2024

Name_____

Combined Science

Higher

Chemistry: Paper 2

The Periodic Table of Elements

1	2											3	4	5	6	7	0
							1 **H** hydrogen 1										4 **He** helium 2
7 **Li** lithium 3	9 **Be** beryllium 4											11 **B** boron 5	12 **C** carbon 6	14 **N** nitrogen 7	16 **O** oxygen 8	19 **F** fluorine 9	20 **Ne** neon 10
23 **Na** sodium 11	24 **Mg** magnesium 12											27 **Al** aluminium 13	28 **Si** silicon 14	31 **P** phosphorus 15	32 **S** sulfur 16	35.5 **Cl** chlorine 17	40 **Ar** argon 18
39 **K** potassium 19	40 **Ca** calcium 20	45 **Sc** scandium 21	48 **Ti** titanium 22	51 **V** vanadium 23	52 **Cr** chromium 24	55 **Mn** manganese 25	56 **Fe** iron 26	59 **Co** cobalt 27	59 **Ni** nickel 28	63.5 **Cu** copper 29	65 **Zn** zinc 30	70 **Ga** gallium 31	73 **Ge** germanium 32	75 **As** arsenic 33	79 **Se** selenium 34	80 **Br** bromine 35	84 **Kr** krypton 36
85 **Rb** rubidium 37	88 **Sr** strontium 38	89 **Y** yttrium 39	91 **Zr** zirconium 40	93 **Nb** niobium 41	96 **Mo** molybdenum 42	[97] **Tc** technetium 43	101 **Ru** ruthenium 44	103 **Rh** rhodium 45	106 **Pd** palladium 46	108 **Ag** silver 47	112 **Cd** cadmium 48	115 **In** indium 49	119 **Sn** tin 50	122 **Sb** antimony 51	128 **Te** tellurium 52	127 **I** iodine 53	131 **Xe** xenon 54
133 **Cs** caesium 55	137 **Ba** barium 56	139 **La*** lanthanum 57	178 **Hf** hafnium 72	181 **Ta** tantalum 73	184 **W** tungsten 74	186 **Re** rhenium 75	190 **Os** osmium 76	192 **Ir** iridium 77	195 **Pt** platinum 78	197 **Au** gold 79	201 **Hg** mercury 80	204 **Tl** thallium 81	207 **Pb** lead 82	209 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[267] **Rf** rutherfordium 104	[270] **Db** dubnium 105	[269] **Sg** seaborgium 106	[270] **Bh** bohrium 107	[270] **Hs** hassium 108	[278] **Mt** meitnerium 109	[281] **Ds** darmstadtium 110	[281] **Rg** roentgenium 111	[285] **Cn** copernicium 112	[286] **Nh** nihonium 113	[289] **Fl** flerovium 114	[289] **Mc** moscovium 115	[293] **Lv** livermorium 116	[293] **Ts** tennessine 117	[294] **Og** oganesson 118

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

* The Lanthanides (atomic numbers 58 – 71) and the Actinides (atomic numbers 90 – 103) have been omitted.

Relative atomic masses for **Cu** and **Cl** have not been rounded to the nearest whole number.

AQA

Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

GCSE
COMBINED SCIENCE: TRILOGY

H

Higher Tier
Chemistry Paper 2H

Wednesday 12 June 2019 Morning Time allowed: 1 hour 15 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.
- Fill in the boxes at the top of this page.
- Answer **all** questions in the spaces provided.
- 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	
TOTAL	

Information
- The maximum mark for this paper is 70.
- 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 Water that is safe to drink contains dissolved substances.

0 1 . 1 What do we call water that is safe to drink?

[1 mark]

Tick (✓) **one** box.

Desalinated ☐

Filtered ☐

Fresh ☐

Potable ☐

0 1 . 2 Describe a test for pure water.

Give the result of the test if the water is pure.

[2 marks]

Test _____

Result _____

Do not write outside the box

0 1 . 3 Describe a method to determine the mass of dissolved solids in a 100 cm^3 sample of river water.

[4 marks]

0 1 . 4 A sample of river water contains 125 mg per dm^3 of dissolved solids.

Calculate the mass of dissolved solids in grams in 250 cm^3 of this sample of river water.

Give your answer to 2 significant figures.

[4 marks]

Mass of dissolved solids = _____ g

Do not write outside the box

0 1 . 5 A water company allows a maximum of 500 mg per dm^3 of sulfate ions in drinking water.

A sample of drinking water contains 44 mg per dm^3 of sulfate ions.

Calculate the percentage (%) of the maximum allowed mass of sulfate ions in the sample of drinking water.

[2 marks]

Percentage (%) of the maximum allowed mass = _____ %

13

Do not write outside the box

0 2 This question is about atmospheric pollutants from fuels.

0 2 . 1 Fuel burns in a car engine.

Describe how oxides of nitrogen are produced in a car engine.

[2 marks]

Question 2 continues on the next page

Do not write outside the box

0 2 . 2 **Table 1** shows the carbon footprint during the manufacture and use of three cars.

Table 1

Car	Mass of CO_2 produced during manufacture in kg	Mass of CO_2 produced when driving in kg per km	Total mass of CO_2 produced from manufacture and 40 000 km driving in kg	Total mass of CO_2 produced from manufacture and 100 000 km driving in kg
Car A	14 000	0.123	18 920	26 300
Car B	20 000	0.085	23 400	28 500
Car C	23 000	0.044	24 760	27 400

Evaluate the carbon footprint of the cars.

Use information from **Table 1**.

[6 marks]

8

Do not write outside the box

0 3 This question is about chromatography of food colouring.

0 3 . 1 Food colouring is a formulation.

What is a formulation?

[1 mark]

0 3 . 2 Explain how paper chromatography separates the dyes in a food colouring.

Do **not** give details of how to do the experiment.

[2 marks]

0 3 . 3 Explain how the student could tell from the chromatogram that the food colouring contained more than one dye.

[2 marks]

Question 3 continues on the next page

Do not write outside the box

0 3 . 4 Explain how the student could use chromatography to identify unknown dyes in the food colouring.

[3 marks]

8

Do not write outside the box

0 4 This question is about copper and fuels.

0 4 . 1 Copper is extracted from low-grade ores by phytomining.

Describe how copper metal is produced by phytomining.

[4 marks]

0 4 . 2 Another method of extracting copper from low-grade ores is bioleaching.

A solution of copper sulfate ($CuSO_4$) produced by bioleaching has a concentration of 0.319 g/dm^3

Relative atomic masses (A_r): Cu = 63.5 O = 16 S = 32

Calculate the number of moles of copper that can be produced from 1 dm^3 of this solution.

[3 marks]

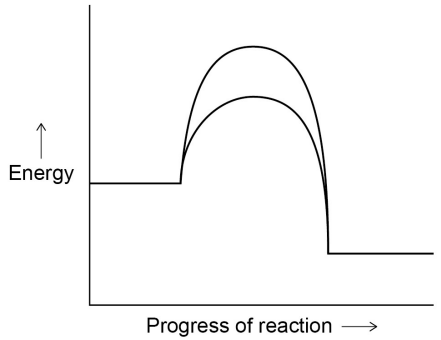
Number of moles of copper = _____ mol

Do not write outside the box

Copper is used as a catalyst.

Figure 1 shows reaction profiles for a reaction with and without a catalyst.

Figure 1



0 4 . 3 How do the reaction profiles show that using a catalyst does **not** affect the overall energy change for the reaction?

[1 mark]

Tick (✓) **one** box.

