AQA

Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

GCSE CHEMISTRY

H

Higher Tier Paper 2

Tuesday 13 June 2023 Morning Time allowed: 1 hour 45 minutes

Materials

For this paper you must have:
- a ruler
- a scientific calculator
- the periodic table (enclosed).

Instructions
- Use black ink or black ball-point pen.
- Pencil should only be used for drawing.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.
- In all calculations, show clearly how you work out your answer.

Information
- The maximum mark for this paper is 100.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
TOTAL	

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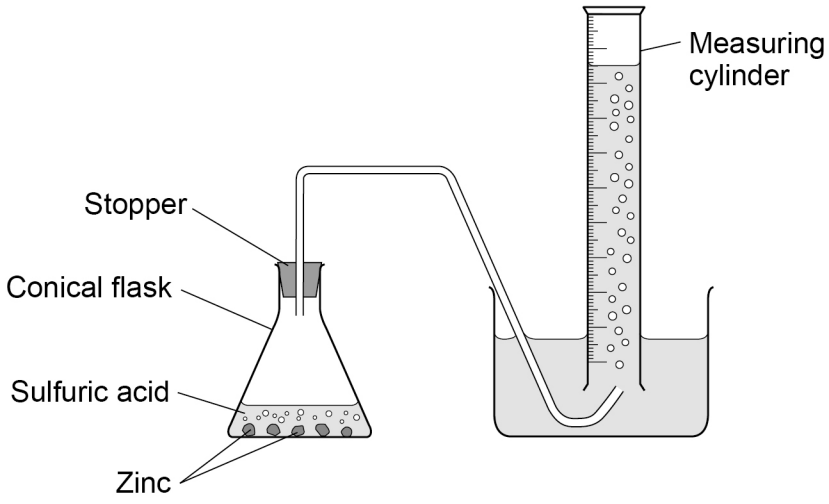
0 1 A student investigated the rate of the reaction between zinc and sulfuric acid.

Hydrogen gas is produced during this reaction.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Add 50 cm^3 of sulfuric acid to a conical flask.

2. Add 2.0 g of zinc to the conical flask.

3. Quickly put a stopper in the conical flask and start a timer.

4. Measure the time taken to collect 20 cm^3 of gas.

5. Repeat steps 1 to 4 three more times.

0 1 . 1 Suggest why the stopper must be put in the conical flask as quickly as possible in **step 3**.

[1 mark]

To reduce the escape of gas

Do not write outside the box

0 1 . 2 The student calculated the rate of the reaction for each trial.

Table 1 shows the results of the calculations.

Table 1

	Trial 1	Trial 2	Trial 3	Trial 4
Rate of reaction in cm^3/s	0.78	0.81	0.68	0.81

↑ anomaly

Determine the mean time taken to collect 20 cm^3 of gas.

Do **not** include any anomalous results.

Use the equation:

$$\text{mean rate of reaction} = \frac{\text{volume of gas collected}}{\text{mean time taken}}$$

[5 marks]

Mean Rate = $\frac{0.78 + 0.81 + 0.81}{3}$

$= 0.80\ cm^3/s$

Mean Time:

Mean Rate = $\frac{\text{Volume of gas collected}}{\text{Mean Time}}$

$0.80\ cm^3/s = \frac{20\ cm^3}{\text{Mean Time}}$

Mean Time = $\frac{20\ cm^3}{0.80\ cm^3/s} = 25s$

Mean time taken = 25 s

Question 1 continues on the next page

Do not write outside the box

0 1 . 3 The student changed the investigation so that the mean time taken to collect 20 cm^3 of gas was greater.

Which **two** changes would increase the mean time taken to collect 20 cm^3 of gas?

[2 marks]

Tick (✓) **two** boxes.

Use a catalyst	☐
Use a larger conical flask	☐
Use a lower temperature	✓
Use smaller pieces of zinc	☐
Use sulfuric acid of a lower concentration	✓

0 1 . 4 Hydrogen gas is produced during this reaction.

Describe the test for hydrogen gas.

Give the result of the test.

[2 marks]

Test Use a burning / lit splint

Result burns with a squeaky pop sound

10

Do not write outside the box

Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

Do not write outside the box

0 2 This question is about alcohols and carboxylic acids.

Alcohols are used as fuels.

A student burned 1.00 g of six alcohols and determined the energy released from each.

Table 2 shows the results.

Table 2

Alcohol	Formula of one molecule of the alcohol	Energy released in kJ/g
Ethanol	C_2H_5OH	29.6
Propanol	C_3H_7OH	33.6
Butanol	C_4H_9OH	36.1
Pentanol	$C_5H_{11}OH$	37.7
Hexanol	$C_6H_{13}OH$	38.9
Heptanol	$C_7H_{15}OH$	39.8

0 2 . 1 Calculate the mass of ethanol that must be burned to release the same amount of energy as burning 1.00 g of heptanol.

