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

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.

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

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.

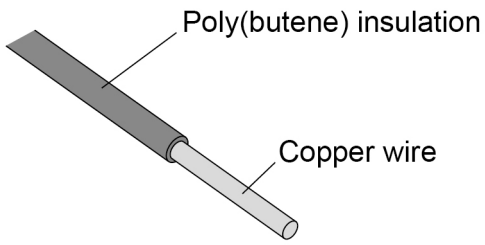
Do not write outside the box

0 1 This question is about copper wire and copper compounds.

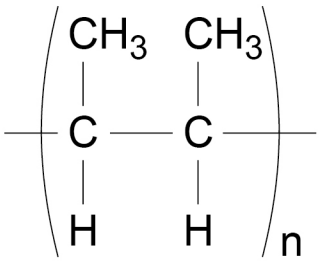
Copper is used to make electrical wires.

Figure 1 shows how copper electrical wire is insulated using an addition polymer called poly(butene).

Figure 1



0 1 . 1 The addition polymer poly(butene) has the displayed structural formula:

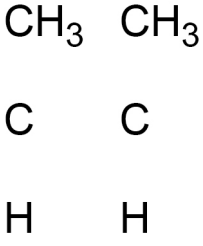


Poly(butene) is produced from the monomer butene.

Complete **Figure 2** to show the displayed structural formula of butene.

[2 marks]

Figure 2



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Copper can be obtained by recycling scrap copper wire.

0 1 . 2 Suggest why poly(butene) insulation must be removed from scrap copper wire before the copper is recycled.

[1 mark]

0 1 . 3 Describe how scrap copper wire can be recycled to make new copper water pipes.

[2 marks]

0 1 . 4 Suggest **two** reasons why recycling scrap copper is more sustainable than extracting copper from copper ores.

[2 marks]

1

2

Question 1 continues on the next page

Copper sulfate is a compound of copper.

Copper sulfate solution contains copper(II) ions and sulfate ions.

0 1 . 5 A solution can be added to copper sulfate solution to show the presence of copper(II) ions.

Name the solution added.

Give the result of the test.

[2 marks]

Name of solution added _____

_____

Result _____

_____

0 1 . 6 Describe **one** test to show the presence of sulfate ions in copper sulfate solution.

Give the result of the test.

[2 marks]

Test _____

_____

Result _____

_____

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 2 A student investigated the change in mass when hydrated cobalt chloride was heated.

The word equation for the reaction is:

hydrated cobalt chloride ⇌ anhydrous cobalt chloride + water

This is the method used.

1. Add 2.0 g of hydrated cobalt chloride to an empty test tube.
2. Measure the mass of the test tube and contents.
3. Heat the test tube and contents gently for 30 seconds.
4. Allow the test tube and contents to cool.
5. Measure the mass of the test tube and contents.
6. Repeat steps 3 to 5 until the mass of the test tube and contents does not change.

Table 1 shows the results.

Table 1

Total heating time in seconds	Mass of test tube and contents in grams
0	26.5
30	26.2
60	25.9
90	25.6
120	25.6

Do not write outside the box

0 2 . 1 Determine the mass of the empty test tube.

[1 mark]

Mass of empty test tube = _____ g

0 2 . 2 Explain why the mass of the test tube and contents decreased.

[2 marks]

0 2 . 3 Suggest why the test tube and contents were heated until the mass did not change.

[1 mark]

Question 2 continues on the next page

Do not write outside the box

Energy is taken in from the surroundings when hydrated cobalt chloride is heated.

0 2 . 4 When 238 g of hydrated cobalt chloride is heated until the mass does not change, 88.1 kJ of energy is taken in.

The student heated 2.00 g of hydrated cobalt chloride until the mass did not change.

Calculate the energy taken in during this reaction.

Give your answer to 3 significant figures.

[3 marks]

Energy taken in (3 significant figures) = _____ kJ

0 2 . 5 What type of reaction takes place when hydrated cobalt chloride is heated?

[1 mark]

8

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 3 This question is about life cycle assessments (LCAs).

0 3 . 1 Milk bottles can be made from glass or from a polymer.

Table 2 shows information about milk bottles of equal volume.

Table 2

	Glass	**Polymer**
Raw materials	Limestone Sand Sodium carbonate	Crude oil
Energy needed to process raw materials in kilojoules	6750	1710
Energy needed to manufacture bottle in kilojoules	750	90
Mass of bottle in grams	200	20
Mean number of times used during lifetime of bottle	25	1
One disposal method at end of useful life	Recycled to make different glass products	Recycled to make different polymer products

Evaluate the use of glass for milk bottles compared with the use of a polymer for milk bottles.

Use features of life cycle assessments (LCAs) in your answer.

Use **Table 2**.

[6 marks]

Do not write outside the box

0 3 . 2 Milk is also sold in cardboard cartons.

A carton is made using 40 cm^3 of cardboard.

The density of the cardboard is 0.40 g/cm^3.

Calculate the mass of the carton.

Use the equation:

$$\text{density} = \frac{\text{mass}}{\text{volume}}$$

[3 marks]

Mass = _____ g

9

Do not write outside the box

0 4 This question is about the fractions obtained from crude oil.

0 4 . 1 Crude oil is separated into fractions by fractional distillation.

The fractions obtained from crude oil include:

- lubricating oil
- naphtha
- petroleum gases.

Table 3 shows the boiling point range of these fractions.

Table 3

Fraction	Boiling point range in °C
Lubricating oil	300–350
Naphtha	90–200
Petroleum gases	< 25

Explain how these fractions are obtained from crude oil by fractional distillation.

[4 marks]

Do not write outside the box

0 4 . 2 Fractions from crude oil can be processed to produce feedstock for the petrochemical industry.

Which **two** are useful materials produced from this feedstock?

[2 marks]

Tick (✓) **two** boxes.

Alloys ☐

Ceramics ☐

Detergents ☐

Fertilisers ☐

Solvents ☐

Another fraction obtained from crude oil is petrol.

0 4 . 3 Petrol contains a hydrocarbon with the formula C_9H_{20}

Complete the equation for the complete combustion of C_9H_{20}

You should balance the equation.

[2 marks]

C_9H_{20} + _____ → _____ + _____

0 4 . 4 Petrol obtained from crude oil contains sulfur impurities.

Explain why sulfur impurities are removed before petrol is burned in car engines.

[2 marks]

Do not write outside the box

0 4 . 5 **Table 4** shows information about two more fractions obtained from crude oil.

