OCR
Oxford Cambridge and RSA

H

Monday 29 November 2021 – 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.

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 Butane is a hydrocarbon molecule with a low boiling point.

Which statement about butane is correct?

A Butane is a large molecule and has strong intermolecular forces.

B Butane is a large molecule and has weak intermolecular forces.

C Butane is a small molecule and has strong intermolecular forces.

D Butane is a small molecule and has weak intermolecular forces.

Your answer ☐ **[1]**

2 Lumps of zinc react with dilute sulfuric acid.

What change would **decrease** the rate of this reaction?

A Further diluting the sulfuric acid with water.

B Using a larger volume of sulfuric acid.

C Using warmer sulfuric acid.

D Using zinc powder instead of zinc lumps.

Your answer ☐ **[1]**

3 The Earth's early atmosphere formed 4.5 billion years ago.

Which process produced the gases in the Earth's early atmosphere?

A Combustion

B Condensation

C Photosynthesis

D Volcanic activity

Your answer ☐ **[1]**

4 What are the conditions usually used for the production of ammonia in the Haber process?

$N_2 + 3H_2 \rightleftharpoons 2NH_3$

A 200 °C, 450 atmospheres pressure and an iron catalyst

B 450 °C, 2 atmospheres pressure and a vanadium(V) oxide catalyst

C 450 °C, 200 atmospheres pressure and an iron catalyst

D 450 °C, 200 atmospheres pressure and a nickel catalyst

Your answer ☐ **[1]**

5 A scientist predicts that they should make 96 tonnes of product in a reaction.

They only actually make 81 tonnes of product.

What is the **percentage yield**?

A 15%

B 19%

C 84%

D 119%

Your answer ☐ **[1]**

6 When iron rusts it forms hydrated iron(III) oxide.

$4Fe + 3O_2 \rightarrow 2Fe_2O_3$

What happens to iron in this reaction?

A Iron is decomposed.

B Iron is neutralised.

C Iron is oxidised.

D Iron is reduced.

Your answer ☐ **[1]**

7 The concentration of a solution of sodium hydroxide, NaOH, is 0.725 mol / dm^3.

What is the concentration of this solution in **g / dm^3**?

(The relative atomic mass, A_r, of H is 1.0, of Na is 23.0 and of O is 16.0).

A 0.018 g / dm^3

B 29.0 g / dm^3

C 55.2 g / dm^3

D 725.0 g / dm^3

Your answer ☐ **[1]**

8 What is the formula of the functional group in **carboxylic acids**?

A –C=C–

B –COOH

C $–CO_2$

D –OH

Your answer ☐ **[1]**

9 What is the **balanced half equation** for the formation of bromine from bromide ions?

A $Br^- - e^- \longrightarrow Br$

B $Br^- \longrightarrow Br - e^-$

C $2Br^- - 2e^- \longrightarrow Br_2$

D $2Br^- \longrightarrow Br_2 - 2e^-$

Your answer ☐ **[1]**

10 Metals can be extracted by biological methods.

Plants absorb metals through their roots and concentrate them in their cells.

What is this method of metal extraction called?

A Bioleaching

B Carbon capture

C Organic extraction

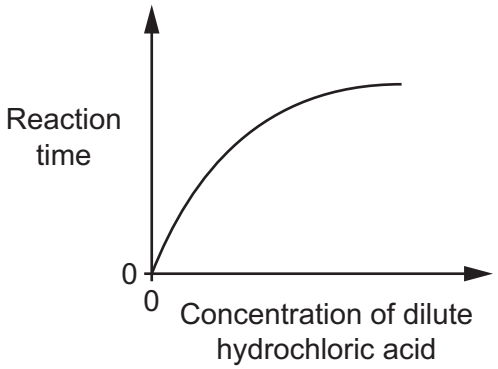
D Phytoextraction

Your answer ☐ **[1]**

11 A student investigates the reaction between magnesium and dilute hydrochloric acid.

Which graph shows the effect of the **concentration** of the dilute hydrochloric acid on the reaction time?

A



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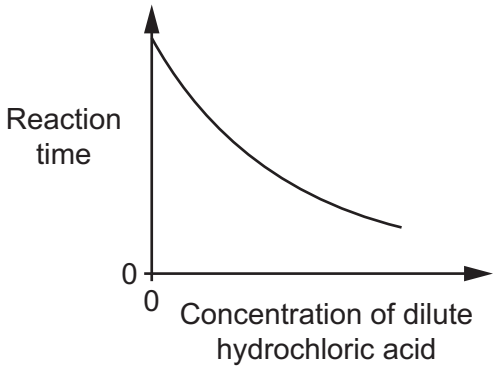