[2 marks]

Energy from 1.00g heptanol = 39.8 kJ

Equivalent mass of ethanol = $\frac{39.8\ kJ}{29.6\ kJ/g}$ = 1.34g

Mass = 1.34 g

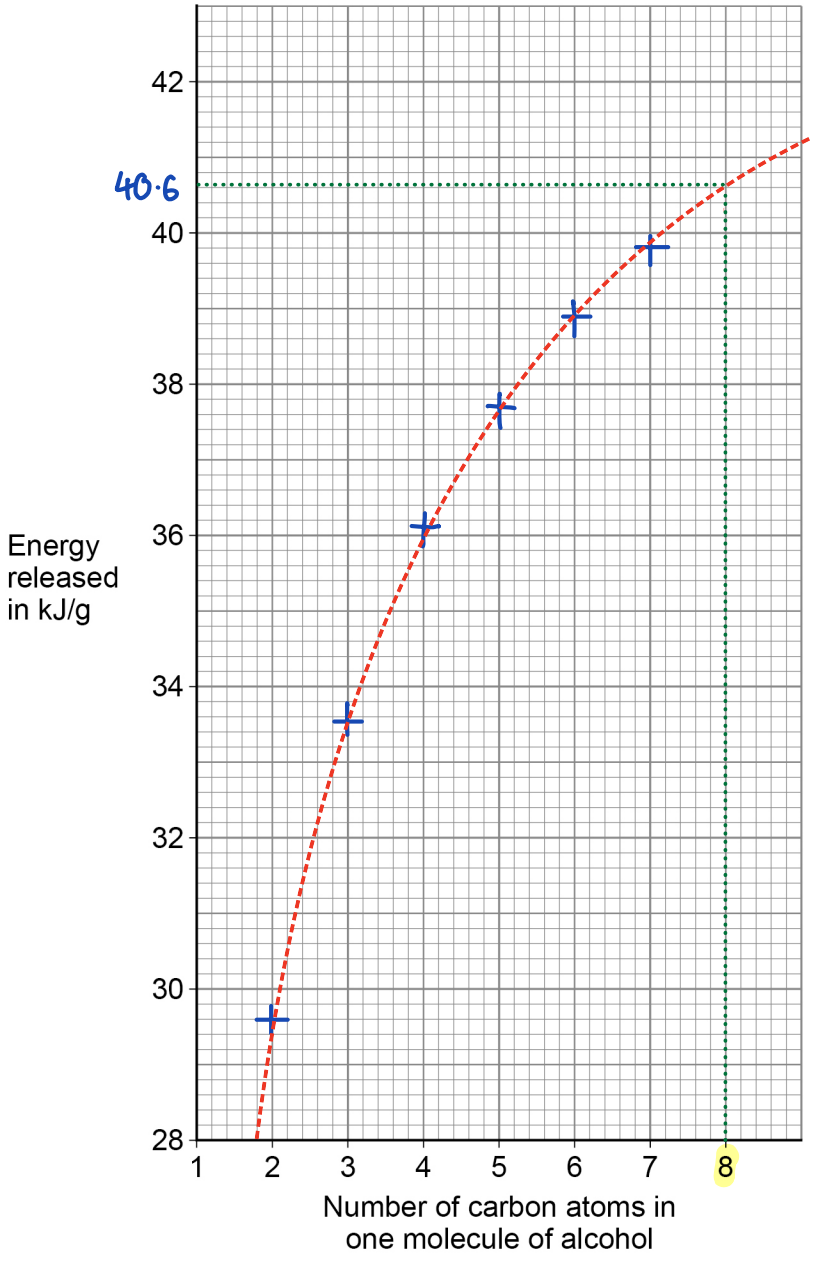
0 2 . 2 The energy released in kJ/g varies with the number of carbon atoms in one molecule of each alcohol.

Plot the data from **Table 2** on **Figure 2**.

[2 marks]

Do not write outside the box

Figure 2



0 2 . 3 Estimate the energy released in kJ when 1.00 g of octanol ($C_8H_{17}OH$) is burned.

Use **Figure 2**.

[1 mark]

Energy released = 40·6 kJ

Turn over ►

Do not write outside the box

Carbon dioxide is produced when alcohols are burned.

Carbon dioxide is identified by bubbling the gas through limewater.

0 2 . 4 Complete the sentence.

Choose the answer from the box.

[1 mark]

calcium chloride	**calcium hydroxide**	**calcium nitrate**	**calcium sulfate**

Limewater is an aqueous solution of calcium hydroxide.

0 2 . 5 Give the result of the test when carbon dioxide is bubbled through limewater.

[1 mark]

limewater turns milky / cloudy

Do not write outside the box

Ethanoic acid can be produced from ethanol.

0 2 . 6 What is reacted with ethanol to produce ethanoic acid?

[1 mark]

Tick (✓) **one** box.

A halogen ☐

An alkali metal ☐

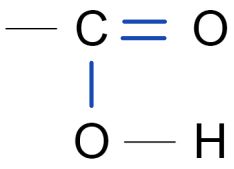
An oxidising agent ☑

Water ☐

0 2 . 7 Ethanoic acid contains the functional group –COOH

Complete the displayed structural formula of this functional group.

