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Monday 20 June 2022 – Morning

GCSE (9–1) Chemistry A (Gateway Science)

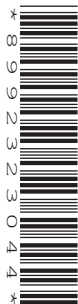**J248/04** Paper 4 (Higher Tier)

Time allowed: 1 hour 45 minutes

You must have:
* a ruler (cm/mm)
* the Data Sheet for GCSE (9–1) Chemistry A (inside this document)

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

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number ☐☐☐☐☐   Candidate number ☐☐☐☐

First name(s) _____

Last name _____

INSTRUCTIONS
* Use black ink. You can use an HB pencil, but only for graphs and diagrams.
* Write your answer to each question in the space provided. If you need extra space use the lined pages at the end of this booklet. The question numbers must be clearly shown.
* Answer **all** the questions.
* Where appropriate, your answer should be supported with working. Marks might be given for a correct method, even if the answer is wrong.

INFORMATION
* The total mark for this paper is **90**.
* The marks for each question are shown in brackets **[ ]**.
* Quality of extended response will be assessed in questions marked with an asterisk (*).
* This document has **32** pages.

ADVICE
* Read each question carefully before you start your answer.

Turn over

SECTION A

Answer **all** the questions.

You should spend a maximum of 30 minutes on this section.

Write your answer to each question in the box provided.

1   Large molecules produced by fractional distillation are cracked to make smaller molecules.

Octane, C_8H_{18}, is cracked to form ethene, C_2H_4, and one other product.

What is the formula of the other product?

A C_3H_6

B C_6H_{12}

C C_6H_{14}

D C_8H_{16}

Your answer [ ]   **[1]**

2   Dilute hydrochloric acid reacts with marble chips.
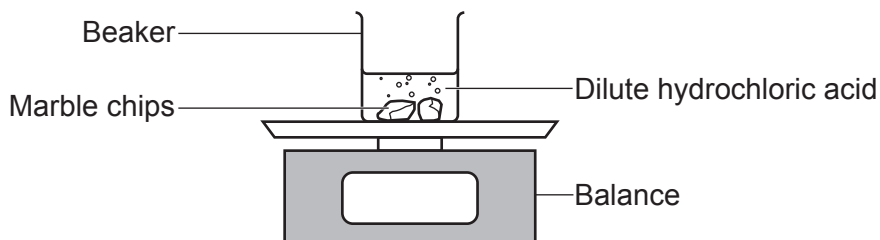
Which statement about the reaction is correct?

A   The reaction is faster after 10 seconds than it is after 3 seconds.

B   The reaction slows down with time.

C   The reaction proceeds at a constant rate.

D   The mass of the beaker and its contents stay the same.

Your answer [ ]   **[1]**

3 Which functional group does a monomer need to contain to form addition polymers?

A

B

C   —O—H
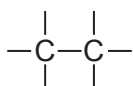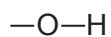
D
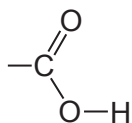
Your answer ☐ **[1]**

4 Which test identifies sulfate ions?

A A flame test

B Adding a few drops of barium chloride solution

C Adding a few drops of silver nitrate solution

D Adding a few drops of sodium hydroxide solution

Your answer ☐ **[1]**

5 A student investigates the reaction between sodium thiosulfate solution and dilute hydrochloric acid.

They want to find out how temperature changes the rate of reaction.

The diagram shows their experiment.