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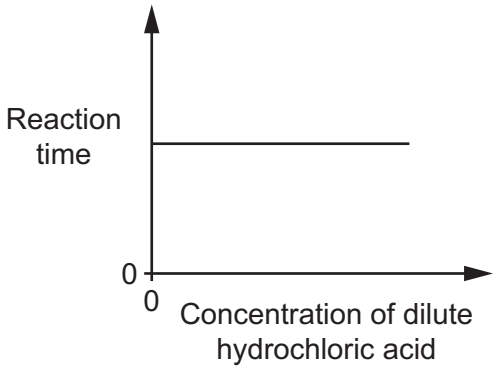

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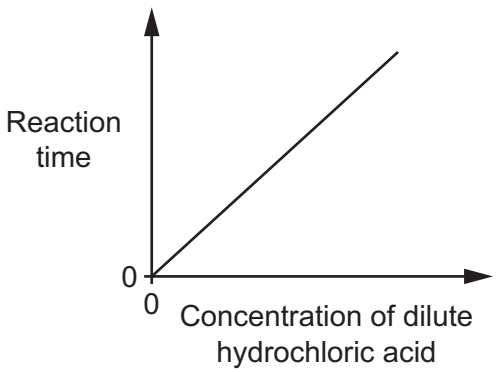

Your answer ☐ **[1]**

12 Which of these functional groups can react together to form a **condensation** polymer?

A –C=C– and –COOH

B –C=C– and $–NH_2$

C –COOH and $–NH_2$

D –OH and $–NH_2$

Your answer ☐ **[1]**

13 An alcohol and a carboxylic acid react to form an ester and water in an equilibrium reaction.

alcohol + carboxylic acid $\rightleftharpoons$ ester + water

Why is an acid catalyst used in this reaction?

A The catalyst is changed chemically during the reaction.

B The equilibrium concentration of the ester is increased.

C The purity of the ester is increased.

D The time taken to reach equilibrium is decreased.

Your answer ☐ **[1]**

14 Fertilisers can be made in a batch process in the laboratory or in a continuous process in industry.

The table gives some information about these two processes.

	Batch process	**Continuous process**
A	Easily automated	High production rate
B	Frequent shut-down periods	Large number of workers
C	Low production rate	High relative cost of equipment
D	Small number of workers	Low relative cost of equipment

Which row of the table is correct about the processes?

Your answer ☐ **[1]**

15 Sacrificial protection is a method used to prevent iron from rusting.

Sacrificial protection involves plating the iron with a more reactive metal such as zinc.

Which statement explains how sacrificial protection works?

A The more reactive metal gains electrons more easily than the iron.

B The more reactive metal is less readily oxidised than the iron.

C The more reactive metal is more readily reduced than the iron.

D The more reactive metal loses electrons more easily than the iron.

Your answer ☐ **[1]**

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SECTION B

Answer **all** the questions.

16 A student analyses a sample of ethanol, C_2H_5OH, using a mass spectrometer.

The structure of ethanol is shown.

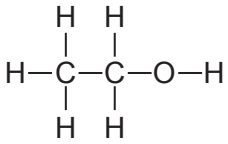

Fig. 16.1 shows the mass spectrum of the ethanol.

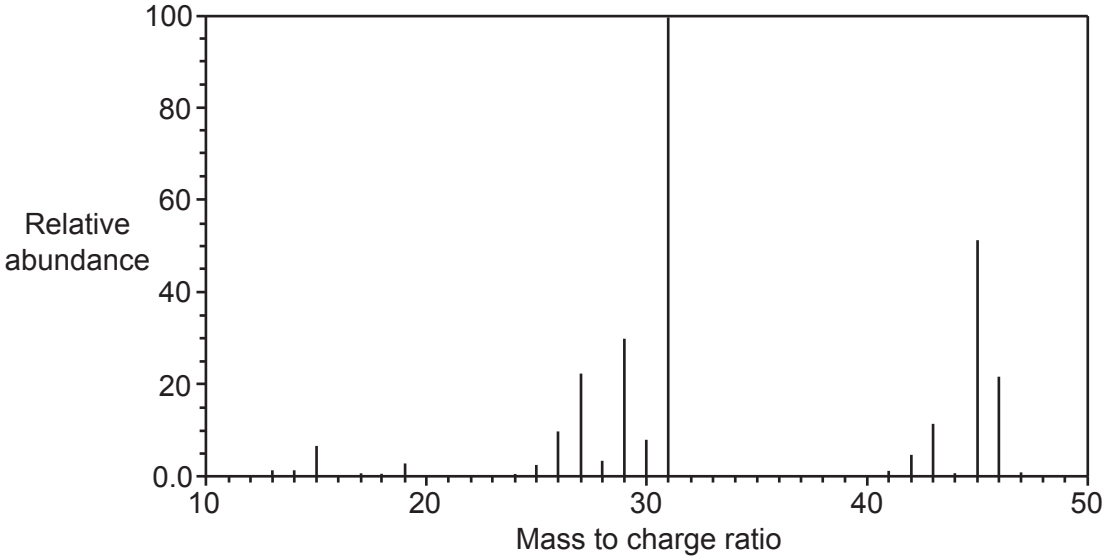

Fig. 16.1

The student also analyses the sample using an infrared spectrometer.