[1 mark]



Question 2 continues on the next page

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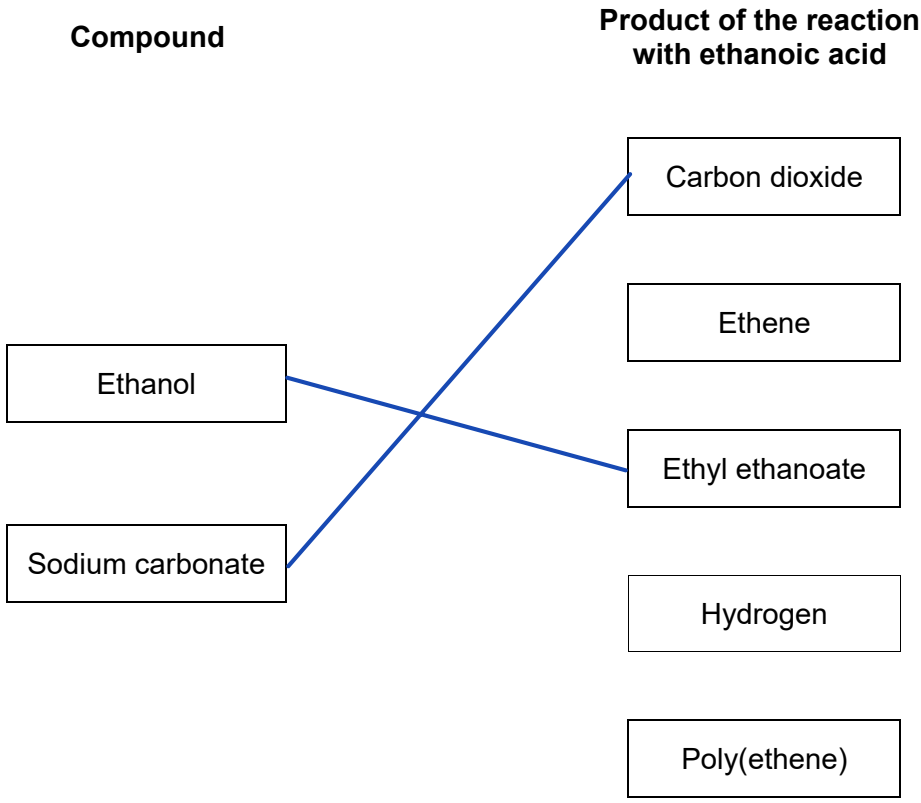
0 2 . 8 Ethanoic acid reacts with different compounds.

Draw **one** line from each compound to a product of the reaction of the compound with ethanoic acid.

[2 marks]



11

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Turn over for the next question

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ANSWER IN THE SPACES PROVIDED

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0 3 This question is about chemical analysis.

Potassium bromide is used in medicine.

A scientist tested a sample of medicine to show the presence of potassium ions and of bromide ions.

The sample is soluble in water.

0 3 . 1 Plan a method the scientist could use to show that the sample of medicine contains potassium ions **and** bromide ions.

The scientist has:

- a Bunsen burner
- a metal wire
- test tubes
- a dropping pipette
- distilled water
- dilute nitric acid
- silver nitrate solution.

You should give the results of the tests.

[6 marks]

Potassium Ions:

Place sample on clean metal wire
Introduce into blue flame of Bunsen burner
Observe lilac flame colour showing presence of potassium ions.

Bromide Ions:

Dissolve sample in distilled water
In a test tube add dilute nitric acid
Add silver nitrate solution using dropping pipette
Observe cream precipitate showing presence of bromide ions

Do not write outside the box

The scientist could also use an instrumental method to show the presence of potassium ions in the medicine.

0 3 . 2 Which instrumental method could be used to show the presence of potassium ions in the medicine?

[1 mark]

Flame emission spectroscopy

0 3 . 3 Give **one** advantage of using this instrumental method instead of a chemical test.

[1 mark]

More accurate can determine the concentration of ions present.

8

Turn over for the next question

Do not write outside the box

0 4 This question is about greenhouse gases and climate change.

Carbon dioxide and methane are greenhouse gases.

0 4 . 1 Which of the following is also a greenhouse gas?

[1 mark]

Tick (✓) **one** box.

Chlorine ☐

Nitrogen ☐

Oxygen ☐

Water vapour ✓

In the past 50 years, there has been an increase in:

- the world population
- the concentration of carbon dioxide in the atmosphere
- the concentration of methane in the atmosphere
- the mean temperature of the atmosphere at the Earth's surface.

Most scientists think this information can be used to explain climate change.

0 4 . 2 Explain why the increase in world population may have caused the increase in the concentration of carbon dioxide in the atmosphere.

[2 marks]

Increased population so more energy required. So more fossil fuels burned.

Do not write outside the box

0 4 . 3 Explain why the increase in world population may have caused the increase in the concentration of methane in the atmosphere.

[2 marks]

Increased population so more food required.
So more methane-producing food production.
(more cattle)

0 4 . 4 Describe **two** potential effects of the increase in the mean temperature of the atmosphere at the Earth's surface.

[2 marks]

1 Rising sea levels

2 Melting ice

0 4 . 5 The mean temperature of the atmosphere at the Earth's surface has increased.

Most scientists think that this has been caused by an increase in the concentration of greenhouse gases in the atmosphere.

Give **one** reason why some scientists do **not** accept this theory.

[1 mark]

There may be other reasons for changes in the mean temperature of the atmosphere at the Earth's surface.

8

Turn over for the next question

Do not write outside the box

0 5 Copper is extracted from metal ores.

Chalcopyrite is a metal ore containing a compound with the formula $CuFeS_2$

0 5 . 1 $CuFeS_2$ reacts with oxygen to produce copper(II) sulfate and iron(II) sulfate.