- Both reaction profiles show exothermic reactions. ☐
- Both reaction profiles start at the same energy level and end at the same energy level. ☐
- Both reaction profiles show the activation energy. ☐
- The activation energy for the uncatalysed reaction is much lower than for the catalysed reaction. ☐

Do not write outside the box

0 4 . 4 Copper is a catalyst in a reaction to produce ethanol from carbon dioxide.

Ethanol (C_2H_5OH) is used as a fuel.

Suggest why producing ethanol from carbon dioxide is sustainable.

[2 marks]

0 4 . 5 Chemistry plays an important role in sustainable development.

What is sustainable development?

[2 marks]

12

Turn over for the next question

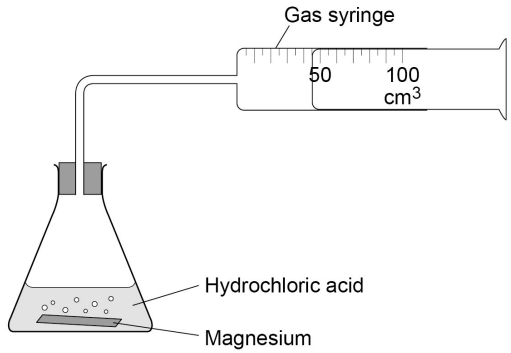
Do not write outside the box

0 5 This question is about magnesium.

A student investigated the rate of the reaction between magnesium and hydrochloric acid.

Figure 2 shows the apparatus.

Figure 2



0 5 . 1 Which is the correct ionic equation for the reaction?

[1 mark]

Tick (✓) **one** box.

$Mg + 2H^+ \rightarrow Mg^{2+} + H_2$ ☐

$Mg^{2+} + 2Cl^- \rightarrow MgCl_2$ ☐

$Mg + 2HCl \rightarrow MgCl_2 + H_2$ ☐

$Mg^+ + Cl^- \rightarrow MgCl$ ☐

Do not write outside the box

0 5 . 2 What happens in the reaction between magnesium and hydrochloric acid?

[1 mark]

Tick (✓) **one** box.

Electron sharing ☐

Electron transfer ☐

Proton transfer ☐

Question 5 continues on the next page

Do not write outside the box

0 5 . 3 **Table 2** shows the student's results.

Table 2

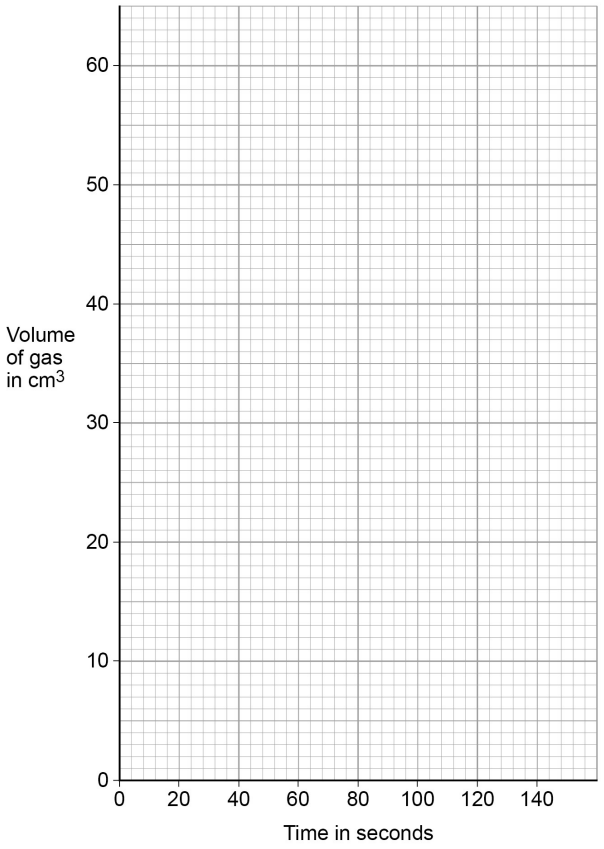
Time in seconds	0	10	35	50	95	120	140
Volume of gas in cm^3	0.0	12.5	36.0	43.5	59.0	60.0	60.0

Plot the data from **Table 2** on **Figure 3**.

Draw a line of best fit.

[3 marks]

Figure 3



Do not write outside the box

0 5 . 4 Describe the changes in the rate of this reaction.

[3 marks]

0 5 . 5 Explain why the rate of this reaction changes.

Give your answer in terms of collision theory.

[3 marks]

11

Turn over for the next question

Do not write outside the box

0 6 This question is about oxygen (O_2) and sulfur dioxide (SO_2).

0 6 . 1 Give the test and result for oxygen gas.

[2 marks]

Test

Result

0 6 . 2 The reaction between oxygen and sulfur dioxide is at equilibrium.

$$O_2(g) + 2SO_2(g) \rightleftharpoons 2SO_3(g)$$

Some of the sulfur trioxide (SO_3) is removed.

Explain what happens to the position of the equilibrium.

[2 marks]

Do not write outside the box

0 6 . 3 Sulfur dioxide is an atmospheric pollutant.

Sulfur dioxide pollution is reduced by reacting calcium oxide with sulfur dioxide to produce calcium sulfite.

$$CaO + SO_2 \rightarrow CaSO_3$$

7.00 g of calcium oxide reacts with an excess of sulfur dioxide.

Relative atomic masses (A_r): O = 16 S = 32 Ca = 40

Calculate the mass of calcium sulfite produced.

[4 marks]

Mass of calcium sulfite produced = _____ g

8

Turn over for the next question

Do not write outside the box

0 7 This question is about hydrocarbons and crude oil.

0 7 . 1 Hydrocarbon fuels are produced from crude oil.

Describe how crude oil is separated into fractions.

[4 marks]

Butane is a hydrocarbon.

0 7 . 2 Two equations for the combustion of butane are:

- $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$
- $2C_4H_{10} + 5O_2 \rightarrow 8C + 10H_2O$

Why are different products formed?

[1 mark]

0 7 . 3 One other product of the combustion of butane is carbon monoxide.

Balance the equation.

[1 mark]

_____ C_4H_{10} + _____ O_2 → _____ CO + _____ H_2O

Do not write outside the box

0 7 . 4 Carbon dioxide is a greenhouse gas.

Describe the greenhouse effect in terms of the interaction of short and long wavelength radiation with matter.

[4 marks]

10

END OF QUESTIONS

Do not write outside the box

There are no questions printed on this page

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ANSWER IN THE SPACES PROVIDED

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
01.1	potable		1	AO1.1 5.10.1.2	A
01.2	boil (water) (boils) at 100°C	allow boils at 100°C for **2** marks ignore heat do **not** accept filter do **not** accept incorrect test **alternative approach** freeze (water) (1) (freezes) at 0°C (1) if no other mark awarded, allow 1 mark for evaporate or distil water **and** no solid left	 1 1	AO2 5.8.1.1	E
01.3	**Level 2:** The design/plan would lead to the production of a valid outcome. All key steps are identified and logically sequenced.		3–4	AO1.1 5.10.1.2 10.2.13	E
	Level 1: The design/plan would not necessarily lead to a valid outcome. Some steps are identified, but the plan may not be logically sequenced.		1–2		
	No relevant content		0		
	Indicative content • weigh container. • measure volume (100 cm^3) of water into container. • evaporate / heat until dry. • weigh container and remaining solids. • determine mass of dissolved solids To access Level 2 there should be an indication of using a known volume of water, heating until dry and determining the mass of solid.				