Table 4

Fraction	Range of number of carbon atoms in each molecule
Kerosene	11–15
Heavy fuel oil	20–40

A student predicted that heavy fuel oil is more viscous than kerosene.

The student's prediction was correct.

Justify the student's prediction.

[2 marks]

Do not write outside the box

The heavy fuel oil fraction can be processed to produce smaller hydrocarbon molecules.

0 4 . 6 Name the process which produces smaller hydrocarbon molecules from heavy fuel oil.

Give the conditions used in this process.

[3 marks]

Name of process _____

Conditions _____

_____

_____

0 4 . 7 Hydrocarbon molecules containing seven and eight carbon atoms can be produced when heavy fuel oil is processed.

Which pair of hydrocarbon molecules would **both** turn bromine water colourless?

[1 mark]

Tick (✓) **one** box.

C_7H_{14} and C_8H_{16} ☐

C_7H_{14} and C_8H_{18} ☐

C_7H_{16} and C_8H_{16} ☐

C_7H_{16} and C_8H_{18} ☐

16

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ANSWER IN THE SPACES PROVIDED

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0 5 This question is about water.

0 5 . 1 Sewage is waste water.

Sewage contains organic matter.

Describe how sewage is treated to remove organic matter.

[4 marks]

Question 5 continues on the next page

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Sea water and ground water are treated to make them potable.

Table 5 shows information about the composition and treatment of sea water and of ground water.

Table 5

	Sea water	**Ground water**
Concentration of sodium ions and chloride ions before **Process 1**	Na^+ : 0.5 mol/dm^3 Cl^- : 0.5 mol/dm^3	Na^+ : 0.001 mol/dm^3 Cl^- : 0.001 mol/dm^3
Process 1	Reverse osmosis	Filtration
Concentration of sodium ions and chloride ions after **Process 1**	**X**	Na^+ : 0.001 mol/dm^3 Cl^- : 0.001 mol/dm^3
Process 2	Add ozone	Expose to ultraviolet light

0 5 . 2 Sea water is desalinated during **Process 1**.

Which pair of concentrations could represent **X** in **Table 5**?

[1 mark]

Tick (✓) **one** box.

Na^+ : 0.003 mol/dm^3 Cl^- : 0.003 mol/dm^3 ☐

Na^+ : 0.003 mol/dm^3 Cl^- : 0.5 mol/dm^3 ☐

Na^+ : 0.5 mol/dm^3 Cl^- : 0.003 mol/dm^3 ☐

Na^+ : 0.5 mol/dm^3 Cl^- : 0.5 mol/dm^3 ☐

0 5 . 3 Explain why the concentrations of sodium ions and of chloride ions in the ground water in **Table 5** are unchanged by **Process 1**.

[2 marks]

Do not write outside the box

0 5 . 4 Explain why the ground water in **Table 5** requires **Process 2** before the water is safe to drink.

[2 marks]

0 5 . 5 After treatment the ground water in **Table 5** is sold by a company as pure water.

The ground water in **Table 5** is not chemically pure because the water contains sodium ions and chloride ions.

Suggest what the company means by 'pure'.

[1 mark]

0 5 . 6 Chlorine is also used to treat some ground water.

Describe the test for chlorine gas.

Give the result of the test.

[2 marks]

Test

Result

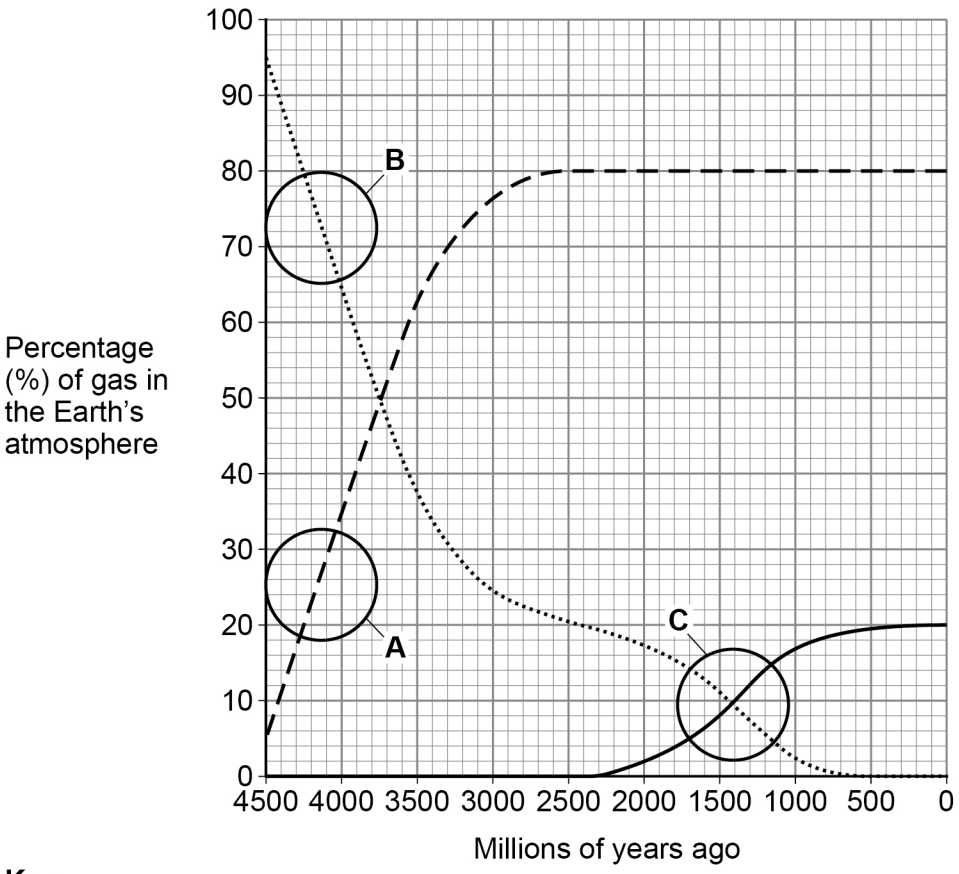
12

Do not write outside the box

0 6 This question is about the chemistry of the Earth's atmosphere.

Figure 3 shows how the percentages of gases in the Earth's atmosphere may have changed since the atmosphere was formed.

Figure 3



0 6 . 1 Explain the change in the percentage of gas in the region labelled **A** on **Figure 3**.