Add dilute hydrochloric acid and start timing

Sodium thiosulfate solution

Cross drawn on piece of paper disappears
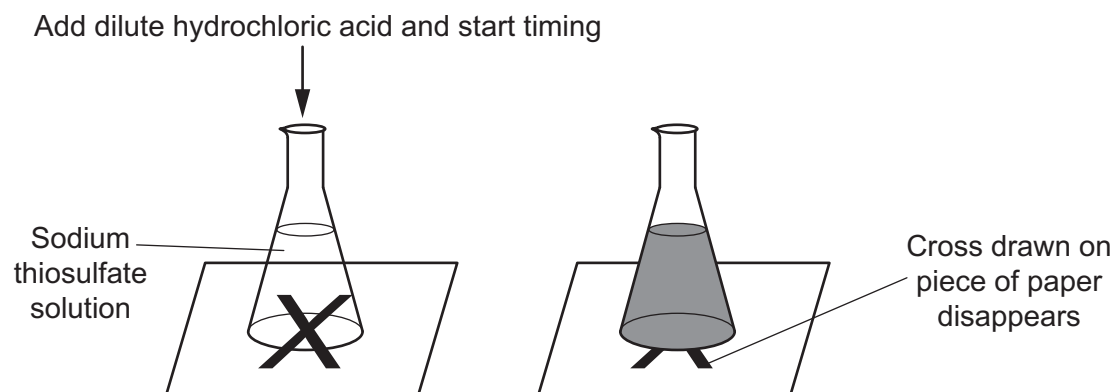
Which two variables should the student keep constant in the experiment?

	Variables	
A	temperature	volume of hydrochloric acid
B	time	volume of sodium thiosulfate
C	volume of hydrochloric acid	time
D	volume of hydrochloric acid	volume of sodium thiosulfate

Your answer [1]

6 Why are balloons filled with helium gas able to float in the air?

A Helium is colourless.

B Helium is in Group 0 and is unreactive.

C Helium has a low boiling point.

D Helium has a low density.

Your answer [1]

7 The table shows some of the advantages and disadvantages of using hydrogen/oxygen fuel cells to power vehicles.

	Advantage	**Disadvantage**
A	do not produce greenhouse gases	hydrogen fuel comes from hydrocarbons, which are fossil fuels
B	hydrogen fuel comes from the electrolysis of water, which uses electricity	no moving parts
C	hydrogen is a gas and stored in a large tank	hydrogen is explosive
D	only by-products are water and heat	fuel cells do not go 'flat'

Which row in the table is correct?

Your answer [ ] **[1]**

8 Which gases is the Earth's early atmosphere thought to have contained?

A Carbon dioxide and oxygen

B Carbon dioxide and water vapour

C Methane and oxygen

D Nitrogen and oxygen

Your answer [ ] **[1]**

9 A student reacts dilute hydrochloric acid with marble chips. Carbon dioxide gas is made.

- The student repeats the experiment with different size marble chips.
- They use 20 g of marble chips in each experiment.

The graph shows the student's results
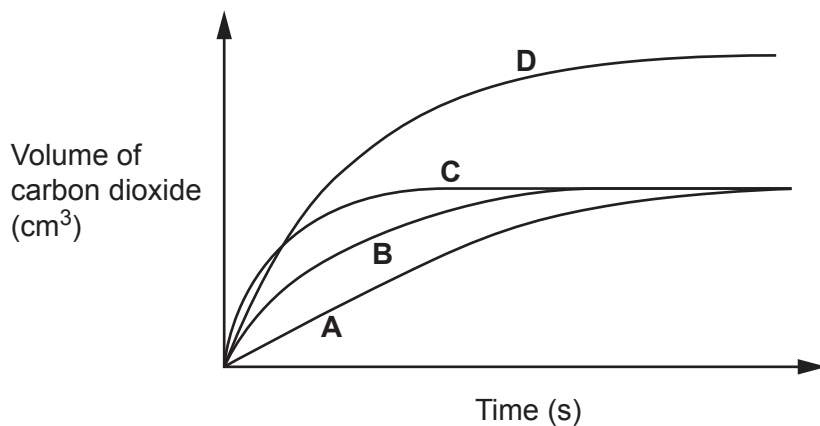
Which line shows the result for the **smallest** marble chips?

Your answer ☐ **[1]**

10 Which statement about polymerisation is correct?

A Amino acid monomers make polymers called proteins by addition polymerisation.

B DNA is a polymer made from four identical monomers called nucleotides.

C Polyesters are condensation polymers made from monomers containing carboxylic acid and alcohol functional groups.

D Poly(ethene) is a polymer made from ethene monomers by condensation polymerisation.

Your answer ☐ **[1]**

11 Sodium, in Group 1, reacts with fluorine in Group 7.

Sodium fluoride is made.

What is the **balanced symbol** equation for the reaction?