01.4	(conversion of cm^3 to dm^3) (250 cm^3 =) $\frac{250}{1000}$ or 0.25 (dm^3) (conversion of mg to g) (125 mg =) $\frac{125}{1000}$ or 0.125 (g) (0.25 × 0.125) = 0.03125 =0.031 (g)	an answer of 0.031 (g) scores **4** marks allow correct calculation from incorrect attempt(s) at conversion allow an answer correctly rounded to 2 significant figures from an incorrect calculation that uses the values in the question	 1 1 1 1	AO2 5.3.2.5 10.2.13	E
01.5	$\frac{44}{500} \times 100$ = 8.8 (%)	an answer of 8.8 (%) or 9 (%) scores **2** marks allow 9 (%)	1 1	AO2 5.10.1.2 10.2.13	E
Total			**13**		

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
02.1	high temperatures (in the engine) enable oxygen and nitrogen (from air) to react	 allow combine / bond for react	1 1	AO1 5.9.3.1	E

02.2	**Level 3:** A judgement, strongly linked and logically supported by a sufficient range of correct reasons, is given.	5–6		E
	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 Examples of relevant points might include: • car **C** produces the most CO_2 during manufacture • car **A** produces the most CO_2 per km when driving • car **C** produces the most CO_2 from manufacture and 40,000km when driving • car **B** produces the most CO_2 from manufacture and 100,000km when driving Examples of linked statements might include: • car **A** produces least CO_2 during manufacture, but most CO_2 per km • car **C** produces most CO_2 during manufacture, but least CO_2 per km • car **A** produces least CO_2 during manufacture, but car **C** produces the least CO_2 per km Examples of judgements might include: • overall car **A** has the smallest carbon footprint as it has the smallest CO_2 production during manufacture, the smallest mass of CO_2 after 40,000km of driving and the smallest mass of CO_2 produced after 100,000km of driving. • car **A** eventually (after 157,895km) will have the largest carbon footprint because the mass of carbon dioxide produced per km is highest.		AO3 5.9.2.2 5.9.2.45.10.2.1	

Total			**8**

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	a mixture designed as a useful product		1	AO1 5.8.1.2
03.2	dyes distributed differently between the stationary and mobile phase	allow dyes have different solubilities allow dyes have different forces of attraction for stationary phase allow dyes have different forces of attraction for mobile phase allow dyes have different forces of attraction to the paper allow dyes have different forces of attraction to the solvent ignore density	1	AO1 5.8.1.3
	(so dyes) move up the paper at different speeds / rates	allow (so dyes) move different distances up the paper ignore references to time	1	
03.3	(because chromatogram has) different dots / colours		1	AO2 5.8.1.3
	in a (vertical) column	allow above the (original) spot	1	
03.4	run known dyes and food colouring (as a chromatogram)		1	AO2
	compare distances moved **or** compare R_f values		1	AO2
	(so) can identify those that move the same distance as known dyes **or** (so) can identify those that have the same R_f values as known dyes	allow (so) can identify those that move different distances as unknown dyes **or** allow (so) can identify those that have different R_f values as unknown dyes	1	AO2 5.8.1.3

Total			**8**

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	growing plants (on low-grade ore) plants are burnt (to produce ash) (ash dissolved in acid to produce) solution of a copper compound electrolysis (of solution of a copper compound) **or** displacement (by adding scrap iron to a solution of a copper compound)	allow named plant allow named copper compound allow addition of scrap iron (to a solution of a copper compound)	1 1 1 1	AO1 5.10.1.4
04.2	 M_r $CuSO_4$ = 159.5 $\frac{0.319}{159.5}$ = 0.002 (mol)	an answer of 0.002 **or** 2×10^{-3} (mol) scores **3** marks allow correct use of incorrectly calculated value for M_r allow 2×10^{-3} (mol)	 1 1 1	AO2 5.3.2.1 5.3.2.5
04.3	both reaction profiles start at the same energy level and end at the same energy level.		1	AO3 5.6.1.4

04.4	the amount of carbon dioxide used to produce the ethanol is the same as the amount of carbon dioxide given off when the ethanol is burned	 **alternative approach** there is sufficient carbon dioxide (in the atmosphere) (1) because carbon dioxide is constantly produced from burning fossil fuels (1) if no other mark awarded allow for **1** mark burning ethanol produces carbon dioxide	1 1	AO3 5.9.2.2 5.9.3.1

04.5	meets needs of current generation without compromising needs of future generations	 allow so there are enough resources for future generations ignore references to harming / damaging planet / environment	1 1	AO1 5.10.1.1
Total			**12**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	$Mg + 2H^+ \rightarrow Mg^{2+} + H_2$		1	AO2 5.6.1.2 5.1.1.1
05.2	electron transfer		1	AO2 5.11
05.3	all points correctly plotted line of best fit	allow a tolerance of ± ½ a small square allow **1** mark for at least 4 points correctly plotted	2 1	AO2 5.6.1.1
05.4	(rate) decreases (rate decrease) more slowly as time increases (in rate) (rate) becomes zero at time read from graph	allow (rate is) fastest at the beginning allow reaction stops at time read from graph	1 1 1	AO3 5.6.1.1 AO3 5.6.1.1 AO3 5.6.1.1
05.5	 (rate decreases because) fewer particles (of acid / magnesium) as reaction progresses (so) less frequent collisions reaction stops due to limiting factor / reagent	Incorrect reference to energy scores **max. 1** allow (rate decreases because) concentration of acid decreases as reaction progresses allow collisions less likely ignore less / fewer collisions allow reaction stops because a reactant is used up	 1 1 1	AO2 5.6.1.3 AO1 5.6.1.3 AO2 5.6.1.3 5.3.2.4
Total			**11**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	glowing splint relights		1 1	AO1 5.8.2.2
06.2	equilibrium shifts to right-hand side (because) concentration of SO_3 decreases	allow towards the products allow in favour of the forward reaction this marking point is dependent on first marking point being awarded allow pressure decreases allow to increase the concentration of SO_3 allow to re-establish equilibrium	1 1	AO3 AO2 5.6.2.5 5.6.2.7
06.3	(M_r CaO =) 56 (M_r $CaSO_3$ =) 120 $\frac{7}{56} \times 120$ = 15(.0 g)	an answer of 15(.0 g) scores **4** marks in all approaches allow a correct calculation using an incorrectly calculated M_r **alternative approach A** (M_r CaO =) 56 (1) $\frac{7}{56}$ = 0.125 (moles) (1) (mass $CaSO_3$ =) 0.125 × 120 (1) = 15(.0 g) (1)	 1 1 1 1	AO2 5.3.1.2 5.3.2.1 5.3.2.2

		alternative approach B (M_r CaO =) 56 (1) $\frac{56}{7}$ = 8 (factor) (1) (M_r $CaSO_3$ =) 120 (1) $\frac{120}{8}$ = 15(.0 g) (1) **alternative approach C** (M_r CaO =) 56 (1) (M_r $CaSO_3$ =) 120 (1) $\frac{120}{56}$ = 2.14235714 (factor) (1) 2.14235714 × 7 = 15(.0 g) (1)		