[2 marks]

Do not write outside the box

0 6 . 2 Explain the change in the percentage of gas in the region labelled **B** on **Figure 3**.

[2 marks]

0 6 . 3 Compare the changes in the percentages of gases in the region labelled **C** on **Figure 3**.

[2 marks]

0 6 . 4 What process caused the changes in the percentages of gases in the region labelled **C** on **Figure 3**?

[1 mark]

0 6 . 5 Natural gas is a fossil fuel.

Describe how deposits of natural gas were formed.

[3 marks]

10

Do not write outside the box

0 7 Ammonia is produced in the Haber process.

The raw materials for the Haber process are nitrogen and hydrogen.

The equation for the reaction is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

0 7 . 1 Give the sources of the nitrogen and of the hydrogen used in the Haber process.

[2 marks]

Nitrogen _____

Hydrogen _____

0 7 . 2 How does the equation for the reaction show that the atom economy of the forward reaction is 100%?

[1 mark]

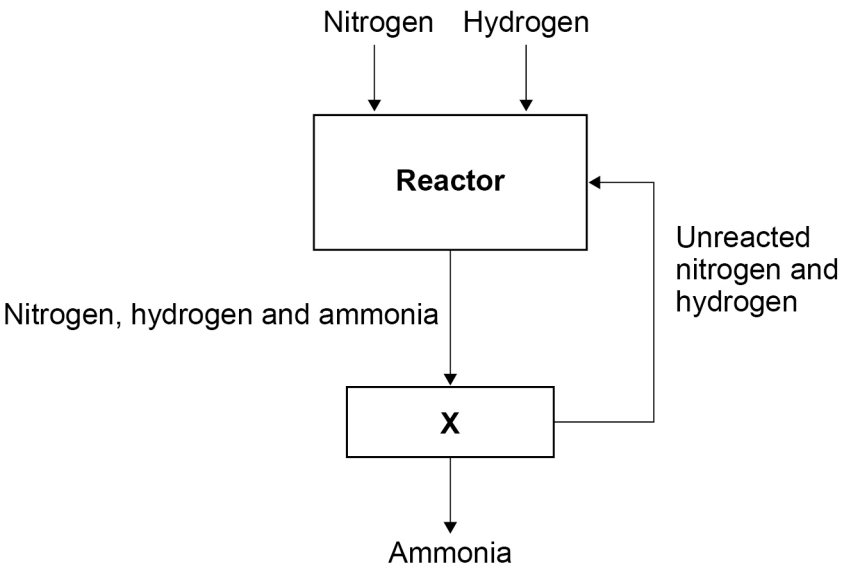
_____

_____

Do not write outside the box

0 7 . 3 **Figure 4** represents the Haber process.

Figure 4



Explain how the ammonia produced is separated from the unreacted nitrogen and hydrogen in **X**.

[2 marks]

Question 7 continues on the next page

The Haber process uses a temperature of 450 °C and a pressure of 200 atmospheres.

Table 6 shows the percentage yield of ammonia produced at 450 °C using different pressures.

Table 6

Pressure in atmospheres	Percentage (%) yield of ammonia
60	9
120	18
180	25
240	31
300	36
360	40
420	43

Do not write outside the box

0 7 . 4 Complete **Figure 5**.

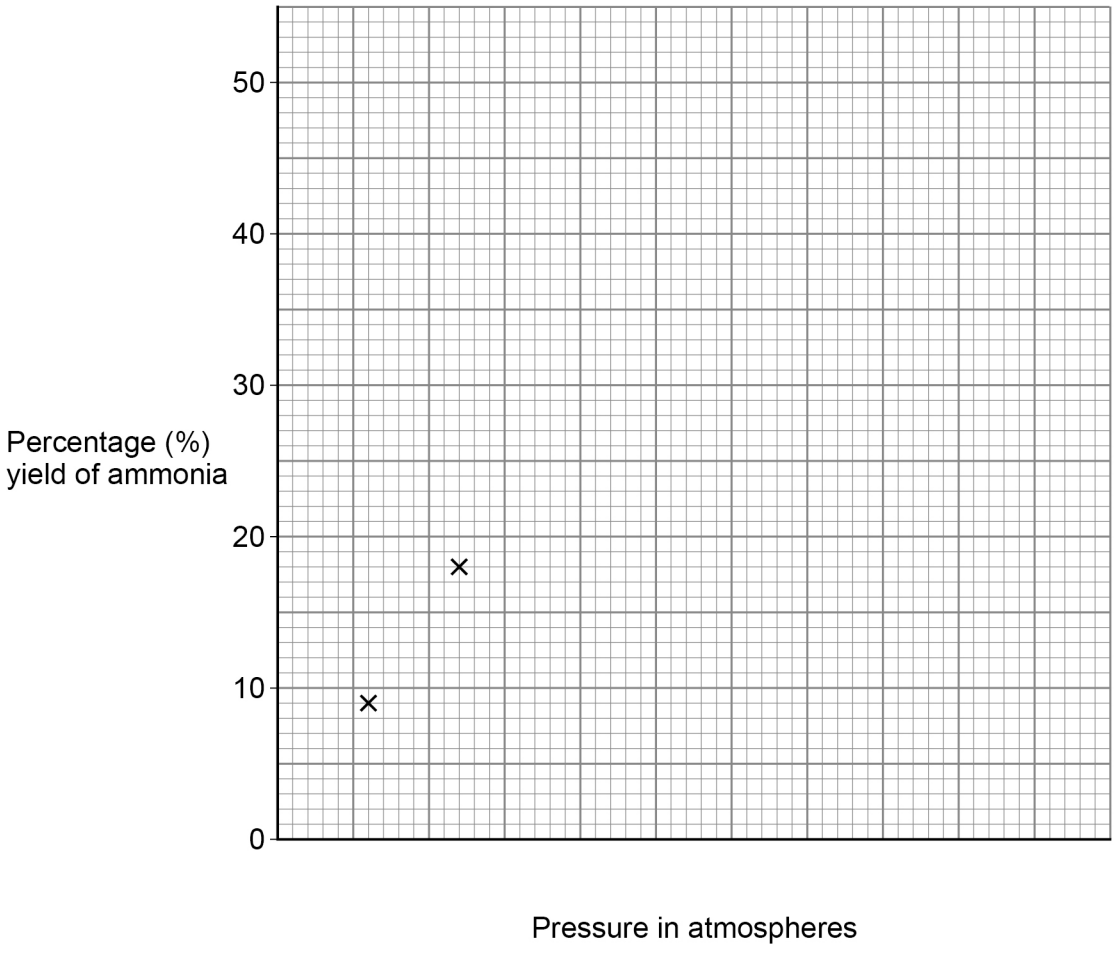
The first two points have been plotted.