A $Na + F \rightarrow NaF$

B $2Na + F_2 \rightarrow 2NaF$

C $Na + F_2 \rightarrow NaF_2$

D $2Na + F \rightarrow Na_2F$

Your answer [ ] **[1]**

12 Which type of material is glass?

A Alloy

B Ceramic

C Composite

D Polymer

Your answer [ ] **[1]**

13 Phytoextraction is used to extract metals from their compounds.

Which statement about phytoextraction is correct?

A Involves growing plants in soil that contains metal compounds

B Involves heating the metal compounds with carbon

C Uses bacteria to separate metals from their compounds

D Uses electricity to separate metals from their compounds

Your answer [ ] **[1]**

14 The actual yield in a reaction is often less than the predicted yield.

Why?

A One reactant is in excess.

B One reactant is the limiting reactant.

C The reaction has an atom economy of less than 100%.

D The reaction is reversible and does not go to completion.

Your answer [   ] **[1]**

15 How is iron protected from corrosion by sacrificial protection?

A Iron is coated in a more reactive metal, like magnesium, which is more readily reduced than iron.

B Iron is coated in a more reactive metal, like tin, which loses electrons more readily than iron.

C Iron is coated in a more reactive metal, like zinc, which gains electrons more readily than iron.

D Iron is coated in a more reactive metal, like zinc, which is more readily oxidised than iron.

Your answer [   ] **[1]**

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SECTION B

Answer **all** the questions.

16 Hydrogen peroxide, H_2O_2, is used as a source of oxygen gas.

Hydrogen peroxide decomposes to make oxygen gas, O_2, and water.

(a) Write the **balanced symbol** equation for this reaction.

.... **[2]**

(b) The decomposition of hydrogen peroxide is very slow at room temperature. The reaction can be speeded up by adding a catalyst.

- A student investigates the decomposition of hydrogen peroxide using two different catalysts, **A** and **B**.
- The student uses $50\,cm^3$ of hydrogen peroxide and $0.5\,g$ of the catalyst in each experiment.

The table shows the student's results.

Time (minutes)	Volume of oxygen (cm^3)	
	Catalyst **A**	Catalyst **B**
0	0.0	0.0
5	4.0	5.0
10	8.0	10.0
15	12.0	15.0
20	16.0	16.5
25	17.5	18.0
30	18.0	18.0
35	18.0	18.0

The results for catalyst **A** are shown on **Fig. 16.1**.

Plot the results for catalyst **B** on **Fig. 16.1** and draw a line of best fit. **[2]**

