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# GCSE (9–1) Chemistry B (Twenty First Century Science)

**J258/03** Breadth in Chemistry (Higher Tier)

## Thursday 17 May 2018 – Morning

### Time allowed: 1 hour 45 minutes

*703012092 3*

**You must have:**
- the Data Sheet (for GCSE Chemistry B (inserted))
- a ruler (cm/mm)

**You may use:**
- a scientific or graphical calculator
- an HB pencil

*J258/03*

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| First name | | | | | | | | | |
| Last name | | | | | | | | | |
| Centre number | | | | | | Candidate number | | | | |

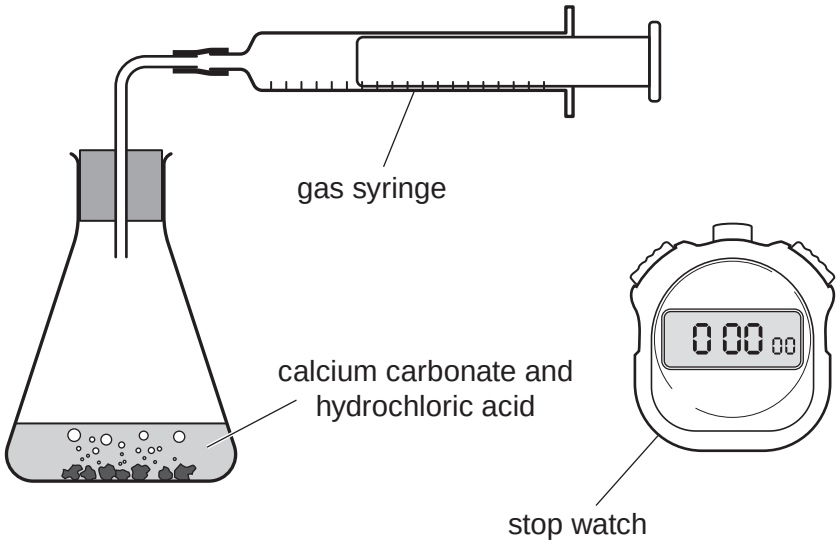
**INSTRUCTIONS**
- The Data Sheet will be found inside this document.
- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number and candidate number.
- Answer **all** the questions.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined page(s) at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the barcodes.

**INFORMATION**
- The total mark for this paper is **90**.
- The marks for each question are shown in brackets **[ ]**.
- This document consists of **24** pages.

Answer **all** the questions.

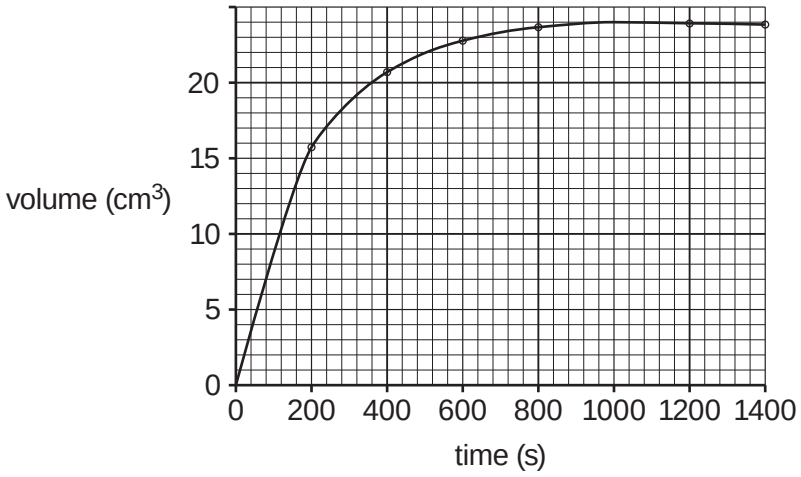
**1** Calcium carbonate reacts with excess hydrochloric acid to make carbon dioxide.

Here is the apparatus Jack uses to investigate the reaction.




Jack records the volume of carbon dioxide made every 200 seconds.

Here is a graph of his results.




**(a)** Use the graph to calculate the rate of reaction over the first 100 s.

Rate = ..... $cm^3/s$ **[2]**

**(b)** Amaya wants to repeat Jack's experiment.

She uses the same mass of calcium carbonate.

She uses the same volume and concentration of hydrochloric acid.

Which **two** other factors does she need to keep the same?

1 .....

2 .....