You should:

- use a suitable scale for the *x*-axis
- plot the remaining data from **Table 6**
- draw a line of best fit.

[4 marks]

Figure 5



0 7 . 5 Determine the percentage yield of ammonia at 450 °C and 500 atmospheres.

Show your working on **Figure 5**.

[2 marks]

Percentage yield = _____ %

Turn over ►

Do not write outside the box

0 7 . 6 The equation for the production of ammonia in the Haber process is:

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

The forward reaction is exothermic.

The conditions used are:

- a temperature of 450 °C
- a pressure of 200 atmospheres
- the presence of an iron catalyst.

Explain why these conditions are chosen for economical production of ammonia in the Haber process.

You should include references to the rate of reaction and the position of equilibrium.

[6 marks]

17

Do not write outside the box

Turn over for the next question

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

0 8 This question is about the reaction between sodium thiosulfate solution and hydrochloric acid.

When hydrochloric acid is added to sodium thiosulfate solution, the mixture gradually becomes cloudy.

The equation for the reaction is:

$$Na_2S_2O_3(aq) + 2\,HCl(aq) \rightarrow 2\,NaCl(aq) + H_2O(l) + SO_2(g) + S(s)$$

0 8 . 1 Sulfur is produced in the reaction.

Why does the mixture become cloudy?

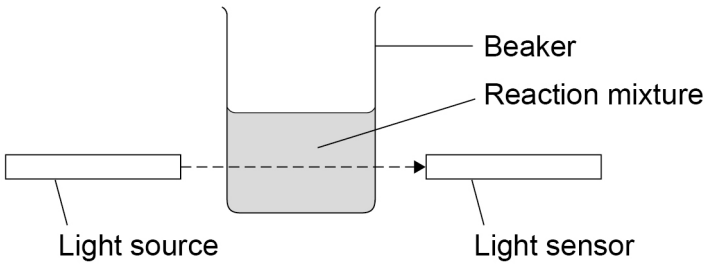
[1 mark]

Do not write outside the box

A student investigated the effect of changing the concentration of sodium thiosulfate solution on the rate of the reaction.

Figure 6 shows the apparatus used.

Figure 6



A smaller percentage of light from the light source reaches the light sensor as the mixture becomes more cloudy.

This is the method used.

1. Measure 50 cm^3 of 0.10 mol/dm^3 sodium thiosulfate solution into the beaker.

2. Add 10 cm^3 of hydrochloric acid to the sodium thiosulfate solution.

3. Immediately start a timer.

4. Record the percentage of light from the light source that reaches the light sensor every 20 seconds for 120 seconds.

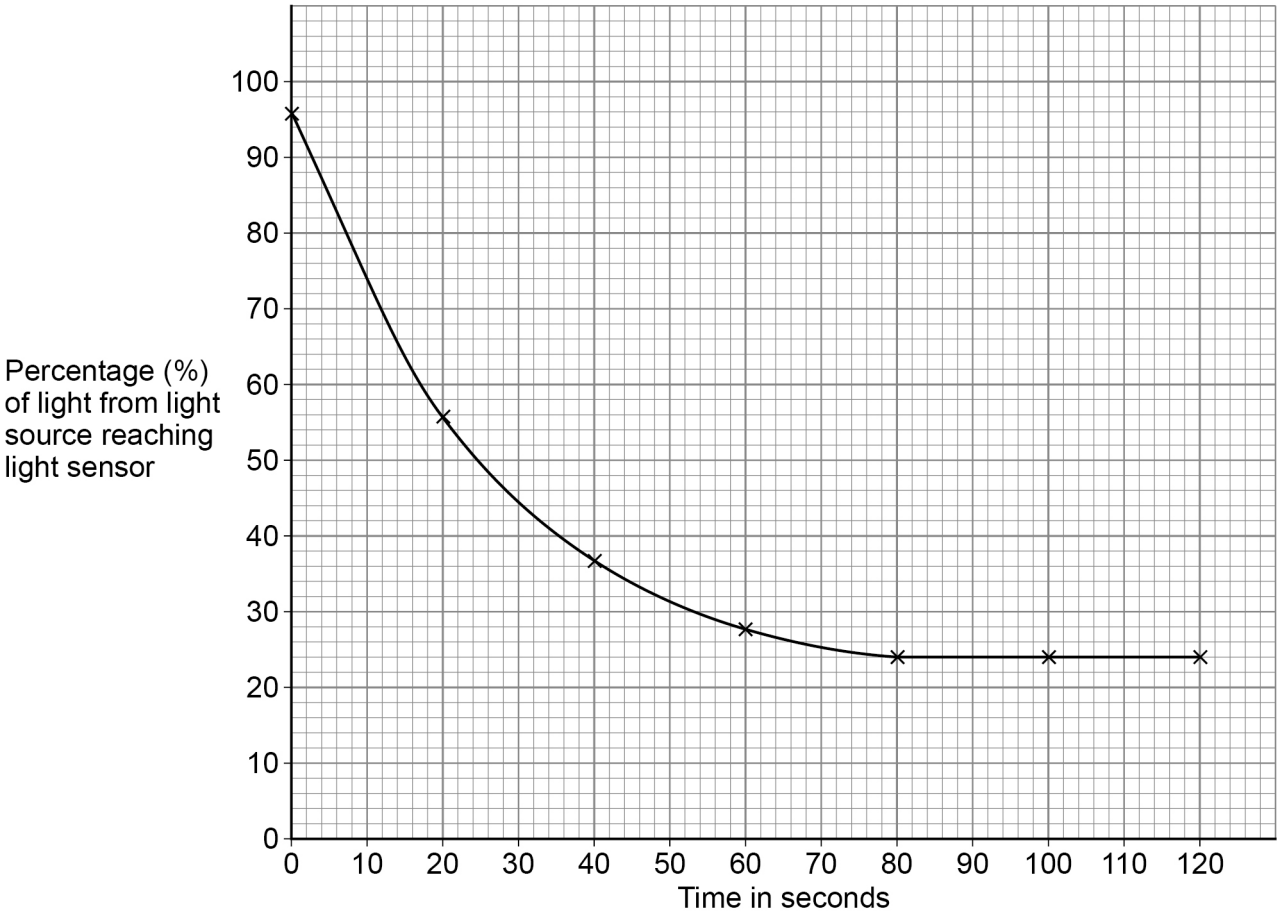
5. Repeat steps 1 to 4 using 0.20 mol/dm^3 sodium thiosulfate solution.