Complete the equation for this reaction.

You should balance the equation.

[2 marks]

$$CuFeS_2 + 4\ O_2 \rightarrow CuSO_4 + FeSO_4$$

0 5 . 2 Calculate the percentage by mass of copper in $CuFeS_2$

Relative atomic masses (A_r): S = 32 Fe = 56 Cu = 63.5

[3 marks]

M_r $CuFeS_2$ $= 63.5 + 56 + (32 \times 2) = 183.5$

% mass Cu $= \frac{63.5}{183.5} \times 100\% = 34.6$

Percentage by mass = 34.6 %

0 5 . 3 Describe a test to show the presence of copper(II) ions in a solution of copper(II) sulfate.

Give the result of the test.

[2 marks]

Test Add sodium hydroxide solution

Result Blue precipitate

(or flame test: giving green flame)

Do not write outside the box

0 5 . 4 Copper can be extracted from low-grade ores by bioleaching.

Describe what is meant by bioleaching.

[2 marks]

The use of bacteria to produce leachate solutions that contain metal / copper compounds.

9

Turn over for the next question

Do not write outside the box

0 6 This question is about chromatography.

A student investigated an orange food colouring using two different types of chromatography paper.

The food colouring:

- contained a mixture of red and yellow dyes
- was soluble in water.

This is the method used.

1. Draw a start line on a piece of type **A** chromatography paper.
2. Put a spot of orange food colouring on the line.
3. Put the paper into a beaker containing water as a solvent.
4. Wait for the water to travel up the paper.
5. Measure the distance above the start line moved by the red and yellow dyes and the water.
6. Repeat steps 1 to 5 using type **B** chromatography paper.

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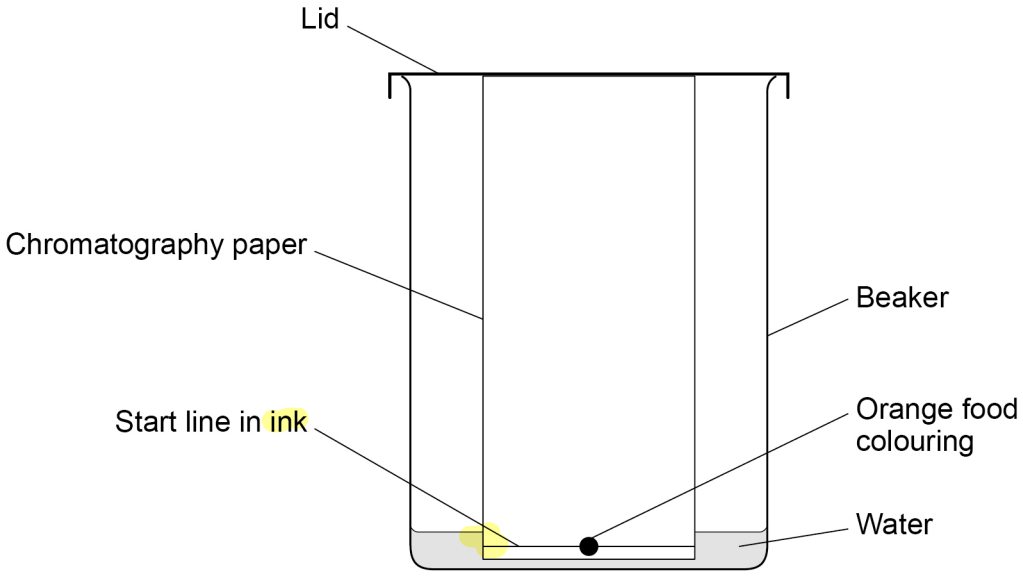
Figure 3 shows how the student set up the apparatus.

Figure 3



0 6 . 1 The student made **two** mistakes when setting up the apparatus.

Give **two** mistakes the student made.

[2 marks]

1 The start line is drawn in ink

2 The start line is below the water level

Question 6 continues on the next page

Another student set up the apparatus correctly.

Table 3 shows the results.

Table 3

	Type A chromatography paper		Type B chromatography paper	
	Red dye	**Yellow dye**	**Red dye**	**Yellow dye**
Distance moved by dye in cm	4.8	6.6	5.4	**X**
Distance moved by water in cm	12.0	12.0	12.0	12.0
R_f value	0.40	0.55	0.45	0.60

0 6 . 2 Determine value **X** in **Table 3**.

[3 marks]

R_f value = $\frac{\text{Distance moved by dye}}{\text{Distance moved by water}}$

$0.60 = \frac{X}{12.0}$

$X = 12.0 \times 0.60$

$= 7.2$ cm

X = 7.2 cm

Do not write outside the box

Changing the type of chromatography paper resulted in different R_f values for the red dye.

0 6 . 3 Explain why the R_f values for the red dye are different using the two types of chromatography paper.

Use **Table 3**.

[3 marks]

The Rf value is smaller for Paper A

Because the red dye is more attracted to Paper A than B.

So, the red dye spends a greater proportion of the time distributed in Paper A than in B.

0 6 . 4 What other change to the investigation could result in a different R_f value for the red dye?

[1 mark]

Use a different solvent.

9

Turn over for the next question

Do not write outside the box

0 7 Manganese dioxide catalyses the decomposition of hydrogen peroxide solution.