**[2]**

**(c)** Jack repeats his experiment with more concentrated hydrochloric acid.

He keeps **all** other factors the same. The rate of reaction is faster.

Explain why.

Write about particles in your answer.

.....

.....

..... **[2]**

**(d)** 0.10 g of calcium carbonate makes 24 $cm^3$ of carbon dioxide.

Jack uses 0.070 g of calcium carbonate.

What volume of carbon dioxide does he make?

Give your answer to **2** significant figures.

Volume = ..... $cm^3$ **[3]**

**2** Fizzy water can be found naturally.

The water is fizzy because it contains dissolved carbon dioxide gas. The carbon dioxide comes from the decomposition of rocks that contain carbonate compounds.

One compound found in rocks is magnesium carbonate.

Ali investigates the decomposition of magnesium carbonate by heating a small amount in a test tube. This is the equation for the reaction.

$MgCO_3(s) \longrightarrow MgO(s) + CO_2(g)$

**(a)** Ali weighs the test tube before and after heating.

The mass of the test tube after heating is less.

Ali says that this means the **law of conservation of mass** is not correct.

Explain why Ali is **wrong**.

.....

.....

..... **[2]**

**(b)** Calculate the atom economy for the production of carbon dioxide in this reaction.

Use the formula: atom economy = $\frac{\text{mass of atoms in desired product}}{\text{total mass of atoms in reactants}} \times 100\%$

Give your answer to **1** decimal place.

Atom economy = ..... % **[4]**

**(c)** In theory, 42.0 g of $MgCO_3$ loses 22.0 g of carbon dioxide when it completely decomposes.

Ali heats 4.2 g of $MgCO_3$.

**(i)** Calculate the mass of carbon dioxide lost when 4.2 g of $MgCO_3$ completely decomposes.

Mass = ..... g **[1]**

**(ii)** In Ali's experiment, the mass of carbon dioxide lost is 1.8 g.

Calculate the percentage yield of carbon dioxide in Ali's experiment.

Percentage yield = ..... % **[1]**

**(d)** Magnesium oxide, MgO, is an ionic compound.

Draw a 'dot and cross' diagram for the ions in magnesium oxide.

Show the outer electron shells only.

**[2]**

**3** The table shows the properties of three polymers.

| Polymer | Relative breaking strength | Flexibility | Temperature at which it softens (°C) |
|---|---|---|---|
| **A** | very high | fairly flexible | 250 |
| **B** | low | very flexible | 70 |
| **C** | fairly low | stiff | 150 |

**(a)** A firm wants to make cups to hold boiling water.

Discuss the suitability of **each** polymer.

.....

.....

.....

.....

..... **[3]**

**(b)** Which of polymers **A**, **B** and **C**, has the **weakest** intermolecular forces?

Give a reason for your answer.

Polymer .....

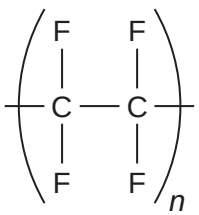
Reason .....

.....

**[2]**

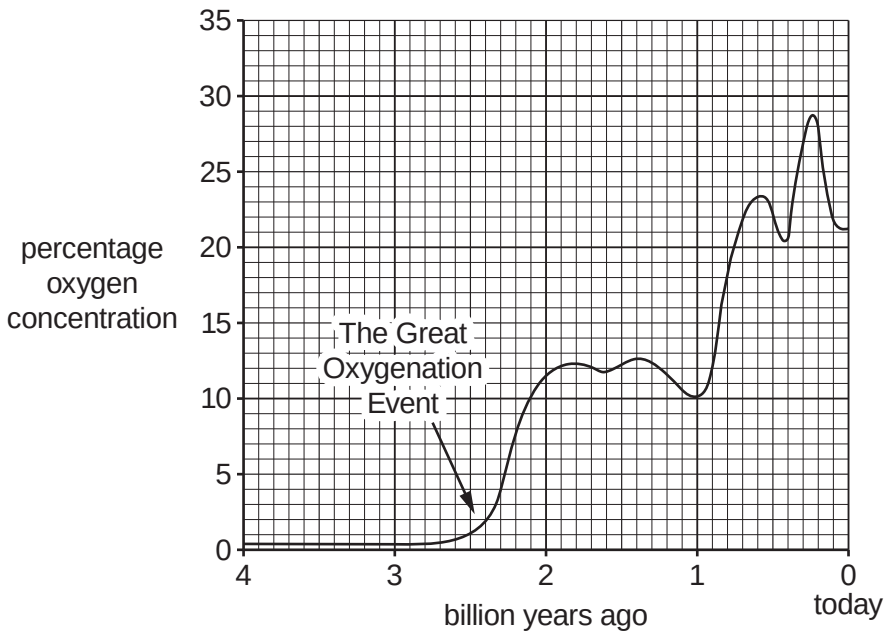
**(c)** Polymer **A** is an addition polymer.