Question 8 continues on the next page

Do not write outside the box

Figure 7 shows the results for 0.10 mol/dm^3 sodium thiosulfate solution.

Figure 7



Do not write outside the box

0 8 . 2 The percentage of light reaching the light sensor decreases by 1% when 7.1×10^{-5} moles of sulfur is produced.

Determine the rate of reaction in mol/s for the production of sulfur at 30 seconds.

You should draw a tangent on **Figure 7**.

[5 marks]

Rate = _____ mol/s

0 8 . 3 Explain why the rate of reaction changes between 0 and 60 seconds.

Answer in terms of concentration.

Use **Figure 7**.

[2 marks]

Do not write outside the box

Figure 8 is a repeat of **Figure 7**.

Figure 8

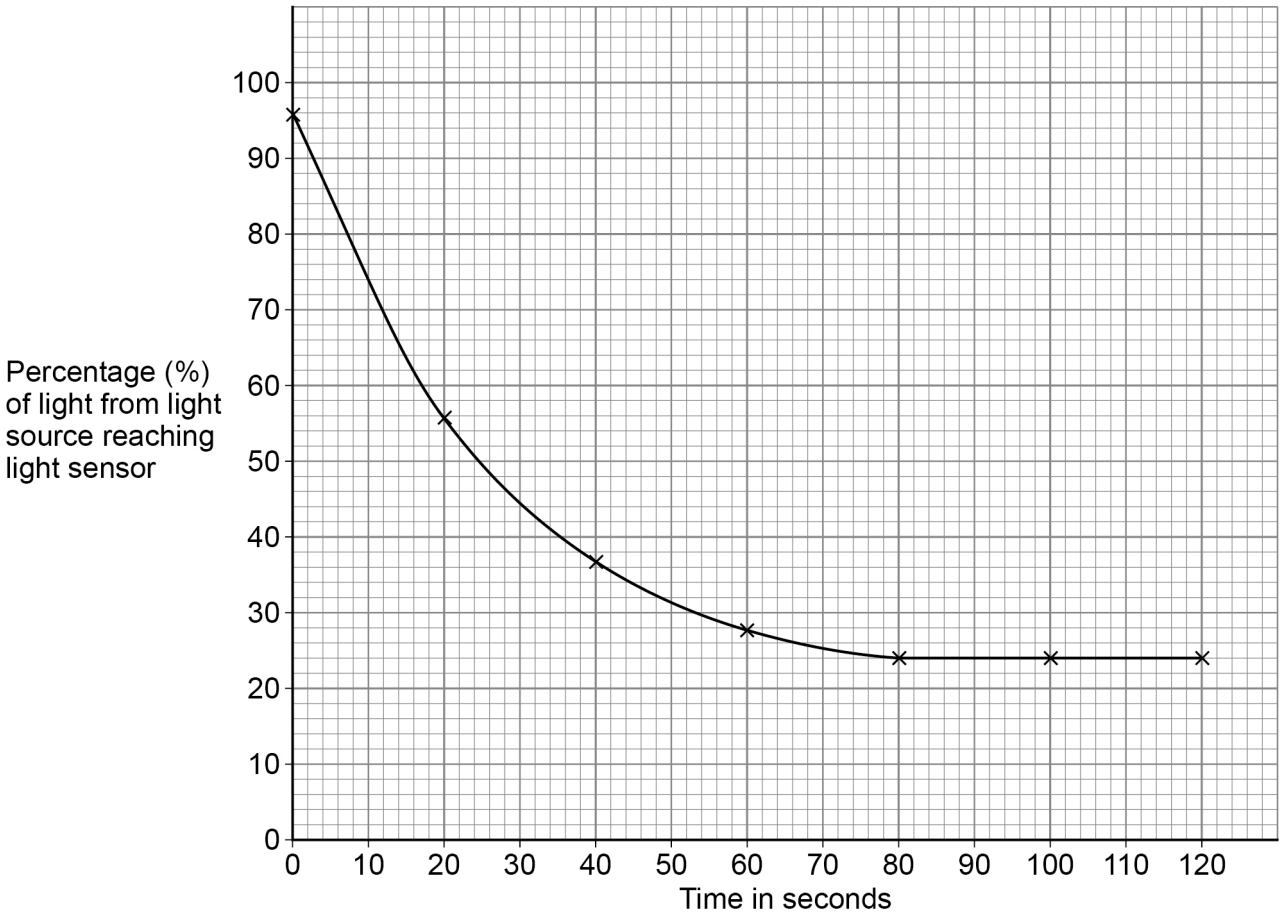


Figure 8 shows the results for 0.10 mol/dm^3 sodium thiosulfate solution.

Sodium thiosulfate solution was in excess in the investigation.

0 8 . 4 The line of best fit on **Figure 8** is horizontal between 80 and 120 seconds because the reaction stopped.

Why did the reaction stop?

[1 mark]

0 8 . 5 Sketch a line on **Figure 8** to show the results you would predict for 0.20 mol/dm^3 sodium thiosulfate solution.

[2 marks]

Do not write outside the box

The same student did the investigation again the next day.

The student found that the same method produced different results for the percentage of light reaching the light sensor.

0 8 . 6 How could the student improve the method so that the same percentages of light reached the light sensor?

[1 mark]

Tick (✓) **one** box.

Record the percentage of light every 10 seconds. ☐

Stop light from other sources reaching the light sensor. ☐

Use a larger volume of sodium thiosulfate solution. ☐

Use a more sensitive light sensor. ☐

0 8 . 7 The student improved the method so that similar results were obtained on different days.

What name is given to similar results obtained on different days under the same conditions by the same student?

[1 mark]

Tick (✓) **one** box.