An infrared spectrometer detects covalent bonds in a molecule. Different covalent bonds are detected at different wavenumbers in an infrared spectrum.

Fig. 16.2 shows the infrared spectrum of the ethanol.

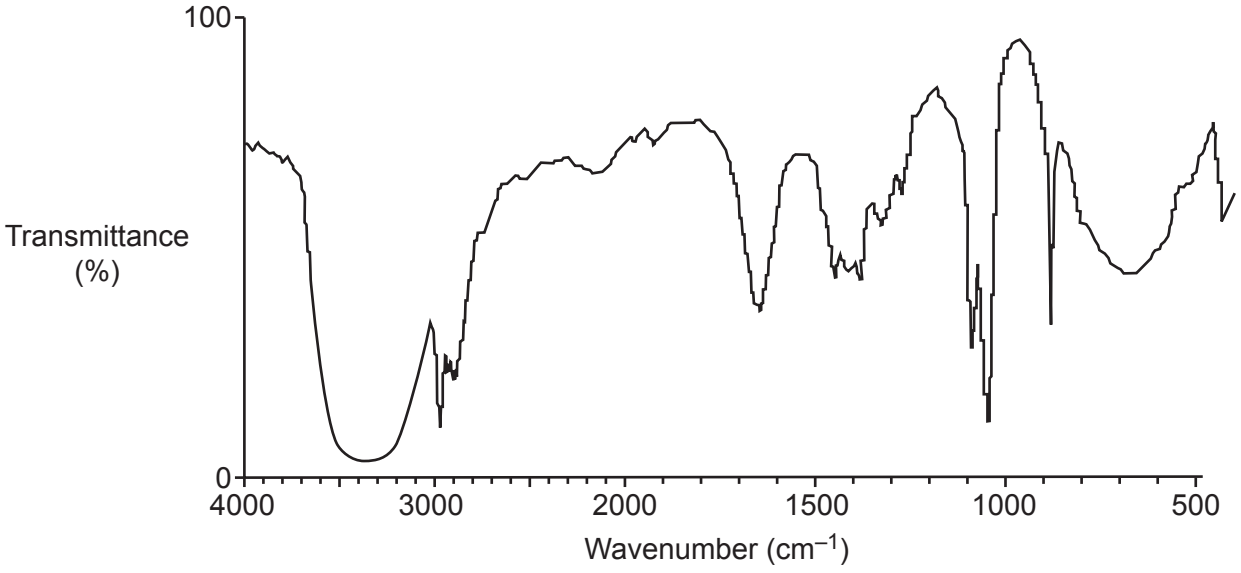

Fig. 16.2

The table shows the wavenumber for different bonds in an infrared spectrum.

Bond	Wavenumber (cm^{-1})
C–H	2850–3300
C–C	750–1100
C=C	1620–1680
C=O	1680–1750
C–O	1000–1300
N–H	3360–3500
O–H	3230–3550

(a) Explain how the mass spectrum **and** the infrared spectrum show that the sample is ethanol, C_2H_5OH.

.....

.....

.....

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

(b) Mass spectrometry and infrared spectrometry are both examples of instrumental methods of analysis.

Describe **two advantages** of instrumental methods of analysis.

1 .....

.....

2 .....

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

(c) Ethanol, C_2H_5OH, burns in a plentiful supply of oxygen to form carbon dioxide and water.

This is an example of complete combustion.

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

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

(ii) If there is a limited supply of oxygen, **incomplete combustion** will happen.

Describe a **disadvantage** of incomplete combustion.

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

(d) Ethanol, C_2H_5OH, can be dehydrated to make ethene, C_2H_4.

$C_2H_5OH \rightarrow C_2H_4 + H_2O$

Calculate the atom economy for the production of ethene from ethanol.

(The relative formula mass, M_r, of C_2H_5OH is 46.0 and of C_2H_4 is 28.0).

Atom economy = ... % **[2]**

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17 A car manufacturer is designing a new car. They need to decide if the car will have a petrol engine or a diesel engine.

(a) The car manufacturer carries out a **life-cycle assessment** for both types of car.

(i) Describe the purpose of a life-cycle assessment.

.....

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

(ii) Describe **two** examples of data, other than waste products and pollution, that could be included in a life-cycle assessment.

1 .....