Total			8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1		maximum of **3** marks if incorrect reference made to cracking ignore fractional distillation ignore fracking		AO1 5.7.1.2
	heat or vaporise (oil)		1	
	temperature gradient in column	allow column is cooler at the top or allow column is hotter at the bottom	1	
	(vapour) condenses (into fractions)		1	
	depending on boiling point of fraction	allow at different levels	1	
07.2	different amounts of oxygen available	allow complete combustion **and** incomplete / partial combustion	1	AO2 5.9.3.1
07.3	$2\ C_4H_{10} + 9\ O_2 \rightarrow 8\ CO + 10\ H_2O$	allow correct multiples / halves	1	AO2 5.7.1.3 5.9.3.1 5.1.1.1

07.4	short wavelength radiation which enters the atmosphere	because uv / ultra violet radiation which enters the atmosphere	1	AO1.1 5.9.2.1
	is absorbed by materials **and** re-emitted		1	
	as a longer wavelength radiation	as ir / infrared radiation	1	
	(the longer wavelength radiation is trapped by) a greenhouse gas / carbon dioxide / methane which stops radiation escaping (from the atmosphere)	allow so temperature increases	1	
Total			**10**	

AQA

Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

GCSE
COMBINED SCIENCE: TRILOGY

H

Higher Tier
Chemistry Paper 2H

Time allowed: 1 hour 15 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.
- 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	
TOTAL	

Information
- The maximum mark for this paper is 70.
- 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

There are no questions printed on this page

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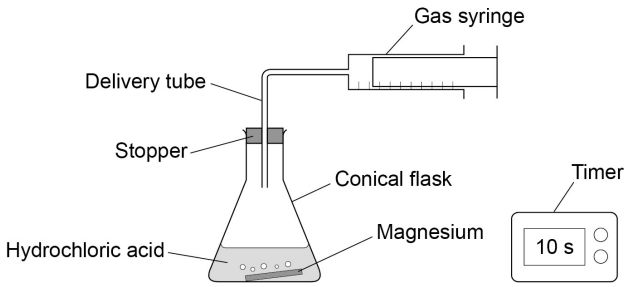
ANSWER IN THE SPACES PROVIDED

0 1 A student investigated the reaction between magnesium and excess hydrochloric acid.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Pour 50 cm^3 of hydrochloric acid into a conical flask.
2. Add a piece of magnesium.
3. Insert stopper and delivery tube and start a timer.
4. Collect the gas produced in a gas syringe.
5. Record the volume of gas produced every 20 seconds for 2 minutes.
6. Repeat steps 1 to 5 with higher concentrations of hydrochloric acid.

0 1 . 1 Give the independent variable and **one** control variable in this investigation.

[2 marks]

Independent variable _____

Control variable _____

Question 1 continues on the next page

Table 1 shows the results from the first experiment using hydrochloric acid with a low concentration.

Table 1

Time in seconds	0	20	40	60	80	100	120
Volume of gas in cm^3	0	48	72	90	97	98	98

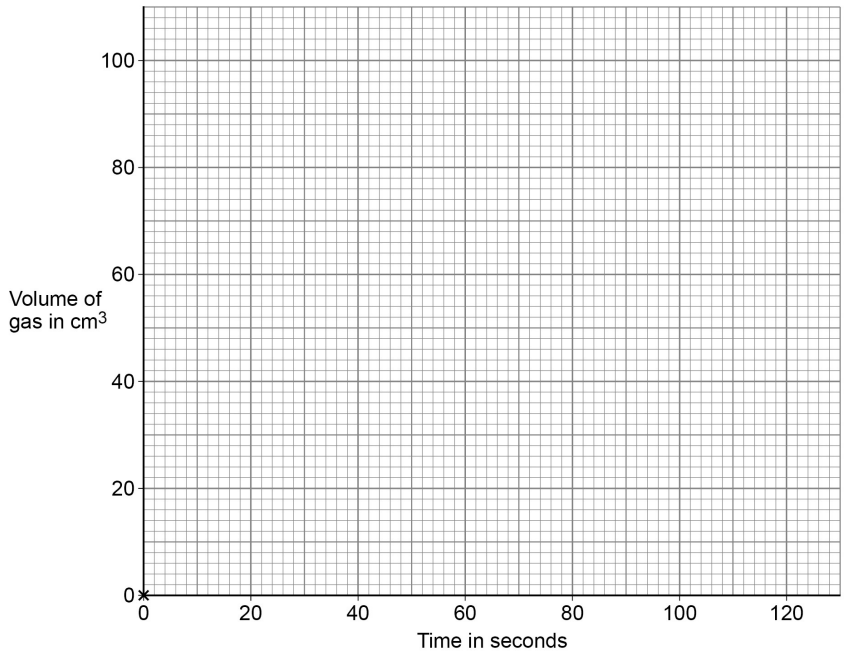
0 1 . 2 Complete **Figure 2.**

You should:

- plot the data from **Table 1** (the point 0,0 has been plotted for you)
- draw a line of best fit.

[3 marks]

Figure 2



Do not write outside the box

0 1 . 3 How does the **rate** of this reaction change with time?

Use **Table 1.**

[1 mark]

Tick (✓) **one** box.

The rate decreases. ☐

The rate stays the same. ☐

The rate increases. ☐

0 1 . 4 The student repeated the experiment using hydrochloric acid with a higher concentration.

Which statement is correct?

[1 mark]

Tick (✓) **one** box.

The activation energy for the reaction was higher. ☐

The magnesium reacted more quickly. ☐

The reaction finished at the same time. ☐

The total volume of gas collected was smaller. ☐

Question 1 continues on the next page

Do not write outside the box

0 1 . 5 Temperature also affects the rate of the reaction.

Explain how increasing the temperature affects the **rate** of the reaction.

You should refer to particles and collisions.

[3 marks]

10

Do not write outside the box

0 2 Crude oil is a resource found in rocks.

Most of the compounds in crude oil are hydrocarbons.

0 2 . 1 Complete the sentence.

[1 mark]

Crude oil is formed by the decomposition of _____.

0 2 . 2 Alkanes are hydrocarbons.

Give the name of the alkane molecule that has three carbon atoms.

[1 mark]

_____

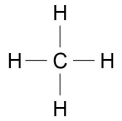
Question 2 continues on the next page

Do not write outside the box

0 2 . 3 **Figure 3** shows two alkane molecules.

Figure 3

Methane



Hexane

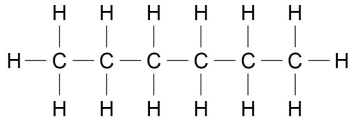


Table 2 shows the melting points and boiling points of methane and hexane.

Table 2

	Melting point in °C	Boiling point in °C
Methane	−183	−162
Hexane	−95	69

Compare the structure and properties of methane and hexane.

[6 marks]

Do not write outside the box

Hydrocarbons are cracked to produce more useful alkanes and alkenes.

0 2 . 4 Decane ($C_{10}H_{22}$) is cracked to produce **two** products.

Complete the equation for the reaction.

[1 mark]

$$C_{10}H_{22} \rightarrow \_\_\_\_\_ + C_2H_4$$

0 2 . 5 C_2H_4 is an alkene.

What is the test for alkenes?

Give the result of the test if an alkene is present.

[2 marks]

Test _____

_____

Result _____

_____

11

Turn over for the next question

Do not write outside the box

0 3 The methods used to produce potable water depend upon available sources of water.

0 3 . 1 Suggest how copper sulfate can be used as a test for the presence of water.

[3 marks]

The boiling point is used to check the purity of a sample of water.

0 3 . 2 In chemistry, what is meant by a 'pure substance'?

[1 mark]

Do not write outside the box

0 3 . 3 The boiling point of a 250 g sample of water was 100.60 °C.

The boiling point of pure water in a data book is 100.00 °C.