Anomalous ☐

Precise ☐

Repeatable ☐

Reproducible ☐

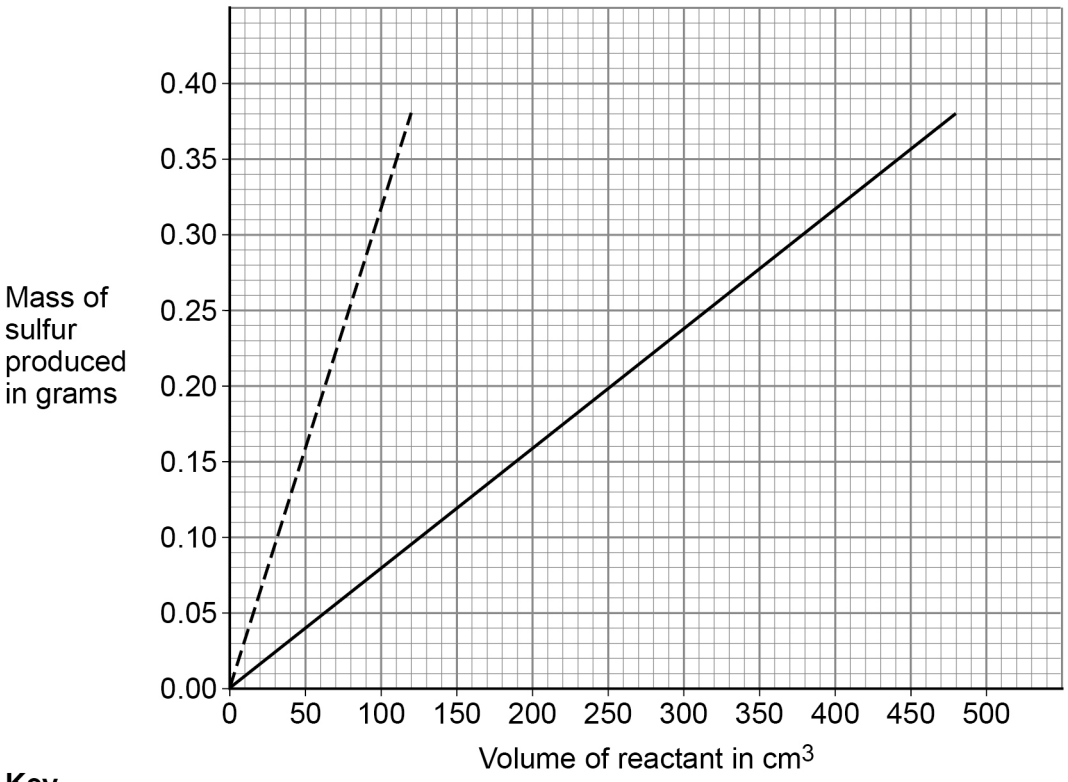
Do not write outside the box

Figure 9 shows the volumes of:

- sodium thiosulfate solution of concentration 0.10 mol/dm^3
- hydrochloric acid of concentration 0.05 mol/dm^3

which completely react to produce different masses of sulfur.

Figure 9



Key

– – – 0.10 mol/dm^3 sodium thiosulfate solution

—— 0.05 mol/dm^3 hydrochloric acid

Do not write outside the box

0 8 . 8 Which expression represents the relationship between the volume (V) of sodium thiosulfate solution used and the mass (m) of sulfur produced?

Use **Figure 9**.

[1 mark]

Tick (✓) **one** box.

$V \propto m$ ☐

$V \sim m$ ☐

$V << m$ ☐

$V = m$ ☐

0 8 . 9 Determine the simplest whole number ratio of the volumes of

sodium thiosulfate solution : hydrochloric acid

which completely react with each other.

Use **Figure 9**.

[3 marks]

Simplest whole number ratio = _____ : _____

17

END OF QUESTIONS

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ANSWER IN THE SPACES PROVIDED

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Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

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Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

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Question number	**Additional page, if required.** **Write the question numbers in the left-hand margin.**

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GCSE
CHEMISTRY
8462/2H

Paper 2 Higher Tier

Mark scheme

June 2022

Version: 1.0 Final Mark Scheme

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

Information to Examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the examiner make their judgement
- the Assessment Objectives and specification content that each question is intended to cover.

The extra information is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right-hand side of the mark scheme is there to provide those extra details which confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent (for example, a scientifically correct answer that could not reasonably be expected from a student's knowledge of the specification).

2. Emboldening and underlining

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.

2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.

2.3 Alternative answers acceptable for a mark are indicated by the use of **or**.
Alternative words in the mark scheme are shown by a solidus eg allow smooth / free movement.

2.4 Any wording that is underlined is essential for the marking point to be awarded.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which students have provided extra responses. The general principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error / contradiction negates each correct response. So, if the number of errors / contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (indicated as * in example 1) are not penalised.

Example 1: What is the pH of an acidic solution?

[1 mark]

Student	Response	Marks awarded
1	green, 5	0
2	red*, 5	1
3	red*, 8	0

Example 2: Name **two** magnetic materials.

[2 marks]

Student	Response	Marks awarded
1	iron, steel, tin	1
2	cobalt, nickel, nail*	2

3.2 Use of symbols / formulae

If a student writes a chemical symbol / formula instead of a required chemical name, or uses symbols to denote quantities in a physics equation, full credit can be given if the symbol / formula is correct and if, in the context of the question, such action is appropriate.

3.3 Marking procedure for calculations

Marks should be awarded for each stage of the calculation completed correctly, as students are instructed to show their working. At any point in a calculation students may omit steps from their working. If a subsequent step is given correctly, the relevant marks may be awarded.

Full marks are **not** awarded for a correct final answer from incorrect working.

3.4 Interpretation of 'it'

Answers using the word 'it' should be given credit only if it is clear that the 'it' refers to the correct subject.

3.5 Errors carried forward

An error can be carried forward from one question part to the next and is shown by the abbreviation 'ecf'.

Within an individual question part, an incorrect value in one step of a calculation does not prevent all of the subsequent marks being awarded.

3.6 Phonetic spelling

Marks should be awarded if spelling is not correct but the intention is clear, **unless** there is a possible confusion with another technical term.

3.7 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.8 Allow

In the mark scheme additional information, 'allow' is used to indicate creditworthy alternative answers.

3.9 Ignore

Ignore is used when the information given is irrelevant to the question or not enough to gain the marking point. Any further correct amplification could gain the marking point.

3.10 Do <u>not</u> accept

Do **not** accept means that this is a wrong answer which, even if the correct answer is given as well, will still mean that the mark is not awarded.

3.11 Numbered answer lines

Numbered lines on the question paper are intended to support the student to give the correct number of responses. The answer should still be marked as a whole.

4. Level of response marking instructions

Extended response questions are marked on level of response mark schemes.