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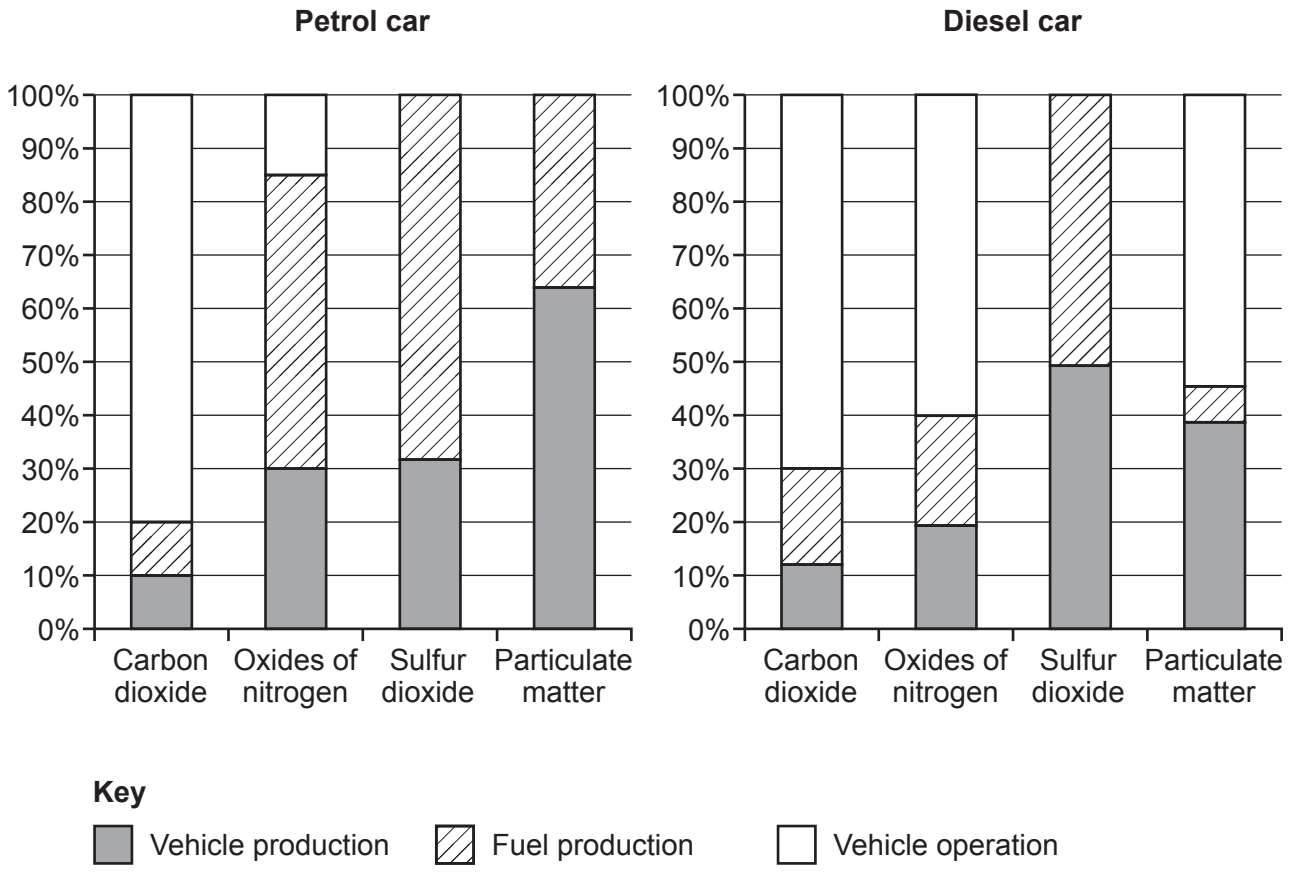
2 .....

.....

[2]

(b) The graphs show the air emission results of a life-cycle assessment for a petrol car and a diesel car.



(i) At which stage are the **most oxides of nitrogen** produced by the **diesel car**?

Tick (✓) **one** box.

Vehicle production ☐

Fuel production ☐

Vehicle operation ☐

[1]

(ii) The car manufacturer estimates that a petrol car produces 29.8 tonnes of carbon dioxide over its lifetime.

A diesel car produces only 20.5 tonnes of carbon dioxide over its lifetime.

Use the graphs to calculate the **mass**, in tonnes, of carbon dioxide produced by the petrol car **and** the diesel car **during vehicle operation**.

Use your answers to calculate the **difference**, in tonnes, in the mass of carbon dioxide produced by the petrol car and the diesel car **during vehicle operation**.