Each 1% of impurity increases the boiling point of water by 0.12 °C.

Calculate the mass of the impurity in the sample of water.

[3 marks]

Mass of the impurity = _____ g

0 3 . 4 Explain how distillation is used to obtain potable water from salty water.

[4 marks]

Question 3 continues on the next page

Do not write outside the box

0 3 . 5 Obtaining potable water from salty water is more expensive than obtaining potable water from ground water.

Explain why.

Refer to the processes used in both methods in your answer.

[2 marks]

13

Do not write outside the box

Turn over for the next question

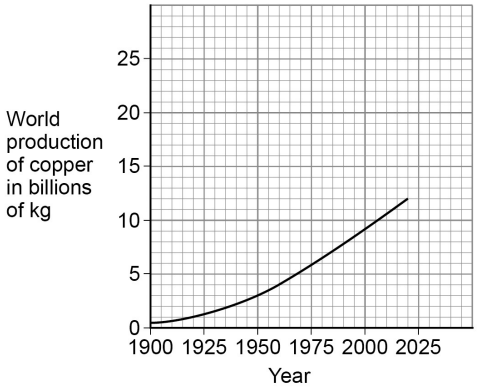
DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Do not write outside the box

0 4 Industries use the Earth's natural copper resources to produce useful products.

Figure 4 shows the world production of copper from 1900 to 2020.

Figure 4



0 4 . 1 Describe the trend shown by the graph in **Figure 4.**

[2 marks]

0 4 . 2 Suggest **one** reason for the trend in **Figure 4.**

[1 mark]

Do not write outside the box

0 4 . 3 Suggest **one** reason why the trend cannot be used to accurately predict the future world production of copper.

[1 mark]

Question 4 continues on the next page

Do not write outside the box

0 4 . 4 High-grade copper resources are now difficult to find.

Phytomining is used to extract copper from low-grade ores.

There are five stages, **A**, **B**, **C**, **D** and **E**, in phytomining.

The stages are **not** in the correct order.

Stage **A** Copper compounds from ash are dissolved in acid.

Stage **B** Plants absorb metal compounds.

Stage **C** Plants are burned.

Stage **D** Plants are harvested.

Stage **E** Solution of copper compound is electrolysed.

What is the correct order of stages **A**, **B**, **C**, **D**, and **E**?

[1 mark]

Tick (✓) **one** box.

B, **C**, **D**, **E**, **A** ☐

B, **D**, **C**, **A**, **E** ☐

D, **B**, **C**, **E**, **A** ☐

D, **C**, **B**, **A**, **E** ☐

Do not write outside the box

0 4 . 5 Give **two** disadvantages of phytomining compared with traditional mining methods.

Do **not** refer to cost in your answer.

[2 marks]

1 _____

_____

2 _____

_____

0 4 . 6 In one year, 8.89×10^9 kg of copper was produced.

41.0% of this copper was produced from recycled copper.

The energy needed to produce 1 kg of copper from copper ore is 70.4 MJ.

The energy needed to produce 1 kg of recycled copper is 27.2 MJ.

Calculate the difference in energy used if all the copper was produced from recycling.

Give your answer to 3 significant figures.

[5 marks]

_____

_____

_____

_____

_____

_____

_____

_____

Difference in energy used (3 significant figures) = _____ MJ

12

Do not write outside the box

0 5 Atmospheric pollution is emitted by cars.

Some car emissions contain nitrogen dioxide.

0 5 . 1 Describe how nitrogen dioxide (NO_2) is produced in the engine of a car that burns fossil fuels.

[3 marks]

_____

_____

_____

_____

_____

_____

Table 3 shows the concentration of nitrogen dioxide in the air in three different areas for 1 week.

Table 3

	Concentration of nitrogen dioxide in the air in micrograms per m^3		
Day	**City centre**	**Countryside**	**Motorway**
Monday	35	8	22
Tuesday	37	8	23
Wednesday	37	8	23
Thursday	34	8	23
Friday	37	8	23
Saturday	29	7	20
Sunday	**X**	6	17

Do not write outside the box

0 5 . 2 The mean value for nitrogen dioxide in the air for the whole week in the city centre is 33 micrograms per m^3.

Calculate the value (**X**) for the concentration of nitrogen dioxide in the air in the city centre on Sunday.

[2 marks]

X = _____ micrograms per m^3

0 5 . 3 Each value in **Table 3** has an uncertainty of ± 2 micrograms per m^3.

Explain why this uncertainty is **most** significant for countryside data.

[2 marks]

Question 5 continues on the next page

Do not write outside the box

Nitrogen dioxide is removed from car emissions by catalytic converters.

0 5 . 4 In a catalytic converter nitrogen dioxide (NO_2) reacts to produce nitrogen and oxygen.

Complete the equation for the reaction.

You should balance the equation.

[2 marks]

_____ NO_2 → _____ + _____

0 5 . 5 The catalyst in a catalytic converter contains platinum.

Platinum is a finite resource.

What is meant by a 'finite resource'?

[1 mark]

0 5 . 6 Emissions from cars contain carbon dioxide.

Explain why carbon dioxide emissions during use and operation are **not** the total carbon footprint for a car.

Refer to the stages of the life cycle assessment of a car in your answer.

[3 marks]

13

Do not write outside the box

0 6 Ammonia is produced when a mixture of nitrogen and hydrogen reacts.

The equation for the reaction is:

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

0 6 . 1 Nitrogen is obtained from the air.

The mixture of nitrogen and hydrogen must **not** contain carbon dioxide and oxygen.

Explain how a sample can be tested to show that carbon dioxide is **not** present in the mixture.

[2 marks]

0 6 . 2 A catalyst is used in the reaction.

Explain how a catalyst increases the rate of a reaction.

[2 marks]

Question 6 continues on the next page

Do not write outside the box

The equation for the reaction to produce ammonia is repeated here.

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

0 6 . 3 The reaction reaches equilibrium.

Explain how an equilibrium is reached.

[2 marks]

0 6 . 4 Suggest how the catalyst affects the equilibrium position.

Give **one** reason for your answer.

[2 marks]

0 6 . 5 What is the effect of increasing the pressure on the reaction to produce ammonia?

[1 mark]

Tick (✓) **one** box.

The yield of ammonia decreases. ☐

The yield of ammonia stays the same. ☐

The yield of ammonia increases. ☐

Do not write outside the box

0 6 . 6 The forward reaction is exothermic.

Explain the effect of increasing the temperature on the yield of ammonia gas produced at equilibrium.