- Level of response mark schemes are broken down into levels, each of which has a descriptor.
- The descriptor for the level shows the average performance for the level.
- There are two marks in each level.

Before you apply the mark scheme to a student's answer, read through the answer and, if necessary, annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1: Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level.

The descriptor for the level indicates the different qualities that might be seen in the student's answer for that level. If it meets the lowest level then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

When assigning a level you should look at the overall quality of the answer. Do **not** look to penalise small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level.

Use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 2 with a small amount of level 3 material it would be placed in level 2 but be awarded a mark near the top of the level because of the level 3 content.

Step 2: Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the example.

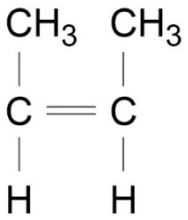
You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other valid points. Students do not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme.

You should ignore any irrelevant points made. However, full marks can be awarded only if there are no incorrect statements that contradict a correct response.

An answer which contains nothing of relevance to the question must be awarded no marks.

Question 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	C=C bond		1	AO2 4.7.3.1
	2x C-H bonds **and** 2x C-CH_3 bonds	do **not** accept extra bonds	1	
		an answer of  scores **2** marks		

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	any **one** from: • (otherwise) the copper (produced) would be impure	allow (otherwise) the copper (produced) would be contaminated	1	AO3 4.10.2.2
	• (otherwise) the copper (produced) would be a mixture			
	• (otherwise) the insulation would burn / melt (during recycling)	allow (otherwise) poly(butene) could produce toxic fumes		
	• copper and poly(butene) are recycled by different methods			

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	(wire heated until) copper melts (re)cast / reformed (into pipes)	 allow (re)shaped / extruded / (re)moulded	1 1	AO1 4.10.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	 any **two** from: (recycling scrap copper) • uses less energy • conserves copper (ore) • (produces) less waste • specified environmental impact	allow converse statements for extracting copper from ores ignore references to cost allow less landfill required	 2	AO1 4.10.1.1 4.10.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.5	 sodium hydroxide (solution) blue precipitate	MP2 dependent on MP1 allow NaOH for sodium hydroxide allow blue solid	 1 1	AO1 4.8.3.2 RPA7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.6	(add acidified) barium chloride (solution)	MP2 dependent on MP1 allow $BaCl_2$ for barium chloride allow (add acidified) barium nitrate (solution) do **not** accept add sulfuric acid	1	AO1 4.8.3.5 RPA7
	white precipitate	allow white solid	1	

Total Question 1		**11**

Question 2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	24.5 (g)		1	AO2 4.6.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.2	water vapour was produced	allow steam for water vapour allow water was produced as a gas	1	AO2 4.3.1.3 4.6.2.2
	(so) water (vapour) escaped (from the tube)	allow (so) the mass of the water (vapour) was not measured	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3	(so that) the reaction was complete	allow (so that) no more water (vapour) was produced	1	AO3 4.6.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.4	(energy =) $\frac{2.00}{238} \times 88.1$		1	AO2 4.6.2.2
	= 0.740336134 (kJ)		1	
	= 0.740 (kJ)	allow an answer correctly calculated to 3 significant figures from an incorrect calculation which uses all the values in the question	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.5	endothermic (reaction)	allow reversible (reaction) allow (thermal) decomposition (reaction)	1	AO1 4.6.2.2

Total Question 2		**8**

Question 3

Question	Answers	Mark	AO / Spec. Ref
03.1	**Level 3:** A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.	5–6	AO3 4.10.1.1 4.10.2.1
	Level 2: Some logically linked reasons are given. There may also be a simple judgement.	3–4	
	Level 1: Relevant points are made. They are not logically linked.	1–2	
	No relevant content	0	
	Indicative content **raw materials** • crude oil is finite • quarrying / mining pollute the environment • glass uses more energy to process raw materials **manufacturing** • glass uses more energy to make bottles • glass is heavier so takes more energy to transport **use and operation** • glass bottles are reusable • reuse of glass conserves (natural) resources • reuse of glass consumes energy during washing • reuse of glass consumes water during washing **disposal** • both glass and polymer bottles can be recycled • recycling polymer conserves finite resources • recycling glass and polymer uses less energy than making new glass and polymer • both methods reduce use of landfill **other points** • energy needed may be derived from fossil fuels • use of fossil fuels causes (specified) pollution • total energy for glass (bottle) (7500 kJ) is greater than total energy for polymer (bottle) (1800 kJ) **reasoned judgement**		

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	mass = density × volume mass = 0.40 × 40 = 16 (g)		1 1 1	AO2 4.10.1.1 4.10.2.1

Total Question 3		**9**

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	crude oil is heated to vaporise (the hydrocarbons)		1	AO1 AO2 4.7.1.2
	there is a temperature gradient in the (fractionating) column	allow a (fractionating) column is cooler going up	1	
	(so) the gases condense at different levels **or** (so) lubricating oil condenses below naphtha (and petroleum gases do not condense)		1	
	(because of their) different boiling points		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	detergents		1	AO1 4.7.1.2
	solvents		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	$C_9H_{20} + 14\,O_2 \rightarrow 9\,CO_2 + 10\,H_2O$	allow multiples allow **1** mark for $C_9H_{20} + O_2 \rightarrow CO_2 + H_2O$ with incorrect / no multipliers	2	AO2 4.1.1.1 4.3.1.1 4.7.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	(when burned sulfur impurities) produce sulfur dioxide		1	AO1 4.9.3.1 4.9.3.2
	(which) causes acid rain **or** (which) causes respiratory problems	allow specified effects of acid rain allow specified respiratory problems	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5		allow converse statements		AO2 4.7.1.3
	as molecular size increases viscosity increases		1	
	(and) heavy fuel oil has larger molecules (than kerosene)		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.6	(name of process) cracking		1	AO1 4.7.1.4
	(conditions) high temperature	allow a stated temperature in the range 300 to 900 °C	1	
	steam / catalyst		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.7	C_7H_{14} and C_8H_{16}		1	AO2 4.7.1.4 4.7.2.1