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

Mass of carbon dioxide produced by the petrol car = ... tonnes

Mass of carbon dioxide produced by the diesel car = ... tonnes

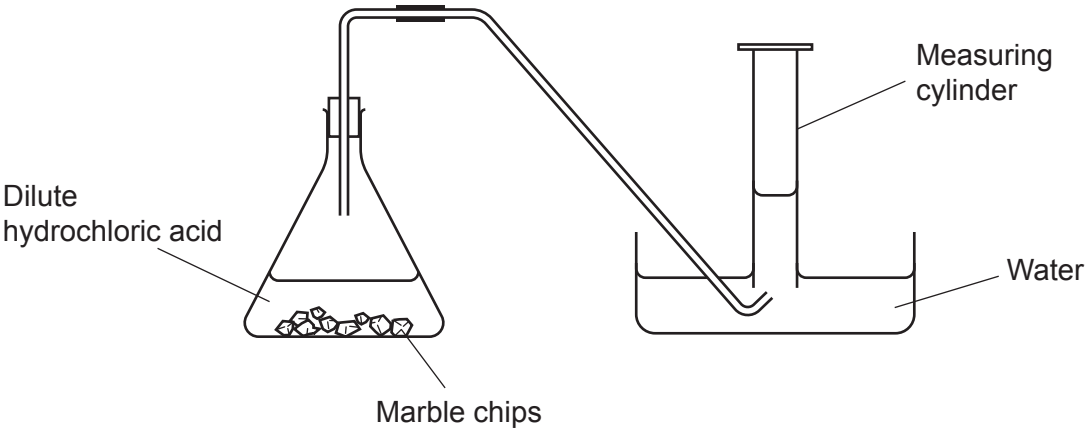
Difference in mass of carbon dioxide = ... tonnes

[4]

18 A student investigates the rate of reaction between large marble chips and dilute hydrochloric acid.

The student measures the volume of carbon dioxide gas given off every 30 seconds.

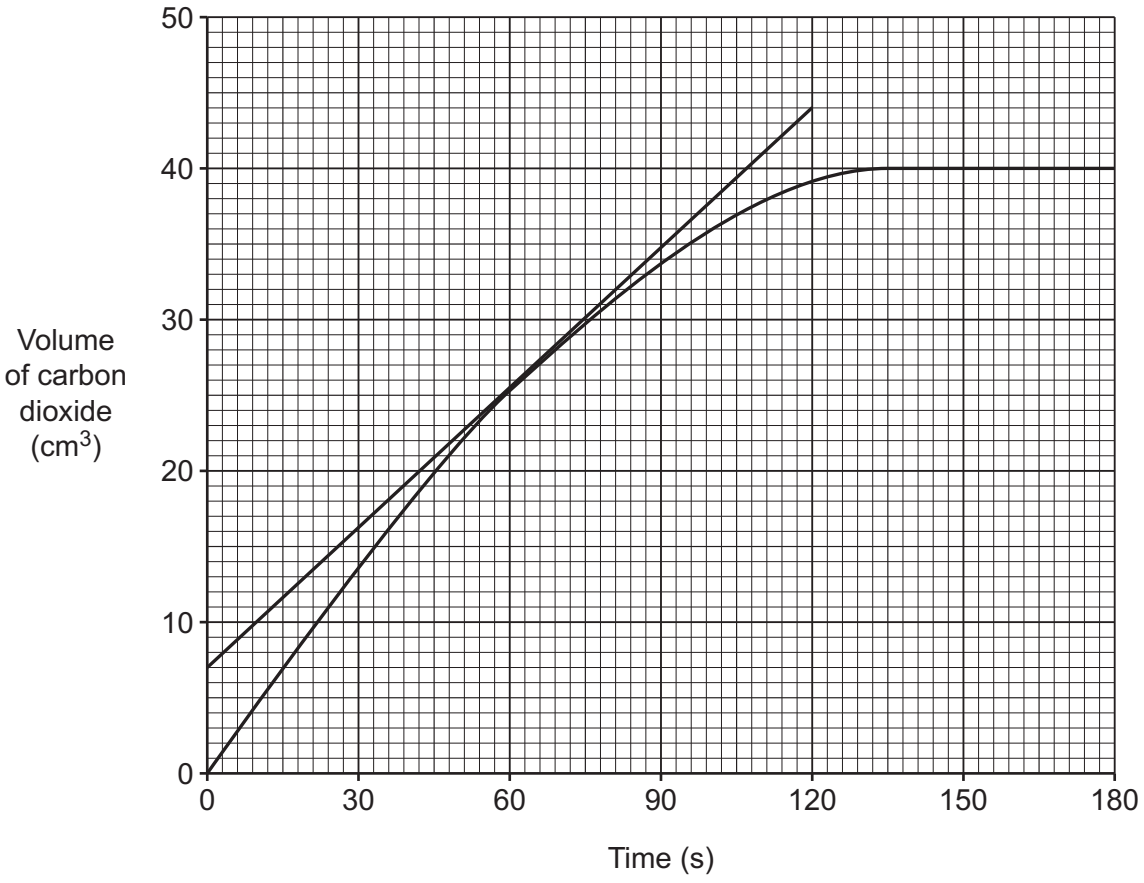
Look at the apparatus they use.