Fig. 16.1

Fig. 16.1 — Graph of Volume of oxygen (cm³) against Time (minutes). Points plotted at (0, 0), (5, 4), (10, 8), (15, 12), (20, 16), (25, 17.5), (30, 18), (35, 18).
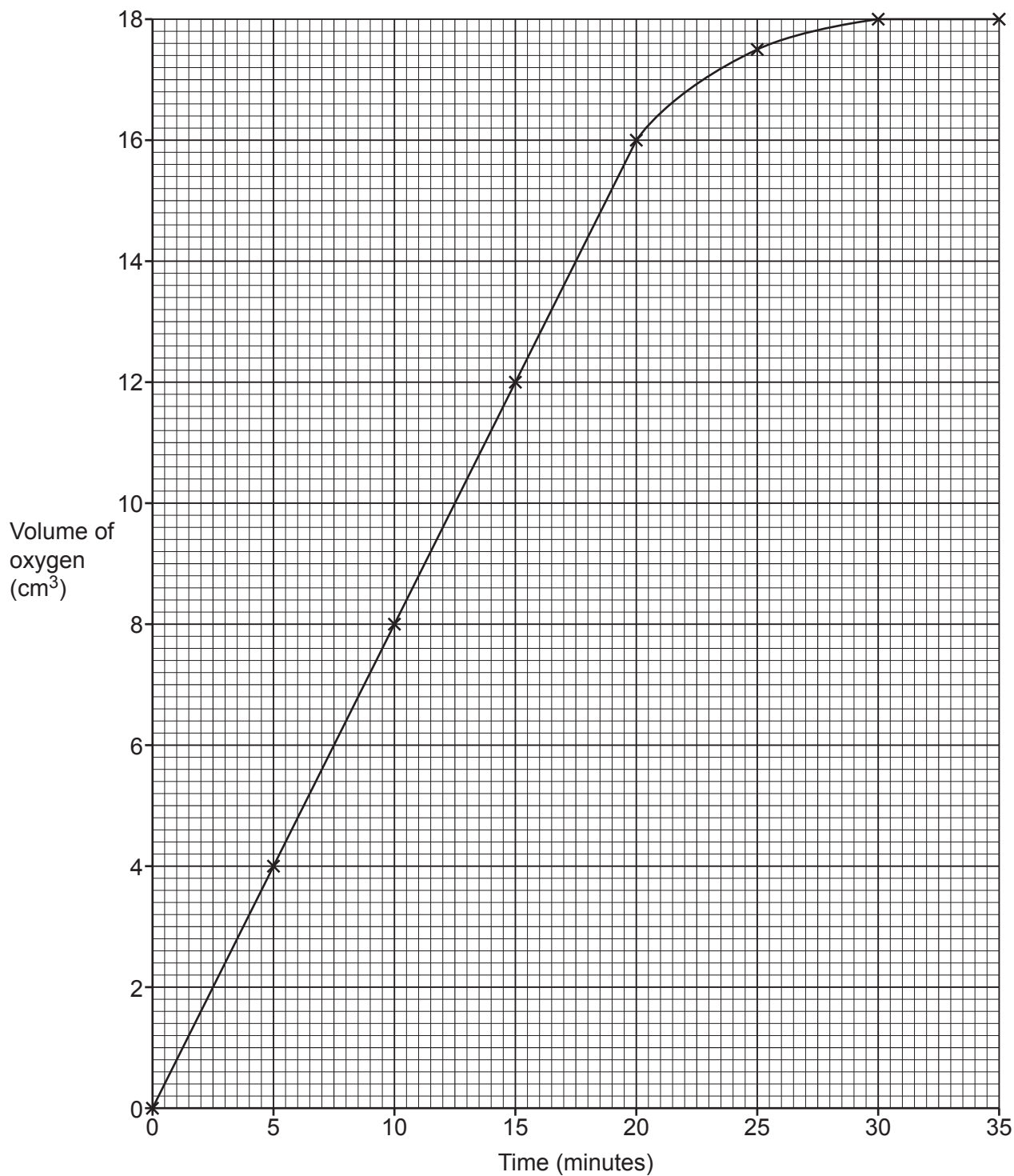
(c) The student thinks catalyst **B** is the better catalyst.

Explain why the student is correct. Use data from the graph.

....

....

.... **[2]**

Turn over

(d) The volume of oxygen made in each experiment is $18\,cm^3$.

Explain why it is the same value.

....

.... **[1]**

(e) The student repeats the experiment with **1.0 g** of catalyst **A** instead of 0.5 g.

What is the volume of oxygen gas made at the end of the experiment?

Volume of oxygen gas = ... cm^3 **[1]**

(f) The student thinks the decomposition of hydrogen peroxide will be faster at 30 °C than at room temperature.

Describe an experiment the student could do, and its results, to show the reaction is faster at 30 °C.

....