[2 marks]

11

END OF QUESTIONS

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

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Question	Answers	Extra information	Mark	AO / Spec.
01.1	**independent** concentration (of hydrochloric acid) **control** any **one** from: • temperature (of hydrochloric acid) • volume of (hydrochloric) acid • length of magnesium • surface area of magnesium	 allow same mass of magnesium allow same form of magnesium ignore amount	1 1	AO1 5.6.1 RPA11
01.2	all points correctly plotted line of best fit	allow a tolerance of ± ½ a small square allow 1 mark for 4 or 5 points correctly plotted must include 0,0	2 1	AO2 5.6.1 RPA11
01.3	the rate decreases		1	AO3 5.6.1 RPA11
01.4	the magnesium reacted more quickly		1	AO3 5.6.1.2

01.5	rate increases (because) particles have more energy (so) more frequent collisions	allow reaction happens faster allow (because) particles move faster allow (because) more particles have energy greater than the activation energy 1	1 1 1	AO1 5.6.1.2 5.6.1.3
Total			**10**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	plankton **or** (ancient) biomass	allow microscopic plants / animals	1	AO1 5.7.1.1
02.2	propane	allow C_3H_8	1	AO1 5.7.1.1

Question	Answers	Mark	AO / Spec. Ref.
02.3	**Level 2:** Scientifically relevant features are identified; the way(s) in which they are similar / different is made clear and (where appropriate) the magnitude of the similarity / difference is noted.	4–6	AO3
	Level 1: Relevant features are identified and differences noted.	1–3	AO1 AO2
	No relevant content	0	
	Indicative content • methane has 1 carbon atom, hexane has 6 • methane has 4 hydrogen atoms, hexane has 14 • both contain C – H bonds • only hexane contains C – C bonds • both are hydrocarbons • hexane has a higher melting point than methane (or converse) • hexane has a higher boiling point than methane (or converse) • methane is a gas at room temperature • hexane is a liquid at room temperature • both are small molecules • hexane has larger molecules than methane • weak forces between molecules • forces between hexane molecules stronger than between methane molecules • hexane is more viscous than methane • both are flammable • methane is more flammable than hexane (or converse) • possible products of combustion from both are: carbon, carbon monoxide, carbon dioxide, water • neither conduct electricity		5.2.2.4 5.7.1.1 5.7.1.3

02.4	C_8H_{18}		1	AO2 5.3.1.1 5.7.1.4
02.5	bromine (water) turns (from orange / brown) to colourless	 MP2 is dependent on MP1 allow decolourises ignore clear	1 1	AO1 5.7.1.4
Total			**11**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	add water to anhydrous copper sulfate	allow a description of heating hydrated copper sulfate to produce anhydrous copper sulfate, followed by addition of water	1	AO2
	colour changes from white		1	AO1
	to blue		1	AO1 5.6.2.1
03.2	a single element or compound	allow an element or compound not (mixed) with any other substance ignore only one type of substance	1	AO1 5.8.1.1
03.3	(% impurity = $\frac{0.6}{0.12}$) = 5		1	AO2 5.8.1.1
	(mass impurity =) $\frac{5}{100}$ × 250		1	
	= 12.5 (g)		1	
03.4	heat salty water	allow boil salty water	1	AO1 5.10.1.2 RPA13
	(so) water evaporates (as water vapour)		1	
	cool the (water) vapour		1	
	(which) condenses to form potable / liquid water		1	

03.5	distillation requires energy (to boil salty water) (but) ground water only needs filtering **and** sterilising	allow distillation requires fuel (to boil salty water)	1 1	AO1 5.10.1.3 RPA13
Total			**13**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	production of copper is increasing at an increasing rate		1 1	AO2 5.10.1.1
04.2	increase in population / demand	allow more uses for copper	1	AO3 5.10.1.1
04.3	any **one** from: • more use of recycling • copper is a finite resource and may run out • alternative metals may be used in future	ignore only an estimate	1	AO3 5.10.1.1
04.4	**B**, **D**, **C**, **A**, **E**		1	AO1 5.10.1.4
04.5	any **two** from: • (phytomining is) slower to produce copper • large area of land required • insufficient yield to meet demand	ignore reference to cost ignore references to carbon dioxide ignore references to global warming allow plants grow slowly	2	AO3 5.10.1.4

04.6	(energy use through recycling = $27.2 \times 8.89 \times 10^9 \times \frac{41}{100}$) $= 9.914 \times 10^{10}$ (energy use through extraction = $70.4 \times 8.89 \times 10^9 \times \frac{59}{100}$) $= 3.693 \times 10^{11}$ (total consumption today = $9.914 \times 10^{10} + 3.693 \times 10^{11}$) $= 4.6844 \times 10^{11}$ (energy use if only recycling used = $27.2 \times 8.89 \times 10^9$) $= 2.418 \times 10^{11}$ (energy saving = $4.6844 \times 10^{11} - 2.418 \times 10^{11}$) $= 2.27 \times 10^{11}$ (MJ)	allow correct use of an incorrect energy use determined in MP1 and/or MP2 allow an answer correctly calculated to 3 significant figures which uses the values in the question	1 1 1 1 1 1 1	AO2 5.10.2.2
Total			**12**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	at high temperatures (in the engine) nitrogen reacts with oxygen (to produce nitrogen dioxide)		1 1 1	AO1 5.9.3.1
05.2	(**X**=) (33×7) – [(37×3)+35+34+29] = 22 (micrograms per m^3)	allow 33x7 = (37x3)+35+34+29+**X**	1 1	AO2 5.9.3.1
05.3	countryside data has smallest values (so) 2 is a higher proportion / percentage of the value	 allow (so) countryside is ± 2 out of a value between 6 to 8	1 1	AO3 5.9.3.1
05.4	$2\,NO_2 \rightarrow N_2 + 2\,O_2$	allow multiples or halves allow 1 mark for N_2 **and** O_2	2	AO2 5.3.1.1 5.10.1.1
05.5	a resource which will run out	allow a non-sustainable resource	1	AO1 5.10.1.1
05.6	(because carbon dioxide is emitted in) extracting / processing raw materials (and) manufacturing (and) disposal at the end of its useful life		1 1 1	AO2 5.9.2.4 5.10.2.1
Total			**13**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	use limewater **or** use calcium hydroxide solution (which) does not turn milky / cloudy	 allow (which) stays colourless	1 1	AO2 5.8.2.3
06.2	provides an alternative pathway (which has) a lower activation energy		1 1	AO1 5.6.1.4
06.3	(when) the apparatus prevents the escape of reactants and products (and the) forward and reverse reactions occur at same rate	allow (in a) closed system	1 1	AO1 5.6.2.3
06.4	equilibrium position stays the same increases the rate of the forward and the reverse reaction by the same amount	allow no effect	1 1	AO3 5.6.1.4 5.6.2.3
06.5	the yield of ammonia increases		1	AO2 5.6.2.4 5.6.2.7

06.6	yield of ammonia decreases (because) system shifts in endothermic direction	 allow (because) system shifts to counteract the change allow (because) system shifts to transfer in energy (from the surroundings)	1 1	AO2 5.6.2.4 5.6.2.6
Total			**11**	

AQA

Please write clearly in block capitals.

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

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

GCSE
COMBINED SCIENCE: TRILOGY

H

Higher Tier
Chemistry Paper 2H

Time allowed: 1 hour 15 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.
- 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	
TOTAL	

Information
- The maximum mark for this paper is 70.
- 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.

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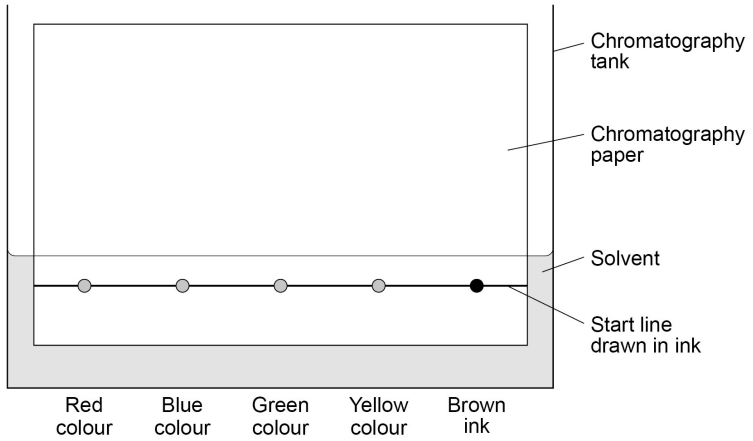
0 1 A student investigated the colours in a brown ink using chromatography.