Oxygen and water are produced.

0 7 . 1 Explain how a manganese dioxide catalyst increases the rate of decomposition of hydrogen peroxide.

[2 marks]

A catalyst provides a different pathway for the reaction, which has a lower activation energy.

A student investigated the rate of this reaction.

This is the method used.

1. Add 50 cm^3 of 2.0 mol/dm^3 hydrogen peroxide solution to a conical flask.

2. Add 1.0 g of manganese dioxide to the conical flask.

3. Place the conical flask on a balance and start a timer.

4. Record the total mass lost from the conical flask every 20 seconds for 180 seconds.

0 7 . 2 Explain why the mass of the conical flask and contents decreased.

[2 marks]

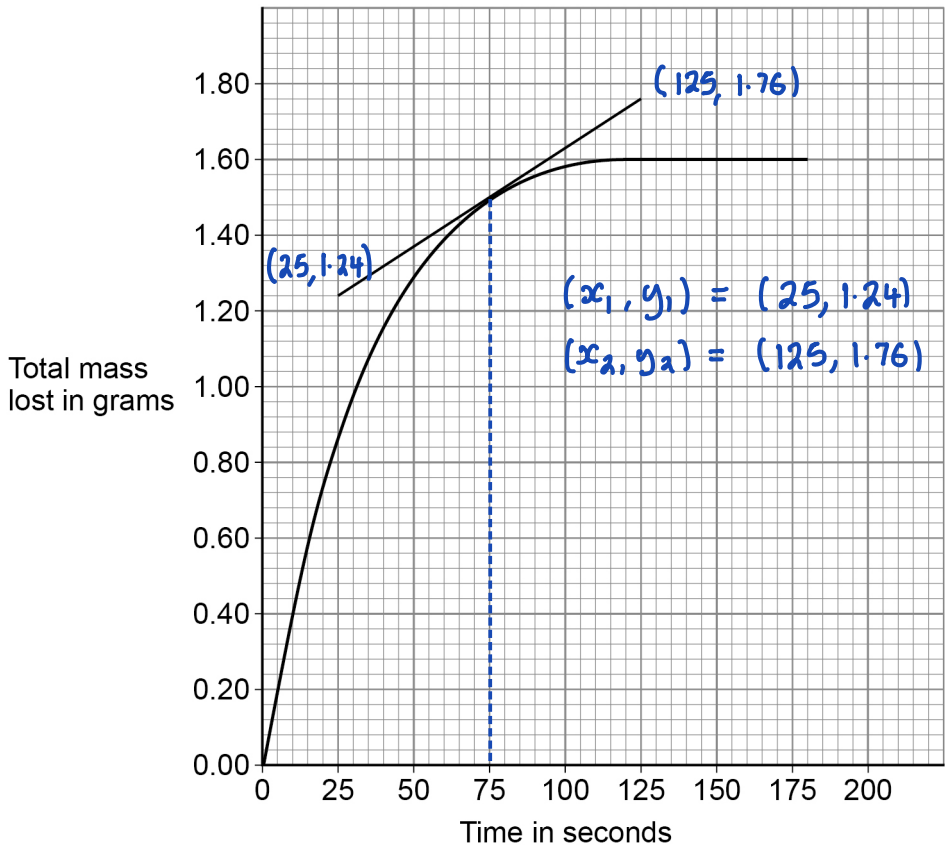
Oxygen is a gas which escaped from the flask.

Do not write outside the box

0 7 . 3 **Figure 4** shows the results for 50 cm^3 of 2.0 mol/dm^3 hydrogen peroxide solution and 1.0 g of manganese dioxide.

A tangent to the line has been drawn at 75 seconds.

Figure 4



Determine the rate of reaction when the time was 75 seconds.

Give your answer to 2 significant figures.

[4 marks]

Rate of reaction = gradient of tangent at $t = 75$ s

Rate = gradient = $\frac{\text{change in } y}{\text{change in } x}$

Gradient = $\frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1} = \frac{1·76 - 1·24}{125 - 25} = \frac{0·52}{100} = 0·0052$ g/s

