2.3 Chemical Reactions: 1-hour Pack

Calculator allowed · about 60 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

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

(3)

2 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. Describe the type of reaction and name the yellow solid formed.

(3)

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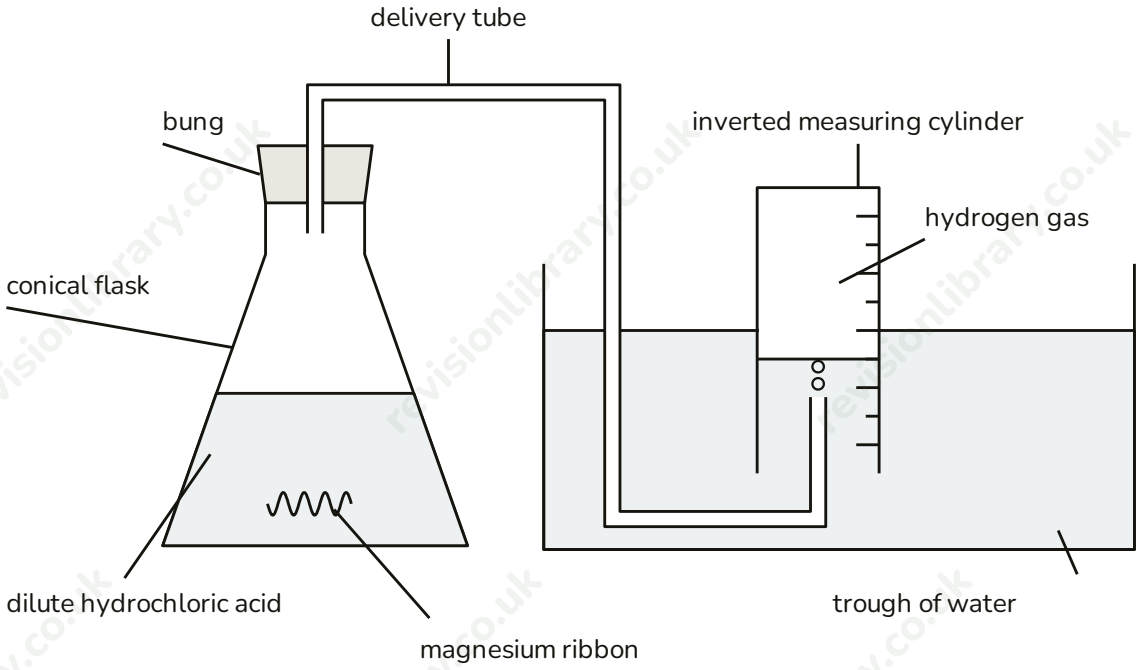
4 Balance each symbol equation by writing the correct numbers in front of the formulae.

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

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

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5 Practical investigation: 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)**

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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. Deduce the order of reactivity of magnesium, zinc and copper from most reactive to least reactive.

(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)**

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8 Two quick-fire questions on spotting chemical reactions.

(a) Which of these is most likely to show that a chemical reaction has taken place? **(1)**

- ☐ A) the substance changes shape
- ☐ B) a gas is given off and bubbles are seen
- ☐ C) the substance dissolves in water
- ☐ D) the substance is cut into smaller pieces

(b) A blue solid is heated and turns into a white solid, giving off a gas. Which observation is best evidence of a chemical change rather than a physical one? **(1)**

- ☐ A) the colour change and gas given off
- ☐ B) the solid getting hot
- ☐ C) the container getting lighter
- ☐ D) the solid staying the same shape

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9 Complete each word equation by filling in the missing word or words.

(a) magnesium + _____ -> magnesium oxide **(1)**

(b) iron + sulfur -> _____ **(1)**

(c) _____ + oxygen -> carbon dioxide + water **(1)**

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10 2.0 cm^3 of a dilute acid exactly neutralises 5.0 cm^3 of an alkali. Assume the same ratio applies whenever these two solutions are mixed.

(a) Calculate the volume of acid needed to exactly neutralise 15.0 cm^3 of the same alkali. **(2)**

(b) A student accidentally adds 8.0 cm^3 of acid to the 15.0 cm^3 of alkali, past the exact neutral point. State what would happen to the pH of the mixture and the colour shown by universal indicator, compared with the exact neutral point. **(2)**