Total Question 4		**16**

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1		allow a description of each process		AO1 4.10.1.3
	screening **or** grit removal	allow filtering to remove (large) solids	1	
	sedimentation (to produce sewage sludge and effluent)		1	
	anaerobic digestion of (solid sewage) sludge		1	
	aerobic biological treatment of (liquid) effluent	allow aerobic digestion of effluent	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	Na^+ : 0.003 mol/dm^3 Cl^- : 0.003 mol/dm^3		1	AO3 4.10.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	the ions pass through the filter	allow the ions are not trapped / removed by the filter	1	AO3 4.1.1.2 4.10.1.2
	(because) the ions are in solution	allow (because) the ions are smaller than the filter pores	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	(the ground water) contains microbes which are harmful (to health) (so) the water is sterilised **or** (so) the microbes are destroyed		1 1	AO3 AO1 4.10.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	(the water is) unadulterated **or** (the water is) in its natural state	allow nothing is added (to the water) allow (the water) contains no microbes	1	AO2 4.8.1.1 4.10.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.6	(use) damp litmus paper (the paper) is bleached **or** (the paper) turns white	MP2 is dependent upon MP1 ignore paper turns red	1 1	AO1 4.8.2.4

Total Question 5		**12**

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	(the percentage of) nitrogen increased (because of intense) volcanic activity		1 1	AO3 AO1 4.9.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	(the percentage of) carbon dioxide decreased (because) carbon dioxide dissolved in oceans **or** (because of) formation of carbonate (precipitates / sediments)	do **not** accept references to photosynthesis	1 1	AO3 AO1 4.9.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	(the percentage of) carbon dioxide decreased **and** (the percentage of) oxygen increased the increase and decrease (in percentage) occur at the same / similar rate	 allow the changes (in percentage) are the same / similar in the same period of time	1 1	AO3 4.9.1.3 4.9.1.4

Question	Answers	Extra information		AO / Spec. Ref.
06.4	photosynthesis	allow a description of photosynthesis	1	AO1 4.9.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	plankton (died)	allow tiny marine organisms (died)	1	AO1 4.9.1.4
	and (the organisms) were covered by sediments	allow and (the organisms) were buried allow and (the organisms) were in anaerobic conditions	1	
	and subjected to high temperature **and** high pressure (over millions of years)		1	

Total Question 6		**10**

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	(nitrogen) air (hydrogen) natural gas	allow atmosphere allow methane allow water / steam	1 1	AO1 4.10.4.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2	there is only one product		1	AO2 4.3.3.2 4.10.4.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3	(mixture is) cooled (so that only) ammonia liquefies	 allow (so that only) ammonia condenses	1 1	AO1 4.10.4.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4	scale labelled at 100, 200, 300 and 400 (atm)	allow scale labelled at 50, 150, 250 and 350 (atm)	1	AO2 4.10.4.1
	all five points plotted correctly	allow a tolerance of ± ½ a small square allow **1** mark for three / four points plotted correctly	2	
	line of best fit		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.5 View with Figure 5	extrapolation to 500 atmospheres		1	AO2 4.10.4.1
	percentage value at 500 atmospheres	allow a tolerance of ± ½ a small square	1	

Question	Answers	Mark	AO / Spec. Ref.
07.6	**Level 3**: Relevant points (reasons/causes) are identified, given in detail and logically linked to form a clear account.	5–6	AO1 4.6.1.3 4.6.1.4 4.6.2.6 4.6.2.7 4.10.4.1
	Level 2: Relevant points (reasons/causes) are identified, and there are attempts at logical linking. The resulting account is not fully clear.	3–4	
	Level 1: Points are identified and stated simply, but their relevance is not clear and there is no attempt at logical linking.	1–2	
	No relevant content	0	
	Indicative content **rate** • higher temperature gives higher rate because of more frequent collisions • higher temperature gives higher rate because more particles have the activation energy • higher pressure gives higher rate because of more frequent collisions • use of catalyst gives higher rate because the activation energy is lowered **equilibrium** • higher temperature shifts the position of equilibrium to the left because reaction is exothermic • higher pressure shifts the position of equilibrium to the right because more molecules on left-hand side • use of catalyst has no effect on the position of equilibrium **other factors** • higher temperature (than 450°C) uses more energy so increases costs • higher pressure (than 200 atmospheres) uses more energy so increases costs • higher pressure (than 200 atmospheres) requires stronger reaction vessels so increases costs • use of a catalyst reduces energy costs **compromise** • the temperature chosen is a compromise between rate of reaction and position of equilibrium • the temperature chosen is a compromise between rate and cost • the pressure chosen is a compromise between yield / rate and cost		

Total Question 7		**17**

Question 8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	(sulfur is a) precipitate / solid **or** (sulfur is an) insoluble substance		1	AO2 4.6.1.2 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.2 **View with Figure 7**	correctly drawn tangent at 30 s		1	AO2 4.6.1.1 RPA5
	correct values for *x* step **and** *y* step from tangent	allow correct use of an incorrectly drawn tangent allow a tolerance of ± ½ a small square for each coordinate	1	
	(ratio =) $\frac{\text{value for y step}}{\text{value for x step}}$	allow correct use of incorrectly determined values from tangent for *x* step and/or *y* step	1	
	correct calculation of ratio		1	
	(conversion rate = ratio × 7.1 × 10^{-5}) correct evaluation of rate (mol/s)	allow correct use of an incorrectly calculated ratio	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.3	rate decreases (because) concentration of reactants decreases **alternative approach:** greatest rate at start (1) (because) greatest concentration of reactants at start (1)	allow the collision frequency decreases allow the collision frequency is highest at the start	1 1	AO2 4.6.1.1 4.6.1.2 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.4	(hydrochloric) acid is used up	allow (hydrochloric) acid is the limiting reactant ignore reactants used up	1	AO3 4.3.2.4 4.6.1.2 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.5 **View with Figure 8**	decreasing curve starting at (0,95) **and** steeper initially than curve for 0.10 mol/dm^3 sodium thiosulfate solution levelling at 24%		1 1	AO2 4.6.1.2 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.6	stop light from other sources reaching the light sensor		1	AO3 4.6.1.2 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.7	repeatable		1	AO3 4.6.1.2 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.8	$V \propto m$		1	AO2 4.6.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.9 View with Figure 9	volume of sodium thiosulfate solution **and** volume of hydrochloric acid at any fixed mass	allow a tolerance of ± ½ a small square for volume readings	1	AO2 4.6.1.2
	$\left(\frac{\text{volume of } Na_2S_2O_3 \text{ solution}}{\text{volume of hydrochloric acid}} = \right)$ 0.25	allow $\left(\frac{\text{volume of hydrochloric acid}}{\text{volume of } Na_2S_2O_3 \text{ solution}} = \right)$ 4 allow correct use of incorrectly determined volumes	1	
	1 : 4		1	

Total Question 8		**17**