(a) State how the student can improve their experiment to measure the volume of carbon dioxide more accurately.

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

(b) The graph shows the student's results.



(i) The student has drawn a tangent to the line on the graph at 60 seconds.

Use the tangent to calculate the **rate of reaction** at 60 seconds.

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

(ii) The student repeats the experiment. The only difference is they use **smaller** marble chips.

Draw a line on the graph to show the results of this experiment. **[2]**

(c) The balanced equation for this reaction is:

$CaCO_3 + 2HCl \longrightarrow CaCl_2 + H_2O + CO_2$

In their experiment the student reacted 0.5 mol of dilute hydrochloric acid, HCl, with 0.5 mol of marble chips, $CaCO_3$.

Use the equation to show that, in this experiment, the calcium carbonate is in excess.

.....

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

(d)* Another student investigates the effect of changing the temperature of the dilute hydrochloric acid on the rate of the reaction.

The table shows the student's results.

Experiment	Concentration of acid (g/dm^3)	Temperature (°C)	Time for reaction to finish (s)
1	10	20	300
2	10	40	80
3	40	40	20

Explain, using the student's results and the reacting particle model, the effect of changing the temperature and of changing the concentration on the **rate** of this reaction.

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..... **[6]**

19 This question is about elements in Group 7 of the Periodic Table.

The table shows some properties of Group 7 elements.

Element	Molecular formula	Melting point (°C)	Boiling point (°C)	Order of reactivity
Fluorine	F_2	–220	.....	most reactive ↕ least reactive
Chlorine	Cl_2	–101	–34	
Bromine	Br_2	–7	59	
Iodine	I_2	114	184	
Astatine	At_2	.....	337	

(a) Complete the table. Use ideas about trends down Group 7. **[2]**

(b) Chlorine reacts with sodium bromide, NaBr, in a displacement reaction.

Write the **balanced symbol** equation for this reaction.

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

(c) Explain, in terms of the arrangement of electrons, the **decrease** in reactivity from fluorine to astatine.

.....

.....

.....

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

(d) Iron reacts with chlorine to form iron chloride.

Look at the equation for the reaction.

$2Fe + 3Cl_2 \rightarrow 2FeCl_3$

Calculate the mass of iron chloride that can be made from 2.80 g of iron.

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

(The relative atomic mass, A_r, of Cl is 35.5 and of Fe is 55.8).

Mass of iron chloride = ... g **[4]**

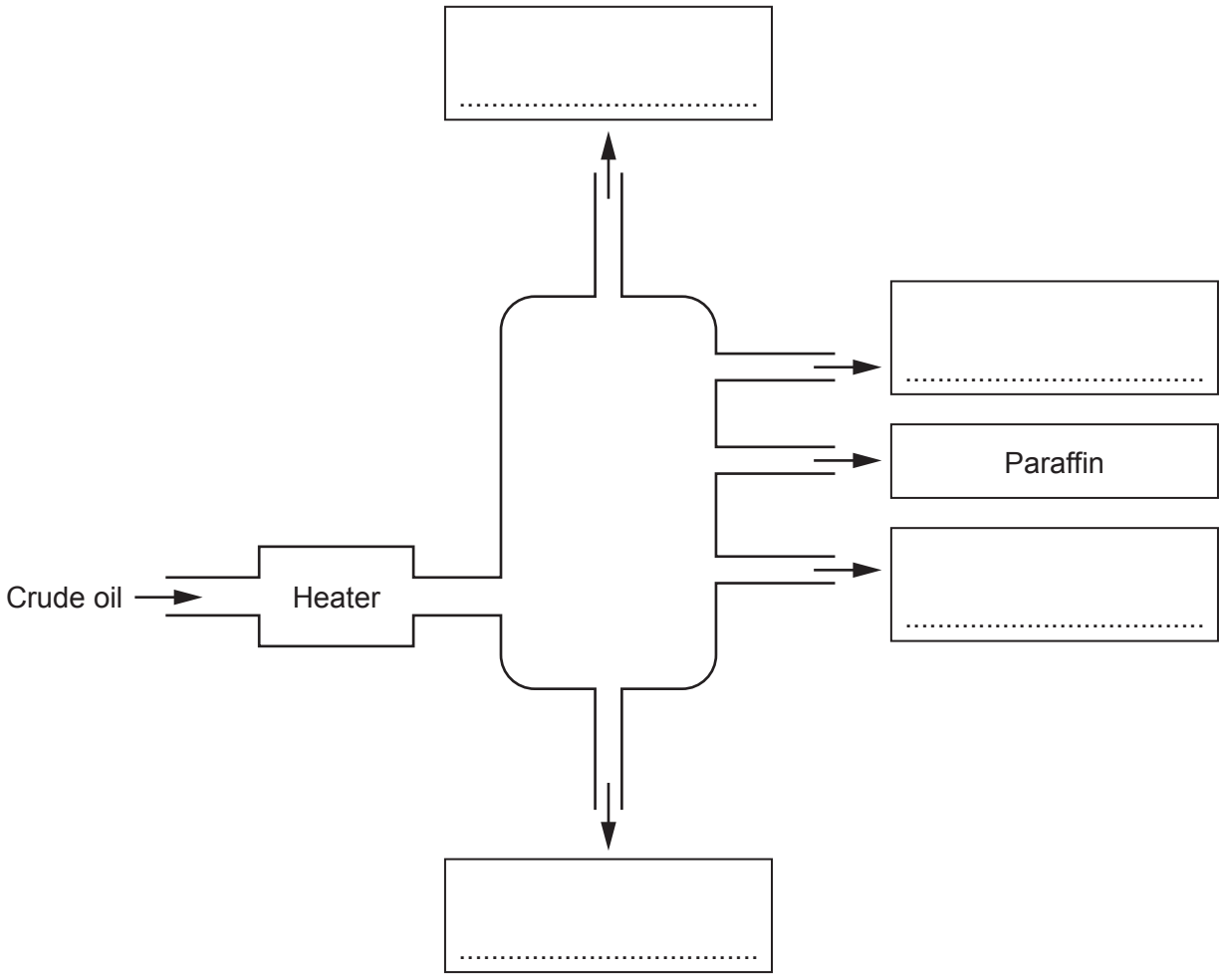
20 The fractional distillation of crude oil makes many useful fractions.