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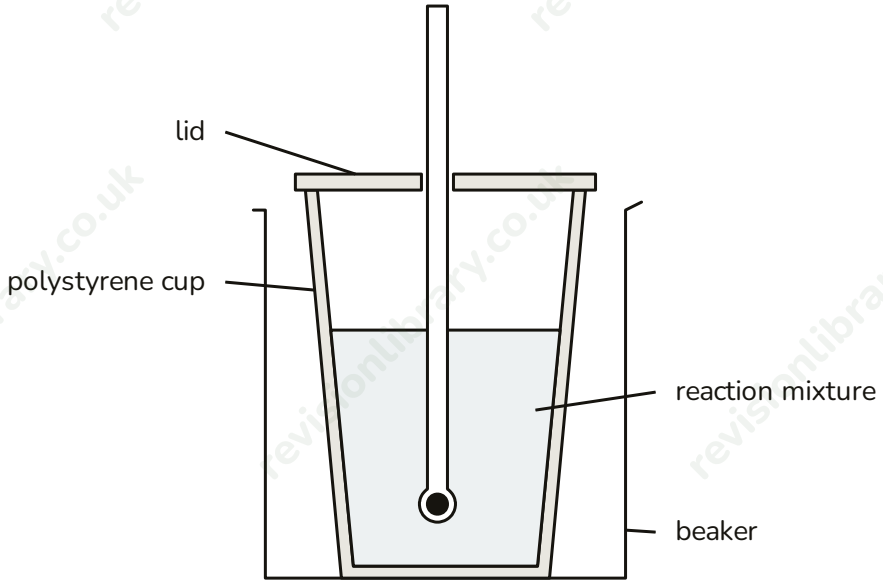
11 10.0 g of solid calcium carbonate is heated strongly in an open test tube until it has fully decomposed into calcium oxide and carbon dioxide gas, which escapes. The solid remaining (calcium oxide) has a mass of 5.6 g.

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

(b) Explain what would happen to the total mass measured on a balance if this same reaction were carried out in a sealed, unbreakable container instead of an open test tube. **(2)**

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12 Practical investigation: Tom investigates temperature changes in reactions. He adds 25 cm^3 of dilute hydrochloric acid to 25 cm^3 of sodium hydroxide solution in a polystyrene cup, and separately dissolves ammonium nitrate solid in water in a second cup, recording the temperature before and after each.



(a) Name the piece of apparatus used to measure the temperature change in this practical. **(1)**

(b) In the acid and alkali experiment, the temperature was 20.0C before mixing and 27.5C at its highest after mixing. Calculate the temperature change. **(1)**

.....

(c) State and explain whether this neutralisation reaction is exothermic or endothermic. **(2)**

.....

.....

(d) In the second experiment, dissolving ammonium nitrate, the temperature fell from 20.0C to 14.0C. Calculate the temperature change and identify the type of reaction. **(2)**

.....

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13 Iron and steel structures can be protected from rusting in several ways: painting the surface, galvanising with a layer of zinc, and sacrificial protection using blocks of a more reactive metal such as magnesium. Compare and evaluate these three methods, and use your knowledge of reactivity and rusting to suggest which would be most suitable for protecting the steel hull of a large ship that spends most of its time in seawater.

(6)

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Mark scheme · 2.3 Chemical Reactions: 1-hour Pack

Question 1

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	B1

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 2

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	B1

Answer: **This is a precipitation reaction: an insoluble yellow solid, lead iodide, forms because it does not dissolve in water.**

Question 3

(a) false cao	B1

(a) Answer: **False**

(b) false cao	B1

(b) Answer: **False**

(c) false cao	B1

(c) Answer: **False**

Question 4

(a) 4 in front of Na on the left	B1
(a) 2 in front of Na_2O on the right, fully balanced: $4Na + O_2 \rightarrow 2Na_2O$, oe cao	B1

(a) Answer: **$4Na + O_2 \rightarrow 2Na_2O$**

(b) 2 in front of HCl on the left	B1
(b) $Ca + 2HCl \rightarrow CaCl_2 + H_2$ fully balanced, oe cao	B1

(b) Answer: **$Ca + 2HCl \rightarrow CaCl_2 + H_2$**

Question 5

(a) independent variable: time cao	B1
(a) dependent variable: volume of (hydrogen) gas collected cao	B1

(a) Answer: **Independent variable: time. Dependent variable: volume of hydrogen gas collected.**

(b) 30 / 30	M1
(b) 1.0 (cm3/s) cao	A1

(b) Answer: **1.0 cm^3/s**

(c) the reaction has finished because one of the reactants (here, the magnesium) has been completely used up	B1
(c) with no magnesium left to react, no more hydrogen gas can be produced, oe	B1

(c) Answer: **The reaction has finished because all the magnesium has been used up, so no more hydrogen gas can be produced.**

(d) the reaction would be faster (steeper initial slope), reaching its final volume sooner	B1
(d) because a higher concentration means more acid particles in the same volume, so more frequent collisions with the magnesium surface per second, oe	B1