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.... **[3]**

17 A teacher investigates the reactions of copper carbonate, $CuCO_3$.

The diagram shows the reactions the teacher does.

```
                        ┌─────────────────────────────┐
                        │  Copper carbonate, CuCO₃    │
                        └─────────────────────────────┘
                                     │
                                     │  Add dilute hydrochloric acid
                                     ▼
┌──────────────────────────────┐   ┌────────┐   ┌────────┐
│ Solution of a green soluble  │ + │ Water  │ + │ Gas Y  │
│ salt, X                      │   └────────┘   └────────┘
└──────────────────────────────┘
         │
         │  Electrolysis
         ▼
   ┌──────────┐   ┌────────────────────────────┐
   │ Copper   │ + │         Gas Z              │
   └──────────┘   └────────────────────────────┘
         │
         │  Flame test
         ▼
```
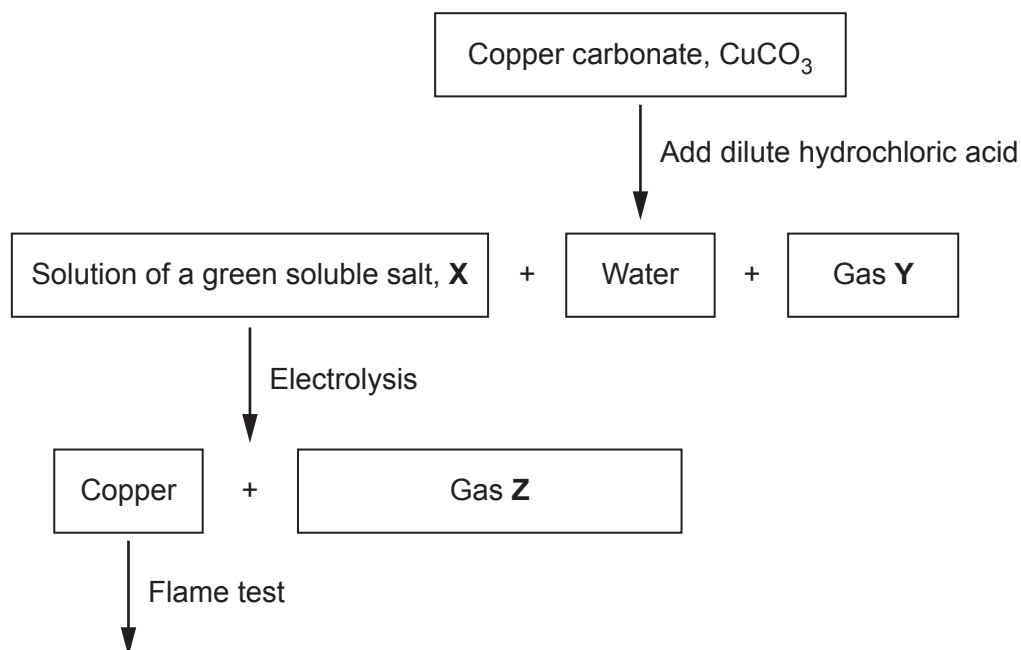
(a) State the name of the soluble salt, **X**.

.... **[1]**

(b) State the name of gas **Y**.

.... **[1]**

(c) Gas **Z** turns damp blue litmus paper white.

State the name of gas **Z**.

.... **[1]**

(d) The teacher performs a flame test of the copper made by the electrolysis of **X**.

What colour flame does the teacher observe?

.... **[1]**

Turn over

(e) Copper metal is extracted from copper oxide by heating with carbon as shown in the equation.

copper oxide + carbon ⟶ copper + carbon dioxide

Explain why copper is extracted.

Use ideas about the reactivity series.

....

.... **[1]**

(f) Copper is used to make useful alloys.

The table gives information about some copper alloys.

Alloy	Main metals	Uses
duralumin	copper and	aircraft parts
brass	copper and	musical instruments
bronze	copper and tin	....

Complete the table. **[2]**

18 The table shows information about some compounds of carbon.

Compound	Formula
A	C_2H_4
B	C_2H_5OH
C	C_3H_7COOH
D	C_4H_{10}
E	C_6H_{14}

(a) Compounds **D** and **E** belong to the homologous series called the **alkanes**.

What is the **general formula** of the alkanes?

.... **[1]**

(b) Which homologous series does compound **C** belong to?

Tick (✓) the correct answer.

Alcohols ☐

Alkenes ☐

Carboxylic acids ☐

Esters ☐

[1]

(c) Compound **A**, C_2H_4, burns in oxygen.

Write the **balanced symbol** equation for the **incomplete** combustion of compound **A**.

.... **[2]**

Turn over

(d) Compound **D** and compound **E** are obtained from crude oil by fractional distillation.

Explain how fractional distillation separates compound **D** and compound **E**.
Use ideas about intermolecular forces.

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....

.... **[3]**

(e) Crude oil is being formed extremely slowly.

What term describes resources, like crude oil, that are being formed extremely slowly?

