable: time cao
- (a) **B1** dependent variable: volume of (hydrogen) gas collected cao
- (a) Answer: **Independent variable: time. Dependent variable: volume of hydrogen gas collected.**
- (b) **M1** 30 / 30
- (b) **A1** 1.0 (cm3/s) cao
- (b) Answer: **1.0 cm3/s**
- (c) **B1** the reaction has finished because one of the reactants (here, the magnesium) has been completely used up
- (c) **B1** with no magnesium left to react, no more hydrogen gas can be produced, oe
- (c) Answer: **The reaction has finished because all the magnesium has been used up, so no more hydrogen gas can be produced.**
- (d) **B1** the reaction would be faster (steeper initial slope), reaching its final volume sooner
- (d) **B1** because a higher concentration means more acid particles in the same volume, so more frequent collisions with the magnesium surface per second, oe
- (d) Answer: **The graph would rise more steeply and level off sooner, because a more concentrated acid has more particles in the same volume, giving more frequent collisions with the magnesium and a faster reaction.**

Question 6

- **M1** magnesium displaces both copper and zinc, so magnesium is more reactive than both
- **M1** zinc displaces copper, so zinc is more reactive than copper
- **M1** copper does not displace magnesium, confirming copper is the least reactive
- **A1** correct order of reactivity, most to least reactive: magnesium, zinc, copper cao
- Answer: **Order of reactivity (most to least reactive): magnesium, zinc, copper.**

Question 7

- (a) **B1** exothermic cao
- (a) Answer: **Exothermic**
- (b) **B1** endothermic cao
- (b) Answer: **Endothermic**
- (c) **B1** exothermic cao
- (c) Answer: **Exothermic**
- (d) **B1** endothermic cao
- (d) Answer: **Endothermic**

Question 8

- (a) **B1** 15 cm3 cao
- (a) Answer: **15 cm3**
- (b) **B1** 27.5 - 20.0 = 7.5 (degrees C) cao
- (b) Answer: **7.5 degrees C**
- (c) **B1** this is close to (or at) the point where exactly enough sodium hydroxide has been added to neutralise all the acid
- (c) **B1** up to this point, all the sodium hydroxide added is reacting (releasing energy); after this point, extra sodium hydroxide is not reacting and simply dilutes/cools the mixture, oe
- (c) Answer: **This is around the neutralisation point, where all the acid has just been neutralised; up to here, all the alkali added is reacting and releasing energy, but any alkali added after this point is not reacting, so the mixture cools instead.**
- (d) **B1** once all the acid has reacted, any extra sodium hydroxide solution added does not react further
- (d) **B1** the extra solution is at room temperature and dilutes the mixture, so the average temperature falls, oe
- (d) Answer: **After neutralisation, extra sodium hydroxide added does not react; it simply dilutes and cools the mixture, since it is added at room temperature, so the temperature falls.**

Question 9

- (a) **B1** water
- (a) **B1** oxygen (from the air)
- (a) Answer: **Water and oxygen.**
- (b) **B1** a suitable method, e.g. painting the gate, oiling/greasing it, or coating it with a layer of a less reactive metal (e.g. galvanising with zinc)
- (b) **B1** explanation that the coating forms a barrier stopping water and/or oxygen reaching the iron surface, oe
- (b) Answer: **Painting the gate creates a barrier layer that stops water and oxygen reaching the iron surface, so it cannot rust.**

Question 10

- **B1** burette cao
- **B1** a reason, e.g. a burette has a fine-control tap (valve) allowing liquid to be added drop by drop, with a scale precise enough to read small volumes accurately, oe
- Answer: **A burette, because it has a tap that allows the acid to be added drop by drop and a precise scale for reading the volume added.**

Question 11

- **B1** manganese dioxide is acting as a catalyst
- **B1** a catalyst speeds up a chemical reaction without being used up (chemically unchanged) at the end, oe
- **B1** this is why the mass of manganese dioxide is the same before and after the reaction
- Answer: **Manganese dioxide is acting as a catalyst: it speeds up the decomposition of hydrogen peroxide without being used up itself, which is why its mass is unchanged.**

Question 12

- **B1** Student B's reaction (using powder) will be faster
- **B1** the powder has a much larger total surface area than the single lump, for the same mass
- **B1** a larger surface area exposed to the acid means more frequent collisions between acid particles and calcium carbonate particles each second, oe
- Answer: **Student B's powdered calcium carbonate reacts faster, because crushing it into a powder greatly increases its surface area, allowing more frequent collisions with acid particles.**

Question 13

- **B1** particles have more kinetic energy at a higher temperature, so they move faster
- **B1** faster-moving particles collide with each other more often (more frequent collisions)
- **B1** more of the colliding particles also have enough energy to react when they collide, so more collisions are successful, oe
- Answer: **At a higher temperature, particles move faster and have more energy, so they collide more often and a greater fraction of those collisions have enough energy to react successfully, increasing the rate of reaction.**

Question 14

- **B1** names the type of reaction: precipitation
- **B1** names the yellow solid formed: lead iodide
- **B1** states that lead iodide is insoluble in water, which is why it appears as a solid rather than staying dissolved, oe
- Answer: **This is a precipitation reaction: an insoluble yellow solid, lead iodide, forms because it does not dissolve in water.**

Question 15

- (a) **B1** true cao
- (a) Answer: **True**
- (b) **B1** false cao
- (b) Answer: **False**
- (c) **B1** false cao
- (c) Answer: **False**

Question 16

- **B1** the products have less stored chemical energy than the reactants
- **B1** the difference in energy is transferred to the surroundings, usually raising their temperature, oe
- Answer: **The products end up with less stored chemical energy than the reactants; the difference in energy is transferred to the surroundings, which is why the surroundings get hotter.**

Question 17

- **Level 1** (1-2): Simple or partial statements, such as change the concentration and measure the gas, with little or no detail about controls, timing or how results would be presented or interpreted.
- **Level 2** (3-4): A sensible method with at least one clear control variable and a correct statement about the expected trend, but explanation of how the results would be shown or interpreted lacks detail or precision.
- **Level 3** (5-6): A detailed, logically ordered method: prepares a range of acid concentrations, uses a fixed length/mass of magnesium each time, names at least two other control variables with reasons, records gas volume at regular time intervals, and explains clearly how a steeper initial slope (or shorter time to reach a fixed volume) for higher concentrations would show a faster rate, with a description of presenting results in a table and as a rate-against-concentration graph.
- **Indicative content:**
  - Independent variable: concentration of hydrochloric acid, prepared as a range of known values (e.g. by diluting a stock acid with water) while keeping total volume of acid the same each time.
  - Controls: use the same length (or mass) of magnesium ribbon each time, the same total volume of acid, the same temperature (e.g. room temperature, checked with a thermometer), and start timing consistently as soon as the magnesium is added.
  - Method detail: connect the flask to a gas syringe with a bung and delivery tube, start a stopwatch as the magnesium is added, and record the volume of gas collected every 10 seconds until the reaction finishes (volume stops increasing).
  - Repeat each concentration at least twice/three times and calculate a mean, to check for anomalies and improve reliability.
  - How results show the effect: plot volume of gas against time for each concentration on the same axes; a steeper initial gradient, and reaching the maximum (final) volume sooner, shows a faster rate of reaction.
  - Alternatively calculate mean rate for each concentration (e.g. volume in first 10 s / 10 s) and plot rate against concentration; if rate increases as concentration increases, this supports the idea that a higher concentration increases the rate.
  - Presentation: record raw and mean gas volumes and calculated rates in a table, then plot a line graph of volume against time for each concentration (or rate against concentration), labelling axes with units.