0 1 . 1 **Figure 1** shows the apparatus used.

Figure 1



Give **two** errors made by the student.

Describe the problem each error would cause.

[4 marks]

Error 1 _____

_____

Problem 1 _____

_____

Error 2 _____

_____

Problem 2 _____

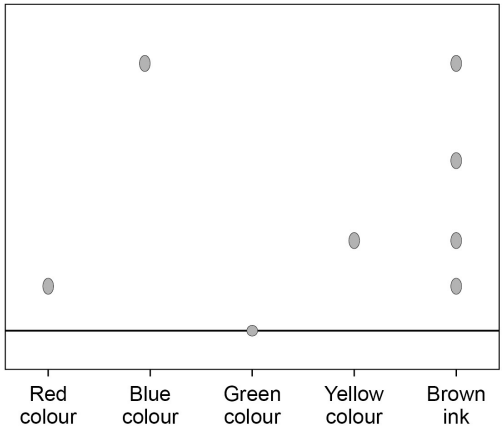
_____

Do not write outside the box

A different student set up the apparatus correctly.

Figure 2 shows the results.

Figure 2



0 1 . 2 Give **two** conclusions the student can make from **Figure 2** about the four colours in the brown ink.

[2 marks]

1 _____

_____

2 _____

_____

Question 1 continues on the next page

Do not write outside the box

0 1 . 3 Why was the green colour still on the start line at the end of the experiment?

[1 mark]

Tick (✓) **one** box.

The experiment was left for too long. ☐

The green colour was insoluble in the solvent. ☐

The green spot contained too many colours. ☐

The green spot was too small. ☐

0 1 . 4 A student calculated the R_f value of a colour to be 0.24

The colour moved 1.8 cm from the start line.

Calculate the distance the solvent moved.

Use the equation:

$$R_f = \frac{\text{distance moved by colour}}{\text{distance moved by solvent}}$$

[3 marks]

_____

_____

_____

_____

_____

_____

Distance moved by solvent = _____ cm

10

Do not write outside the box

0 2 . 1 Water that is safe to drink is called potable water.

Compare how easily potable water can be obtained from:

- waste water (sewage)
- ground water (fresh water).

[6 marks]

Question 2 continues on the next page

Do not write outside the box

A scientist produced potable water from 150 cm^3 of salty water.

0 2 . 2 Which process can be used to produce potable water from salty water?

[1 mark]

Tick (✓) **one** box.

- Distillation ☐
- Electrolysis ☐
- Filtration ☐
- Sterilisation ☐

0 2 . 3 The salty water contains sodium chloride.

The scientist collected 2.40 g of sodium chloride from 150 cm^3 of salty water.

Calculate the concentration of sodium chloride in grams per dm^3

[3 marks]

Concentration of sodium chloride = _____ g/dm^3

10

Do not write outside the box

0 3 This question is about the reaction between sodium thiosulfate solution and hydrochloric acid.

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 3 . 1 The mass of the conical flask and contents was greater at the start of the reaction than at the end.

Explain why.

[2 marks]

Question 3 continues on the next page

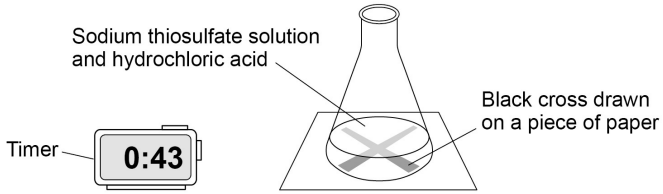
Do not write outside the box

A teacher demonstrated the reaction between sodium thiosulfate solution and hydrochloric acid.

Figure 3 shows the experiment.

The experiment was done in a fume cupboard.

Figure 3



This is the method the teacher used.

1. Pour 50 cm^3 of sodium thiosulfate solution into a conical flask.
2. Put the conical flask on a black cross drawn on a piece of paper.
3. Pour 10 cm^3 of hydrochloric acid into the conical flask and start a timer.
4. Stop the timer when the cross can no longer be seen.
5. Repeat the experiment at different temperatures.

0 3 . 2 What type of variable is time in this reaction?

[1 mark]

Tick (✓) **one** box.

Control ☐

Dependent ☐

Independent ☐

Do not write outside the box

0 3 . 3 **Table 1** shows the results.

Table 1

Temperature in °C	Time in seconds
19	82
32	48
45	43
52	15
63	7
73	3

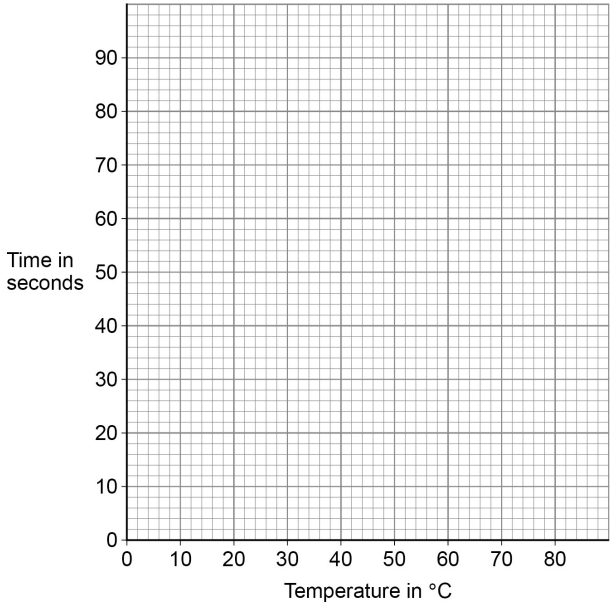
Complete **Figure 4.**

You should:

- plot the data from **Table 1** on **Figure 4**
- draw a line of best fit.

[3 marks]

Figure 4



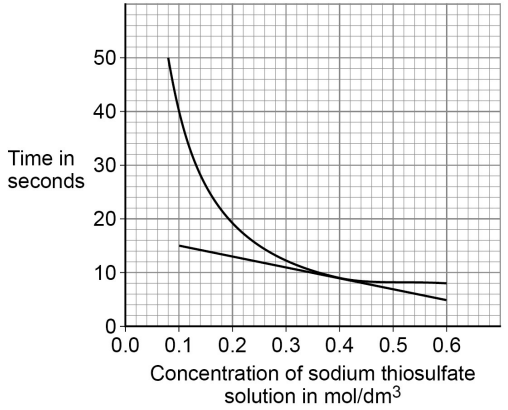
Turn over ►

Do not write outside the box

0 3 . 4 A student investigated the effect of concentration of sodium thiosulfate on the time taken for the reaction at room temperature.

Figure 5 shows the results with a tangent drawn at 0.4 mol/dm^3

Figure 5



Calculate the gradient (slope) of the tangent at 0.4 mol/dm^3

Give the unit.

[4 marks]

Gradient = _____

Unit = _____

Do not write outside the box

0 3 . 5 The student determined the **rate** of the reaction at regular time intervals during an experiment.

Explain why the **rate** decreased during the reaction.

You should give your answer in terms of particles.