Draw the structure of the monomer that forms polymer **A**. **[1]**

| Repeating unit of polymer A | Structure of monomer |
|---|---|
|  | |

**4** The percentage of oxygen gas in the Earth's atmosphere has generally increased over time.

This graph shows the percentage oxygen concentration in the Earth's atmosphere over the last 4 billion years.




**(a) (i)** Describe how the oxygen content of the Earth's atmosphere has changed during the last four billion years.

.....

.....

..... **[2]**

**(ii)** The concentration of oxygen has increased from two billion years ago to today.

By what factor has it increased?

Factor = ..... **[1]**

**(iii)** Explain what caused the sudden increase in oxygen concentration 2.5 billion years ago and explain why the concentration did not continue to rise.

.....

.....

..... **[2]**

**(b)** Iron pyrites in rocks was oxidised to compounds like iron(III) sulfate by the oxygen in the early atmosphere.

Complete the **balanced chemical** equation for this reaction.

..... $FeS_2$ + ..... $O_2$ $\rightarrow$ $Fe_2(SO_4)_3$ + $SO_2$

**[1]**

**5** Ling carries out an investigation of the halogens.

**(a)** Ling reacts some chlorine solution with a solution of potassium bromide.

The solution turns brown.

Explain why.

Include an **ionic** equation in your answer.

.....

.....

.....

..... **[3]**

**(b)** Ling sees that the element astatine, At, is below iodine in Group 7.

She makes some predictions about astatine.

Which predictions about astatine are correct?

Tick (✓) **two** boxes.

- Astatine is white. ☐
- Astatine is a gas. ☐
- Astatine reacts with sodium to form NaAt. ☐
- Astatine is less reactive than iodine. ☐

**[1]**

**6** Nanoparticles of cerium oxide, $CeO_2$, are added to diesel fuel.

They act as a catalyst for the combustion of the fuel.

**(a)** Describe a property of nanoparticles that makes them good catalysts.

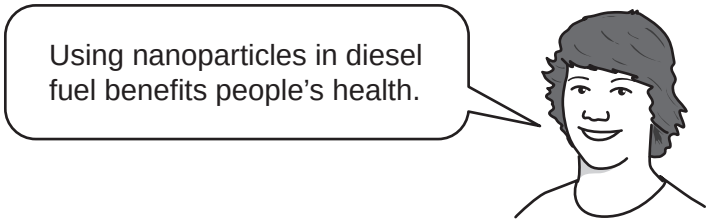
.....

.....

..... **[1]**

**(b)** The addition of nanoparticles allows more complete combustion of the fuel.

Kai talks about nanoparticles in diesel fuel.




Evaluate Kai's statement.

In your answer give arguments **for** and **against** the use of nanoparticles.

.....

.....

.....

.....

..... **[3]**

**(c)** $CeO_2$ contains $O^{2-}$ ions.

Explain how the formula shows that Ce is present as $Ce^{4+}$ ions.

.....

..... **[1]**

**(d)** A nanoparticle has a volume of $8 \times 10^{-27}$ m.

A molecule has a volume of $4 \times 10^{-30}$ m.

Estimate how many **moles** of this molecule there are in the nanoparticle.

Number of moles = ..... mol **[3]**

**7** This is an equation for a reaction that occurs in a lightning flash.

$N_2 + O_2 \rightleftharpoons 2NO$

Very high temperatures are needed.

**(a)** **(i)** Explain how you can tell that this equation refers to an equilibrium.

..... **[1]**

**(ii)** Use ideas about rates to explain what is happening when the reaction reaches dynamic equilibrium.

.....

..... **[2]**

**(b)** Scientists can use this reaction to make nitrogen compounds from gases in the air.

**(i)** Suggest a use for these compounds.

.....

..... **[1]**

**(ii)** The scientists discuss increasing the pressure on the reaction.

Describe and explain the effect on the equilibrium position.

.....

.....

..... **[2]**

**(c)** There are several ways of making nitrogen compounds from nitrogen gas in industry.

Give **two** reasons why scientists may choose this reaction and **one** against.