.... **[1]**

(f) Petrol is a mixture of hydrocarbons obtained from crude oil.

When petrol burns in a car engine the exhaust gases contain nitrogen monoxide, NO, and carbon monoxide, CO.
These are atmospheric pollutants.

Describe one environmental problem for each gas.

NO ....

CO ....
[2]

(g) Most cars have catalytic converters which catalyse the reaction between nitrogen monoxide and carbon monoxide to make nitrogen and carbon dioxide gases.

(i) Explain how the use of a catalyst in the catalytic converter increases this rate of reaction.

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....

.... **[2]**

(ii) The equation shows the reaction that takes place in a catalytic converter.

$$2CO + 2NO \rightarrow N_2 + 2CO_2$$
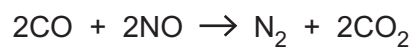
During a car journey, 187 g of carbon dioxide is made by the catalytic converter.

Calculate the **volume of carbon monoxide**, in dm^3, removed from the exhaust gases.

Relative atomic mass (A_r): C = 12.0   O = 16.0

Volume of carbon monoxide = ... dm^3 **[4]**

19 A student neutralises dilute sulfuric acid, H_2SO_4, with ammonia, NH_3, to make ammonium sulfate, $(NH_4)_2SO_4$.

This is the equation for the reaction.

$H_2SO_4 + 2NH_3 \rightarrow (NH_4)_2SO_4$
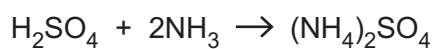
(a) The student makes 4.22 g of ammonium sulfate. The percentage yield is 80%.

Calculate the **mass of sulfuric acid** the student used in the reaction.

Give your answer to **3** significant figures.

Relative atomic mass (A_r): H = 1.0   N = 14.0   O = 16.0   S = 32.1

Mass of sulfuric acid = ... g **[5]**

(b) The table gives some information about the two methods of producing ammonium sulfate.

Laboratory	Industry
titration of dilute sulfuric acid and ammonia solution	uses raw materials to make sulfuric acid and ammonia in several stages
batch process	continuous process
small scale	large scale
slow process	quick process
atom economy is 100%	atom economy is 100%
	ammonium sulfate can be made from by-products of other processes

Evaluate the information to suggest which method is more suited to making large amounts of chemicals such as fertilisers.

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.... **[3]**

(c) Ammonium sulfate, $(NH_4)_2SO_4$, is used as a fertiliser because it contains nitrogen.

State why nitrogen is one of the essential elements needed by plants.

.... **[1]**

20* Magnesium sulfate, $MgSO_4$, is made by a neutralisation reaction.

Methods 1 and 2 show two different ways of making magnesium sulfate.

Method 1 – Reaction of sulfuric acid with magnesium carbonate.

$H_2SO_4 + MgCO_3 \rightarrow MgSO_4 + H_2O + CO_2$

Method 2 – Reaction of sulfuric acid with magnesium oxide.

$H_2SO_4 + MgO \rightarrow MgSO_4 + H_2O$

A company wants to make magnesium sulfate as sustainably as possible.

Use the idea of **atom economy** to help explain which method, 1 or 2, the company should use to make magnesium sulfate.

Relative atomic mass (A_r): C = 12.0   H = 1.0   Mg = 24.3   O = 16.0   S = 32.1

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.... [6]

21 Hydrogen gas is made by the reaction between methane, CH_4, and steam.

The reaction reaches a **dynamic equilibrium**.

This is the equation for the reaction.

$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$

(a) State what is meant by a **dynamic equilibrium**.

....

....

....

.... **[2]**

(b) The position of equilibrium moves if the reaction conditions are changed.

(i) The forward reaction is **endothermic**.

The **temperature** of the equilibrium mixture is **increased**.

State and explain what happens to the position of the equilibrium.

....

....

.... **[2]**

(ii) The highest yield of hydrogen gas is made using a low pressure, such as 1 atmosphere.

The reaction is actually carried out using a catalyst at a pressure of 30 atmospheres.

Suggest why a pressure of 30 atmospheres is used.

....

.... **[1]**

Turn over

(c) A factory uses 200 tonnes of methane a day.