(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

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	M1
correct order of reactivity, most to least reactive: magnesium, zinc, copper cao	A1

Answer: **Order of reactivity (most to least reactive): magnesium, zinc, copper.**

Question 7

(a) exothermic cao	B1

(a) Answer: **Exothermic**

(b) endothermic cao	B1

(b) Answer: **Endothermic**

(c) exothermic cao	B1

(c) Answer: **Exothermic**

(d) endothermic cao	B1

(d) Answer: **Endothermic**

Question 8

(a) B cao	B1

(a) Answer: **B**

(b) A cao	B1

(b) Answer: **A**

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Question 9

(a) oxygen cao **B1**

(a) Answer: **oxygen**

(b) iron sulfide, oe cao **B1**

(b) Answer: **iron sulfide**

(c) methane (or another named hydrocarbon fuel), oe cao **B1**

(c) Answer: **methane**

Question 10

(a) 15.0 x (2.0 / 5.0), or equivalent scaling/ratio method **M1**

(a) 6.0 (cm3) cao **A1**

(a) Answer: **6.0 cm³**

(b) the pH would fall below 7 (the mixture becomes acidic overall), oe **B1**

(b) universal indicator would turn an acidic colour (orange/red) instead of green, oe **B1**

(b) Answer: **The mixture would become acidic (pH below 7), and universal indicator would turn orange or red instead of green.**

Question 11

(a) 10.0 - 5.6 **M1**

(a) 4.4 (g) cao **A1**

(a) Answer: **4.4 g**

(b) the total mass would stay the same (would not decrease), oe **B1**

(b) because the carbon dioxide gas cannot escape and is still weighed as part of the sealed system, so no atoms are lost, oe **B1**

(b) Answer: **The total mass would stay the same, because the carbon dioxide gas produced could not escape and would still be weighed inside the sealed container.**

Question 12

(a) thermometer cao **B1**

(a) Answer: **Thermometer**

(b) 7.5 (C) cao **B1**

(b) Answer: **7.5 C increase**

(c) exothermic cao **B1**

(c) the temperature increased, showing energy was transferred from the reacting chemicals to the surroundings (the solution), oe **B1**

(c) Answer: **Exothermic; the temperature rose by 7.5C, showing that energy was released to the surroundings during neutralisation.**

(d) 20.0 - 14.0 **M1**

(d) 6.0 (C) decrease; endothermic cao **A1**

(d) Answer: **6.0 C decrease; endothermic**

Question 13

Level 1 A basic, undeveloped answer. States that one or more methods can prevent rusting, with little or no scientific detail on how they work and no reasoned comparison or recommendation. **1-2**

Level 2 Describes how at least two of the three methods work (e.g. barrier methods and/or sacrificial protection) with some correct scientific detail. Attempts a comparison or recommendation, but reasoning is limited or only partly linked to the ship's hull scenario. **3-4**

Level 3 Accurately describes how all three methods work, correctly using ideas of barrier protection and sacrificial protection linked to reactivity. Gives a clearly justified evaluation of which method (or combination) is most suitable for a ship's hull, with reasoning based on the seawater environment and practicality of maintenance. **5-6**

Indicative content:

- Painting forms a barrier that stops water and oxygen reaching the iron surface, preventing rusting.
- Painting is cheap and gives a choice of colour/appearance, but the coating is easily scratched or damaged, and once broken the exposed iron underneath will rust; it needs regular reapplication.
- Galvanising coats the iron with a layer of zinc, which acts as a barrier but also as sacrificial protection because zinc is more reactive than iron.
- Because zinc is more reactive, if the zinc coating is scratched the zinc reacts with water and oxygen instead of the iron, so the iron underneath is still protected even when the coating is damaged.
- Sacrificial protection attaches blocks of a metal more reactive than iron, such as magnesium or zinc, directly onto the structure.
- The more reactive metal corrodes (reacts) in place of the iron, because it loses electrons more easily/reacts more readily with water and oxygen than iron does; the blocks need to be checked and replaced periodically as they wear away.
- For a ship's hull in seawater, paint alone is not ideal because the coating is likely to be damaged by waves, floating debris and general wear, quickly exposing bare iron to constant seawater.
- Sacrificial protection (often combined with painting) is well suited to a ship's hull because it continues to protect the iron even where the surface coating has been scratched or worn away, and sacrificial blocks can be inspected and replaced without needing to fully repaint the hull.
- A justified conclusion should recognise that using more than one method together (e.g. paint plus sacrificial anodes) gives the most reliable long-term protection for a hull that is constantly exposed to seawater.

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