Reason for .....

.....

Reason for .....

.....

Reason against .....

.....

**[3]**

**8** Manganese is a metallic element.

**(a)** Manganese is made by heating manganese oxide, $MnO_2$, with carbon.

Carbon monoxide is also formed.

**(i)** Write a **balanced chemical** equation for this reaction.

Include state symbols in your equation.

..... **[2]**

**(ii)** Explain why carbon can be used to extract manganese from its compounds.

Use ideas about reactivity and reduction in your answer.

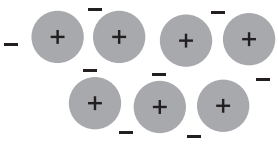
.....

.....

..... **[2]**

**(b)** Explain how the atoms are held together in a metal.

Refer to this diagram in your answer.



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..... **[3]**

**9** Jane has a sample of a white powder, compound **A**.

**(a)** Jane carries out a flame test on compound **A** and sees a lilac flame.

What can Jane conclude about compound **A**?

..... **[1]**

**(b)** Jane looks at the emission spectrum of compound **A**.

**(i)** Describe what an emission spectrum looks like.

.....

.....

..... **[2]**

**(ii)** Describe how Jane could use the spectrum to confirm her answer to **(a)**.

.....

..... **[1]**

**(c)** Jane has a solution of compound **B**, sodium sulfate, $Na_2SO_4$.

She adds acidified barium chloride solution, $BaCl_2$, to a solution of compound **B**.

**(i)** What does she **see** when she does this?

.....

..... **[1]**

**(ii)** Write a **balanced chemical** equation for the reaction that occurs.

..... **[2]**

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**10** Hydrogen for use as a fuel can be made by the electrolysis of water.

**(a)** Which statements about the electrolysis of water are correct?

Ticks (✓) **two** boxes.

The equation for the formation of hydrogen gas is $2H^+ + 2e^- \rightarrow H$. ☐

Hydrogen is produced at the cathode. ☐

Water contains $H^+$ and $OH^-$ ions. ☐

Hydrogen ions are oxidised. ☐

**[1]**

**(b)** This is an equation for the overall reaction that happens when water is electrolysed.

$2H–O–H \rightarrow 2H–H + O=O$

| Bond | Energy change (kJ/mol) |
|---|---|
| H–H | 434 |
| O=O | 498 |
| O–H | 464 |

Use data in the table to calculate the energy needed to break and make bonds during the reaction.

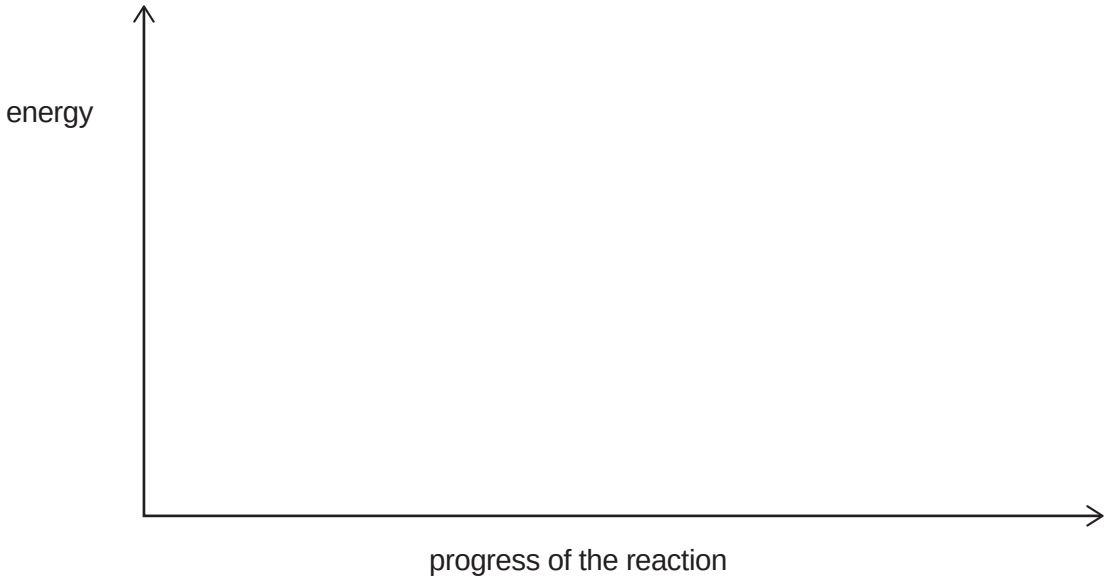
Use your answers to calculate the energy change of the reaction.