Table 20.1 shows the boiling temperatures of some fractions.

Fraction	Boiling temperature (°C)
Bitumen	above 400
Diesel	300–350
LPG	below 40
Paraffin	175–250
Petrol	4–175

Table 20.1

(a) Look at the diagram of a fractionating column.



Complete the diagram by writing the names of the missing fractions in the boxes.

Choose from the fractions in **Table 20.1**.

Use the boiling temperatures in the table to help you. **[2]**

(b) After crude oil is separated into fractions, some fractions are then **cracked**.

(i) Explain why some fractions are cracked.

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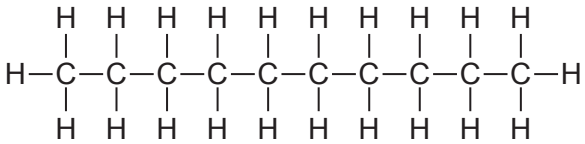
.....

.....

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

(ii) Look at the displayed formula of decane.



The cracking of decane involves the breaking of covalent bonds.

Explain why the cracking of decane makes a mixture of products.

.....

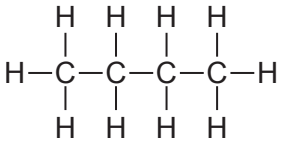
..... **[1]**

(iii) Complete the **balanced symbol** equation for the cracking of a molecule of $C_{30}H_{62}$.

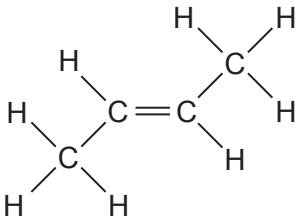
$$C_{30}H_{62} \rightarrow C_{20}H_{42} + 2 \text{ .....}$$

[1]

(c) Look at the displayed formulae of compounds **A** and **B**.



Compound **A**



Compound **B**

A few drops of bromine water are added to $1\,cm^3$ of each of compounds **A** and **B**.

(i) Explain why compound **B** decolourises bromine water but compound **A** does not.

.....

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

(ii) Write the **balanced symbol** equation for the reaction of compound **B** with bromine, Br_2.

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

21 This question is about polymers.

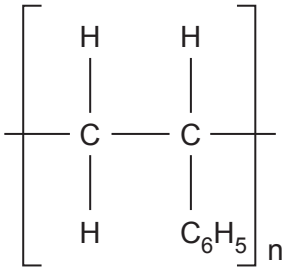
(a) Many biological substances are polymers.

Complete the table to state the type of monomer which forms each of the biological polymers.

Polymer	Type of monomer
DNA	.....
Protein	.....
Starch	.....

[3]

(b) Look at the structure of the polymer called poly(styrene).



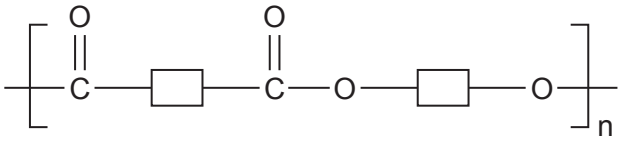
This polymer is made from a **monomer**.

Draw the structure of the monomer.

[2]

(c) Polyesters are also polymers.