The factory produces 68.4 tonnes of hydrogen per day as shown in the equation.

$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$
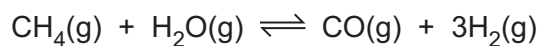
Calculate the **percentage yield of hydrogen**, **H_2**.

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

Relative atomic mass (A_r): H = 1.0   C = 12.0

Percentage yield of hydrogen = ... % **[4]**

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22 A student does a titration with an acid and an alkali.

The student uses dilute hydrochloric acid, sodium carbonate solution and an indicator solution.

The diagram shows the apparatus they use.

Burette

Dilute hydrochloric acid

$25.0\,cm^3$ of sodium carbonate solution + indicator solution
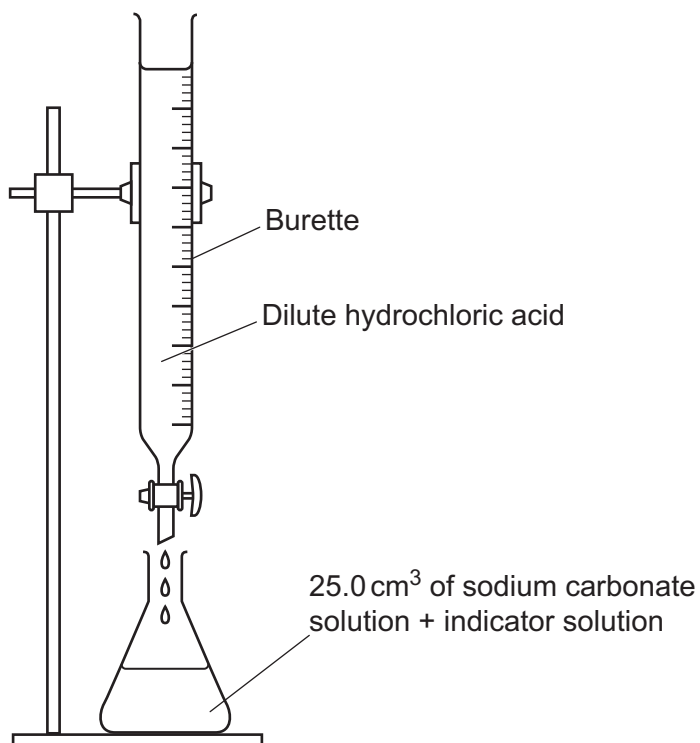
The student uses:
- $25.0\,cm^3$ of sodium carbonate solution in the conical flask
- dilute hydrochloric acid of concentration $0.12\,mol/dm^3$ in the burette.

The student repeats the titration 4 times.

The table shows the student's results.

Titration number	1	2	3	4
Final burette reading (cm³)	20.25	20.51	37.60	39.15
Initial burette reading (cm³)	0.00	0.00	16.10	18.74
Volume of acid used (cm³)	20.25	20.51	....	20.41

(a) (i) Calculate the volume of acid used in titration number **3**.

Write your answer in the table. **[1]**

(ii) The student uses methyl orange as the indicator in the experiment.

Explain why the student does **not** use universal indicator.

....

.... **[1]**

(iii) The student decides to only use the results from titration numbers **2** and **4**.

Explain why.

....

.... **[1]**

(iv) The equation for the reaction between dilute hydrochloric acid and sodium carbonate solution is shown.

$$2HCl + Na_2CO_3 \rightarrow 2NaCl + H_2O + CO_2$$

Calculate the concentration of the sodium carbonate solution in mol/dm^3.

Use the average volume of acid used in titration numbers **2** and **4**.

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

Concentration of the sodium carbonate solution = ... mol/dm^3 **[5]**

Turn over

(b) Sodium chloride, NaCl, is made in the student's titration.

Sodium chloride contains the cation Na$^+$ and the anion Cl^-.

Describe the tests, and their positive results, that the student can do to prove that sodium chloride is made in the reaction.

(i) Cation Na$^+$

Test ....

....

Result ....

....
[2]

(ii) Anion Cl^-

Test ....

....

Result ....

....
[2]

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23 A car manufacturer is concerned about the carbon dioxide, CO_2, emissions of different cars during their lifetime.