Rate (2 significant figures) = 0·0052 g/s

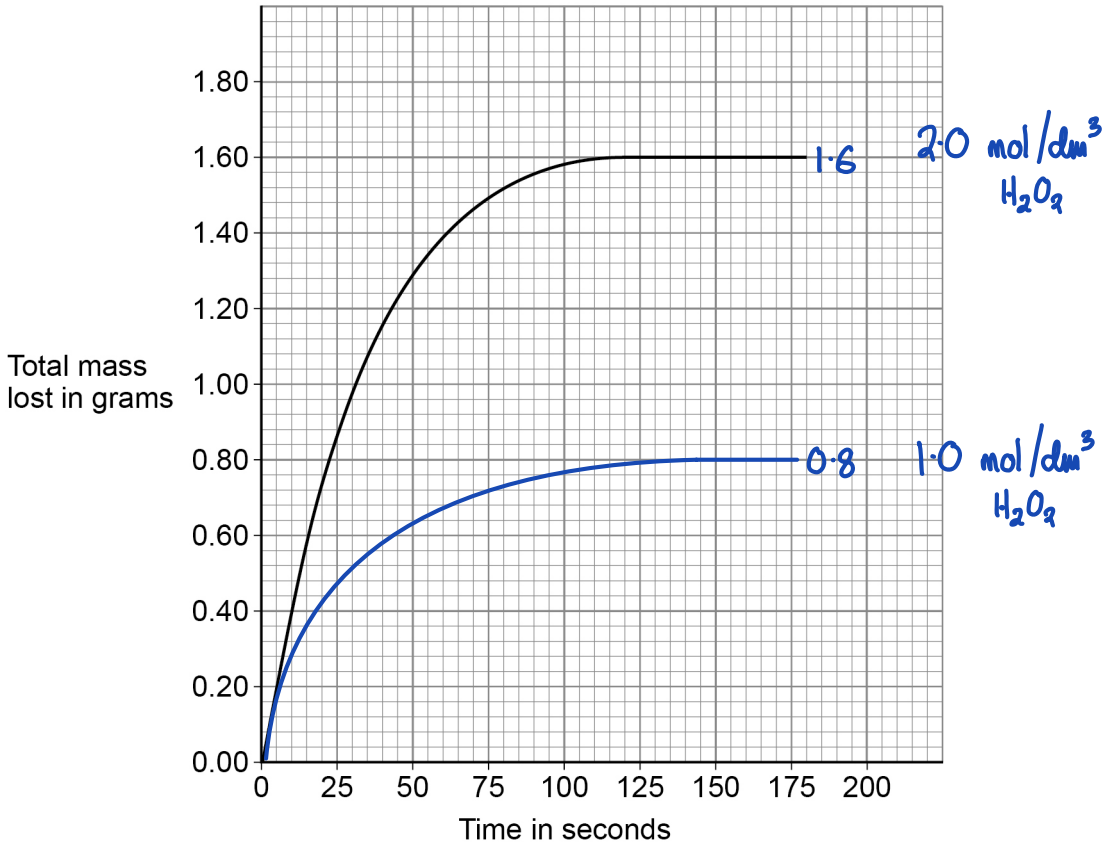
or $5·2 \times 10^{-3}$

Turn over ►

Do not write outside the box

0 7 . 4 The results for 50 cm^3 of 2.0 mol/dm^3 hydrogen peroxide solution and 1.0 g of manganese dioxide are shown again on **Figure 5**.

Figure 5



The student repeated the investigation using 50 cm^3 of 1.0 mol/dm^3 hydrogen peroxide solution and 1.0 g of manganese dioxide.

Sketch the expected results for 1.0 mol/dm^3 hydrogen peroxide solution on **Figure 5**.

[2 marks]

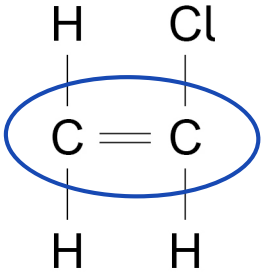
10

Do not write outside the box

0 8 This question is about polymers.

Chloroethene can be used to produce an addition polymer called poly(chloroethene).

The displayed structural formula of chloroethene is

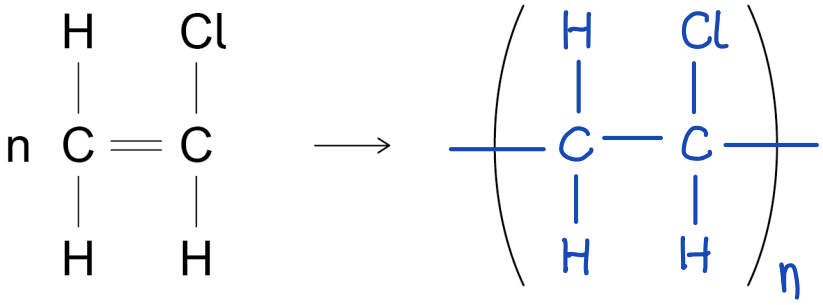


0 8 . 1 Draw a circle around the functional group on the displayed structural formula that allows chloroethene to produce an addition polymer.

[1 mark]

0 8 . 2 Complete the equation for the production of poly(chloroethene) from chloroethene.

[3 marks]



0 8 . 3 Poly(ethene) can be strengthened with wood particles to make a building material.

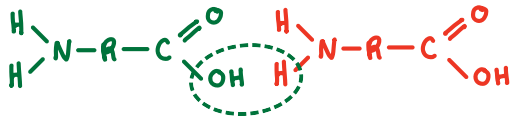
The building material consists of a wood particle reinforcement embedded in a poly(ethene) matrix.

What general name is given to materials like this?

[1 mark]

Composite materials

Turn over ►



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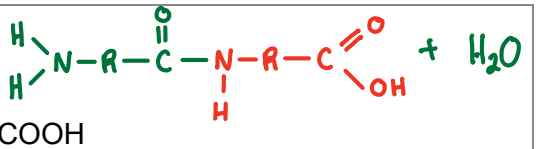
0 8 . 4 The amino acid beta-alanine has the formula



$H_2NCH_2CH_2COOH$

Beta-alanine polymerises to produce a polypeptide and a small molecule.

Name the small molecule produced when beta-alanine polymerises.