Look at the structure of a polyester.

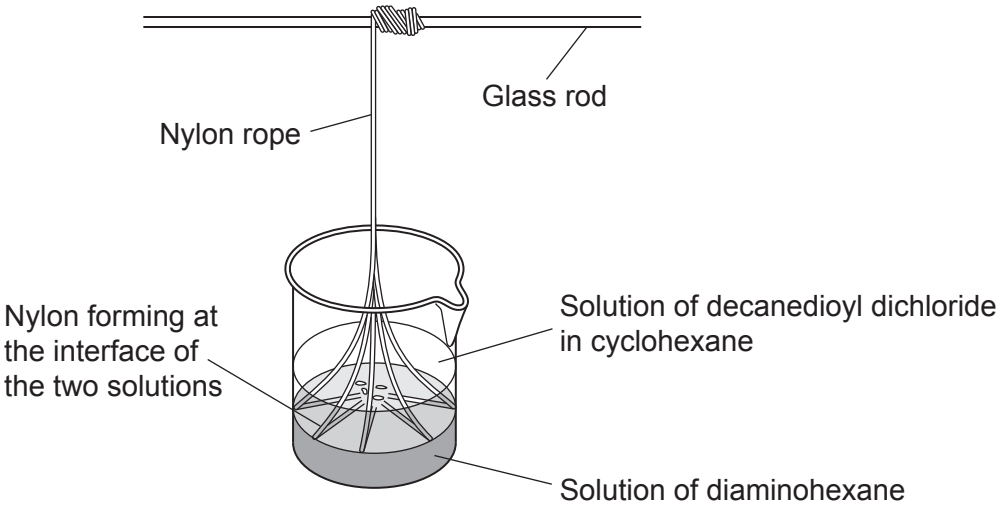


This polymer is made from **two different monomers**.

Draw a molecule of each different monomer.

[2]

(d) Nylon is another polymer.



The chemicals used to make nylon are **corrosive**. Cyclohexane is **highly flammable**.

Describe and explain **two** precautions a teacher should take to carry out this experiment safely.

1 .....

.....

2 .....

.....

[2]

22 A company makes hydrogen iodide, HI, gas by reacting hydrogen gas with iodine gas.

Look at the equation for the reaction.

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

(a) (i) What is the volume of hydrogen gas, in dm^3, needed to react with 150 dm^3 iodine at room temperature and pressure?

Use the balanced symbol equation to help you.

Volume of hydrogen = ... dm^3 **[1]**

(ii) Calculate the volume of hydrogen iodide formed, in dm^3, when 150 dm^3 of iodine completely reacts with hydrogen at room temperature and pressure.

Use the balanced symbol equation to help you.

Volume of hydrogen iodide = ... dm^3 **[1]**

(iii) Calculate the mass, **in kilograms**, of 150 dm^3 of iodine at room temperature and pressure.

One mole of any gas occupies 24 dm^3.

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

(The relative molecular mass, M_r, of I_2 is 253.8).

Mass of iodine = ... kg **[4]**

(b) The reaction to make hydrogen iodide is an equilibrium reaction.

$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

The forward reaction is **exothermic**.

The yield of hydrogen iodide and the rate at which the reaction reaches equilibrium are affected by different conditions.

Look at two possible reaction conditions, **A** and **B**, the company could use for this reaction.

	Temperature (°C)	**Pressure (atmospheres)**	**Catalyst?**
A	450	1	Yes
B	700	3	No

The company decides to use reaction conditions **A**, instead of **B**.

Explain why they make this choice.

Use ideas about **rate of reaction** and **position of equilibrium** to help you.

.....

.....

.....

.....

.....

..... **[4]**

23 A student investigates an ionic compound, **Y**, to identify the two different ions in the compound.

The table shows the results of the tests that the student does.

	Test	Result
Test 1	flame test	yellow-orange flame
Test 2	dilute hydrochloric acid and a few drops of barium chloride solution are added to an aqueous solution of **Y**	white precipitate

(a) Use the results of tests **1** and **2** to write the **formula** of compound **Y**.

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

(b) Another ionic compound, **Z**, also contains two ions.

(i) The student adds a few drops of sodium hydroxide solution to a solution of compound **Z**.

A white precipitate forms.

Explain why this result does **not** identify the **cation** in compound **Z**.

.....

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

(ii) The student adds some dilute hydrochloric acid and a few drops of silver nitrate solution to a fresh solution of compound **Z**.

A white precipitate forms.

The student concludes that the **anion** in compound **Z** is a chloride ion, Cl^-.

Explain why the student cannot be certain that compound **Z** contains chloride ions.

.....

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

(iii) Describe how the student could improve the test in part **(ii)** to confirm that the **anion** in compound **Z** is a chloride ion, Cl^-.

..... **[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).