The car manufacturer does a life-cycle assessment for three types of car they are developing:
- a petrol car
- a diesel car
- an electric car.

The car manufacturer also looks at refuelling the electric car using electricity generated by 'renewable electricity' and '100% coal electricity'.

(a) Why does the car manufacturer do a life-cycle assessment?

....

.... **[1]**

(b) The graph shows the life-cycle assessment for the three types of car.
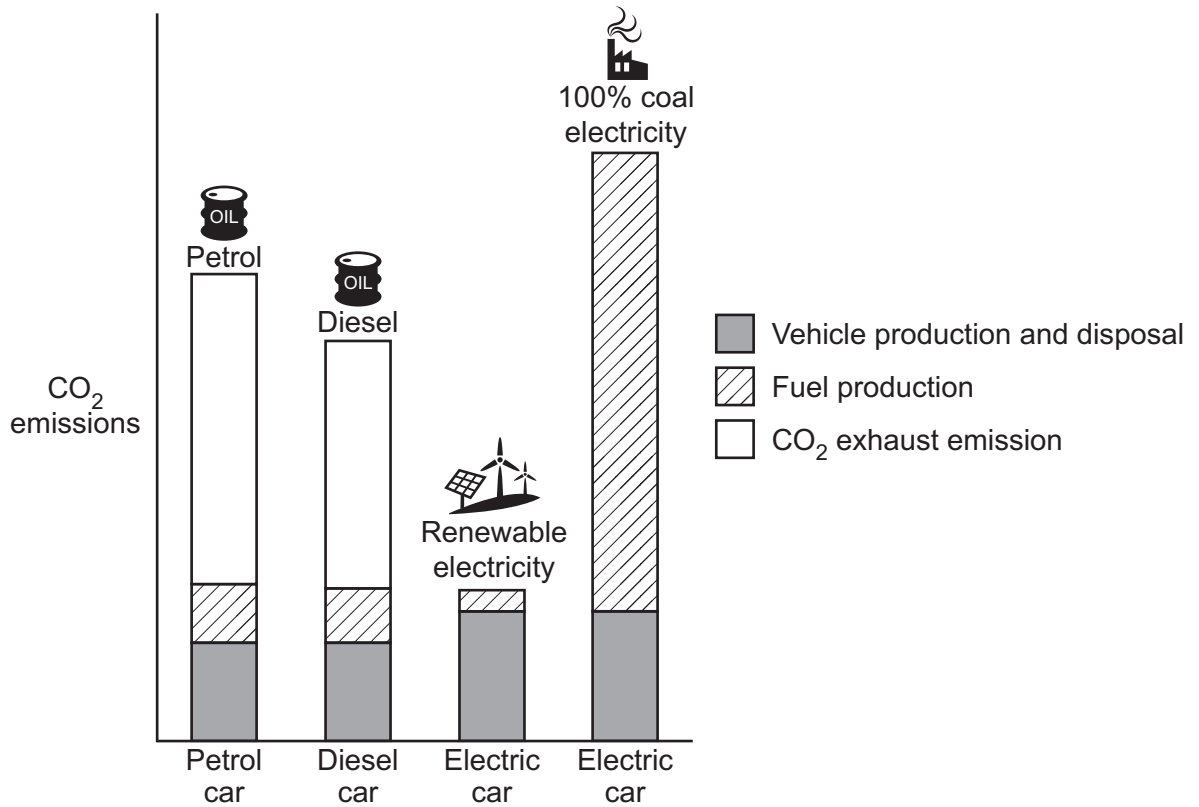
(i) Estimate the percentage of CO_2 emissions for a **diesel car** which come from **fuel production**.

Percentage of CO_2 emissions = ... % **[1]**

(ii) The CO_2 emissions for an electric car are much greater when the car is refuelled using electricity generated by burning coal, rather than renewable electricity.

Suggest why.

....

....

.... **[2]**

(c) Petrol and diesel are both obtained from crude oil.

Petrol molecules are smaller than diesel molecules.

Petrol has a **lower boiling point** than diesel. Explain why.

....

.... **[1]**

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).