[1 mark]

Water

0 8 . 5 An amino acid can be represented as:

H_2N — ▬ — COOH

The relative formula mass (M_r) of this amino acid is 75

Calculate the relative formula mass of the section of this amino acid molecule represented by

— ▬ —

Relative atomic masses (A_r): H = 1 C = 12 N = 14 O = 16

[2 marks]

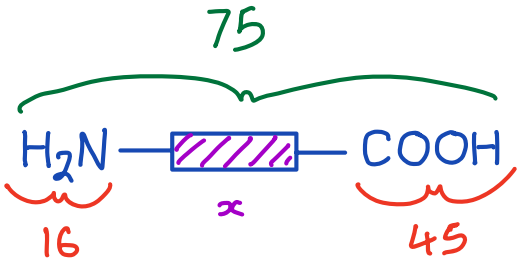
M_r of whole amino acid = 75

M_r of functional groups = 16 + 45

H_2N + COOH = 61

M_r of section = 75 − 61 = 14

Relative formula mass = 14



$NH_2 = 14 + (2 \times 1) = 16$

$COOH = 12 + (2 \times 16) + 1 = 45$

$75 = 16 + x + 45$

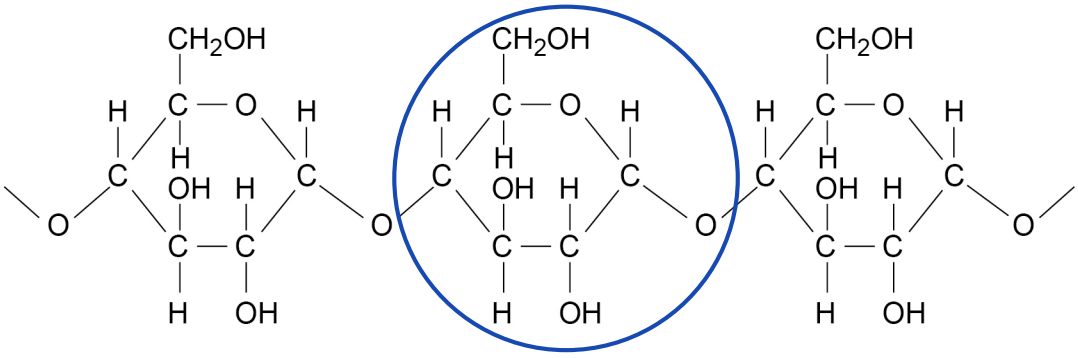
$x = 75 - 16 - 45$

$x = 14$

Do not write outside the box

Figure 6 represents part of a naturally occurring polymer molecule produced from glucose.

Figure 6



0 8 . 6 Draw a circle around the repeating unit in the polymer in **Figure 6**.

[1 mark]

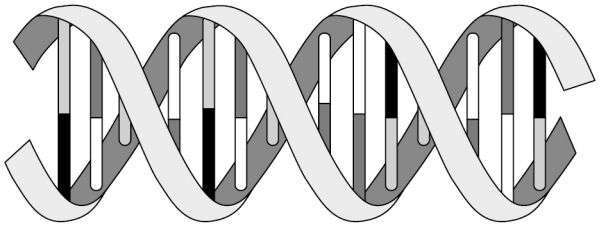
0 8 . 7 Suggest the identity of this polymer.

[1 mark]

Starch

Figure 7 represents the structure of a naturally occurring polymer.

Figure 7



0 8 . 8 Give the general name for the four different monomers which make up the structure shown in **Figure 7**.

[1 mark]

Nucleotides

0 8 . 9 Name the **shape** of the structure shown in **Figure 7**.

[1 mark]

Double helix

12

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There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

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0 9 This question is about reversible reactions.

When 4.68 g of hydrated copper sulfate changes into anhydrous copper sulfate:

- 2.99 g of anhydrous copper sulfate is produced
- 1.47 kJ of energy is taken in from the surroundings.

The equation for the reversible reaction is:

hydrated copper sulfate ⇌ anhydrous copper sulfate + water

4·68g 2·99g x (4·68 − 2·99) 1·69g

0 9 . 1 Calculate the maximum mass of water that can be produced from 11.7 g of hydrated copper sulfate.

[3 marks]

Mass of water in 4·68g h. $CuSO_4$ = 1·69g

" " " 11·7g " = $\frac{11·7}{4·68} \times 1·69$

= 4·23g

Mass = 4·23 g

←

0 9 . 2 15.0 g of anhydrous copper sulfate completely changes into hydrated copper sulfate when water is added.

Calculate the amount of energy transferred to the surroundings.

[2 marks]

2·99g produces 1·47 kJ

15·0g " $\frac{15·0}{2·99} \times 1·47$ = 7·37

Energy = 7·37 kJ

Turn over ►

Do not write outside the box

The gases nitrogen dioxide and dinitrogen tetroxide reach dynamic equilibrium in a sealed container.

The equation for the reaction is:

$$2\ NO_2(g) \rightleftharpoons N_2O_4(g)$$

nitrogen dioxide (brown) ⇌ dinitrogen tetroxide (colourless)

The forward reaction is exothermic.

0 9 . 3 What happens to the position of the equilibrium in this reaction if the temperature is increased?

[1 mark]

Tick (✓) **one** box.