Energy change = ..... kJ/mol **[3]**

**(c)** Complete the reaction profile for the electrolysis of water.

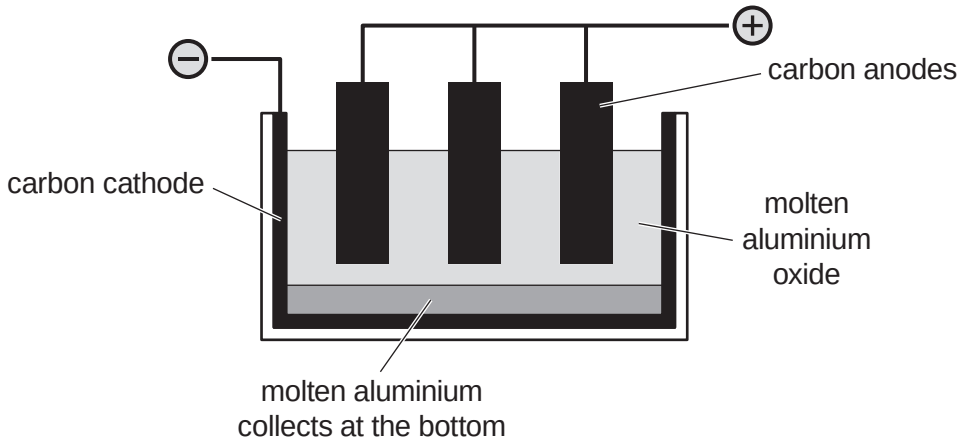
Use these words to label the reaction profile.

**hydrogen** **oxygen** **water** **activation energy**




**[3]**

**11** Aluminium is made by the electrolysis of molten aluminium oxide.




**(a)** The ions present in molten aluminium oxide are $Al^{3+}$ and $O^{2-}$.

Write **half-equations** for the formation of aluminium and oxygen in the electrolysis cell.

Formation of aluminium .....

Formation of oxygen .....

**[2]**

**(b)** Aluminium oxide does not conduct electricity when it is solid.

It conducts electricity when it is molten.

Explain why.

.....

.....

..... **[3]**

**(c)** This is an equation for the overall reaction in the electrolysis cell.

$2Al_2O_3 \rightarrow 4Al + 3O_2$

1.0 kg of aluminium is made in the cell.

Calculate the volume of oxygen (in $dm^3$ at room temperature and pressure) that is made.

Assume one mole of gas has a volume of 24 $dm^3$ at room temperature and pressure.

Volume = ..... $dm^3$ **[4]**

**12** Sulfuric acid is used in car batteries.

Mia has a sample of car battery acid that is diluted to $\frac{1}{100}$ of its original concentration.

She measures the concentration of this acid by titration.

**(a)** This equation shows what happens when pure sulfuric acid is mixed with water.

$H_2SO_4(l) \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$

Explain how this equation shows that sulfuric acid is a **strong** acid.

.....

..... **[1]**

**(b)** Mia does a titration.

She puts the sulfuric acid in a burette.

She measures out 25.0 $cm^3$ of 0.100 $mol/dm^3$ NaOH.

**(i)** She wants to measure the 25.0 $cm^3$ of NaOH as accurately as possible.

Which piece of apparatus should Mia use?

Put a (ring) around the correct answer.

**conical flask** **100 $cm^3$ measuring cylinder** **volumetric pipette** **volumetric flask**

**[1]**

**(ii)** Calculate the number of moles in 25.0 $cm^3$ of 0.100 $mol/dm^3$ NaOH.

Use the equation: concentration ($mol/dm^3$) = number of moles of solute ÷ volume ($dm^3$)

Number of moles = ..... mol **[3]**

**(iii)** This is an equation for sulfuric acid reacting with NaOH.

$2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

Mia finds that 24.5 $cm^3$ of $H_2SO_4$ reacts exactly with the NaOH.

Calculate the concentration of the sulfuric acid in the burette in $mol/dm^3$.

Use the equation: concentration ($mol/dm^3$) = number of moles of solute ÷ volume ($dm^3$)

Give your answer to **2** significant figures.

Concentration = ..... $mol/dm^3$ **[3]**

**END OF QUESTION PAPER**

## ADDITIONAL ANSWER SPACE

If additional space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margin(s).