- Shifts to the left ☑
- Stays the same ☐
- Shifts to the right ☐

$2\ NO_2(g) \rightleftharpoons N_2O_4(g)$

$\longrightarrow$ + HEAT

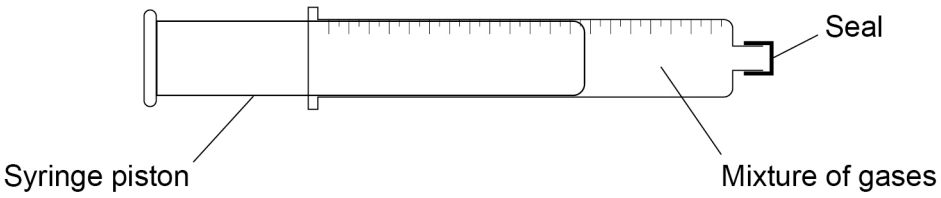
If Temp. increased, equilibrium shifts to oppose change. Produce less heat so more to the left (reverse reaction)

Do not write outside the box

0 9 . 4 A teacher seals a brown-coloured mixture of nitrogen dioxide and dinitrogen tetroxide in a gas syringe.

Figure 8 shows the sealed gas syringe.

Figure 8



$2\ NO_2 \rightleftharpoons N_2O_4$

brown — colourless

The teacher pushes the syringe piston in.

This increases the pressure in the gas syringe.

P ↑ eq^m → RHS

fewer moles gas

What is the colour of the mixture when a new equilibrium position is reached?

[1 mark]

Tick (✓) **one** box.

- The mixture is a darker shade of brown. ☐
- The mixture is the same shade of brown. ☐
- The mixture is a lighter shade of brown. ☑

Question 9 continues on the next page

Do not write outside the box

Hydrogen iodide gas decomposes into hydrogen gas and iodine gas at high temperatures.

The equation for the reaction is:

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

N° mol gas 2 1 + 1 = 2

0 9 . 5 Explain the effect of increasing the pressure on the equilibrium position of this reaction.

[2 marks]

No effect on equilibrium position because there are equal numbers of gas moles on each side of the equation.

0 9 . 6 Suggest the effect of adding a catalyst on the equilibrium position of this reaction.

[1 mark]

No effect on equilibrium position (just gets there more quickly)

Do not write outside the box

Copper forms coloured compounds.

Hydrochloric acid is added to an aqueous solution of copper compound **A**.

The word equation for the reaction is:

copper compound **A** (blue) + hydrochloric acid ⇌ copper compound **B** (yellow) + water

0 9 . 7 The reaction mixture is green when both copper compounds are present in a solution at equilibrium.

How can the equilibrium position be shifted to make the reaction mixture more yellow?

[1 mark]

Tick (✓) **one** box.

Shift → RHS
add HCl

- [✓] Add more hydrochloric acid
- [ ] Add more water
- [ ] Leave the reaction mixture for 30 minutes

0 9 . 8 The concentrations of the substances in this reaction do **not** change at dynamic equilibrium.

Explain why.

[2 marks]

Because the forward and reverse reactions are taking place at the same rate.

13

Turn over ►

Do not write outside the box

1 0 This question is about fertilisers.

Compounds of nitrogen (N), phosphorus (P) and potassium (K) are used as fertilisers to improve agricultural productivity.

Table 4 shows information about three compounds, **A**, **B** and **C**, that can be used as fertilisers.

Table 4

	Compound A	**Compound B**	**Compound C**
Name	potassium chloride	ammonium nitrate	diammonium hydrogen phosphate
Formula	KCl	NH_4NO_3	$(NH_4)_2HPO_4$
Percentage (%) of N, P and K by mass	**K**: 52%	**N**: 35%	**N**: 21% **P**: 23%
Cost in £/kg	0.24	0.23	0.35

1 0 . 1 A scientist analysed the percentages of nitrogen, phosphorus and potassium in a soil.

The percentages of nitrogen and of potassium in the soil were lower than the percentages needed for high agricultural productivity.

There was sufficient phosphorus in the soil for high agricultural productivity.

Evaluate the use of the compounds in **Table 4** to improve the agricultural productivity of this soil.

[4 marks]

Reasons:

A - Only contains K

A - Is the only source of K, so needed

B - Only contains N

B - Contains more N than compound C and is cheaper. Therefore preferable and more cost effective.

C - Contains P which is not needed

A mixture of A and B should be used

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1 0 . 2 How is potassium chloride (compound **A**) obtained from the Earth?

[1 mark]

Mining

1 0 . 3 Name **one** other compound that could be used instead of potassium chloride (compound **A**) to give a similar improvement in agricultural productivity.

[1 mark]

Potassium sulfate

1 0 . 4 Nitric acid is needed to produce ammonium nitrate (compound **B**).

Name a compound needed to produce nitric acid.

[1 mark]

Ammonia

1 0 . 5 Phosphate rock contains phosphorus compounds.

Plants absorb phosphorus from compounds dissolved in rainwater.

Suggest why phosphate rock **cannot** be used directly as a fertiliser.

[1 mark]

Phosphate rock is insoluble in water.

1 0 . 6 Phosphate rock can be treated with different acids to produce salts useful as fertilisers.

Name the salts which are produced by treating phosphate rock with:

- sulfuric acid
- phosphoric acid.

[2 marks]

Sulfuric acid Calcium sulfate

Phosphoric acid Calcium phosphate.

10

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