[2 marks]

12

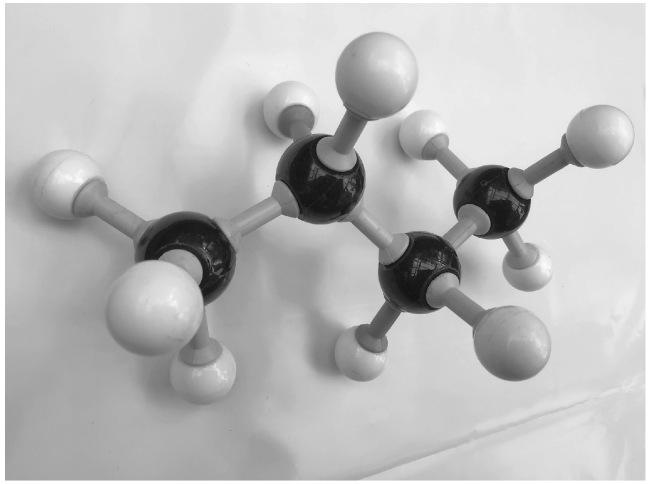
Turn over for the next question

Do not write outside the box

0 4 This question is about hydrocarbons and the uses of hydrocarbons.

0 4 . 1 **Figure 6** shows a model of an alkane.

Figure 6



What is the name of the alkane in **Figure 6**?

[1 mark]

0 4 . 2 What is a hydrocarbon?

[1 mark]

Do not write outside the box

Large hydrocarbon molecules are cracked.

0 4 . 3 When $C_{11}H_{24}$ is cracked, three products are formed.

Complete the equation for the reaction.

[2 marks]

$$C_{11}H_{24} \rightarrow C_5H_{10} + 2 \_\_\_\_\_ + \_\_\_\_\_$$

0 4 . 4 Explain why **one** of the products of cracking is in high demand.

[2 marks]

Question 4 continues on the next page

Do not write outside the box

0 4 . 5 Window frames can be manufactured from wood or from plastic.

Table 2 shows data from a life cycle assessment (LCA) for a wooden window frame and a plastic window frame.

Both window frames are the same size.

Table 2

	Wood	Plastic
Sources of hydrocarbons used for production in kg	5.37	18.23
Greenhouse gases released during production, use and disposal in kg equivalent of CO_2	457	487
Oxides of nitrogen and sulfur dioxide produced in arbitrary units	29.6	37.7
Waste materials in kg	16.5	28.8
Total energy consumption in production, use and disposal in MJ	9150	9713
Lifetime cost to customer to buy and maintain in £	147	102

Do not write outside the box

Evaluate the sustainability of wooden and plastic window frames.

You should include environmental and economic factors.

[6 marks]

12

Turn over for the next question

Do not write outside the box

0 5 This question is about the Earth's atmosphere and the Earth's resources.

0 5 . 1 After the formation of the Earth's early atmosphere, the amounts of nitrogen and oxygen in the atmosphere changed.

Explain the main changes in the amounts of nitrogen and oxygen in the Earth's atmosphere.

[4 marks]

Nitrogen

Oxygen

0 5 . 2 Describe how coal was formed from the carbon dioxide present in the Earth's early atmosphere.

[4 marks]

0 5 . 3 The combustion of 1.0 kg of coal produces more carbon dioxide than the combustion of 1.0 kg of natural gas.

Suggest why.

[1 mark]

Do not write outside the box

Metals are extracted from metal ores found in the Earth.

0 5 . 4 Describe how bioleaching is used to extract copper from low grade ores.

[3 marks]

0 5 . 5 Phytomining uses plants to extract nickel from low grade ores.

The plants contain 0.792% nickel by mass.

The plants are burned to produce ash.

The ash from these plants contains 4.80% nickel by mass.

Calculate the mass of ash produced from burning 1000 kg of plants.

Give your answer in grams in standard form.

[4 marks]

Mass of ash (in standard form) = _____ g

16

Turn over ►

Do not write outside the box

0 6 This question is about catalysts and equilibrium.

0 6 . 1 What type of substance is a catalyst in biological systems?

[1 mark]

Tick (✓) **one** box.

- Algae ☐
- Alkene ☐
- Enzyme ☐
- Formulation ☐

0 6 . 2 Explain how a catalyst increases the rate of a reaction.

[2 marks]

Do not write outside the box

The reversible reaction for the production of ammonia is:

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

0 6 . 3 What can scientists predict using Le Chatelier's Principle?

[1 mark]

0 6 . 4 Describe how a reversible chemical reaction is able to reach equilibrium.

[2 marks]

0 6 . 5 Explain the effect of increasing the pressure on the yield of ammonia.

[2 marks]

0 6 . 6 The forward reaction to produce ammonia is exothermic.

Explain the effect of increasing the temperature on the yield of ammonia.

[2 marks]

10

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 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	any **two** pairs from: (start) line drawn in ink (1) (so ink) will mix with solvent (1) the solvent is above the (start) line (1) (so) colours / ink will dissolve (1) no lid on tank (1) (so) solvent will evaporate (1)	 allow (start) line should be drawn in pencil allow the ink will move up the paper allow the solvent should be below the (start) line	4	AO3 5.8.1.3 RPA12

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.2	any **two** from: • (the brown ink) contains the blue, yellow and red (colours) • (the brown ink) contains an unknown colour • (the brown ink) does not contain green ink • blue (colour) is the most soluble **or** red (colour) is the least soluble	 allow blue (colour) has the highest R_f value allow red (colour) has the lowest R_f value ignore green colour is insoluble	2	AO3 5.8.1.3 RPA12

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.3	the green colour was insoluble in the solvent		1	AO2 5.8.1.3 RPA12

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.4	$0.24 = \frac{1.8}{\text{distance moved by solvent}}$ (distance moved by solvent =) $\frac{1.8}{0.24}$ = 7.5 (cm)		1 1 1	AO2 5.8.1.3 RPA12

Total Question 1		10

Question 2

Question	Answers	Mark	AO / Spec. Ref.
02.1	**Level 2:** Scientifically relevant features are identified, the way(s) in which they are similar / different is made clear and (where appropriate) the magnitude of the similarity / difference is noted.	4–6	AO1 5.10.1.3
	Level 1: Relevant features are identified and differences noted.	1–3	
	No relevant content	0	
	Indicative content **ground water** / **waste water** easier to obtain / more difficult to obtain fewer processes / more processes takes less time / takes more time filtered through filter beds / to remove insoluble particles / screening and grit removal / to remove large particles sedimentation / to produce sewage sludge and effluent aerobic biological treatment of effluent / to reduce solid waste sterilised / using chlorine, ozone or uv light / to kill bacteria / and then sterilised / using chlorine, ozone or uv light / to kill bacteria sludge is anaerobically digested / by specific bacteria / to remove organic matter		

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.2	distillation		1	AO1 5.10.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3	(conversion) ($\frac{150}{1000}$ =) 0.15 (dm^3) (concentration =) $\frac{2.40}{0.15}$ = 16 (g/dm^3) **OR** (conversion) $\frac{1000}{150}$ (1) = 6.67 (1) (6.67 × 2.4) = 16 (g/dm^3) (1) **OR** (concentration =) $\frac{2.4}{150}$ (1) = 0.016 (1) (conversion) (0.016 × 1000) = 16 (g/dm^3) (1)	allow correct use of incorrect / no conversion	1 1 1	AO2 5.3.2.5

Total Question 2		10

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	sulfur dioxide produced (which) escapes from the (conical) flask	allow a gas is produced	1 1	AO3 AO2 5.2.2.2 RPA11

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	dependent		1	AO2 5.6.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	all points correctly plotted line of best fit	allow **1** mark for 3, 4 or 5 points correctly plotted allow a tolerance of ± ½ a small square	2 1	AO2 AO3 5.6.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.4	correct values for *x* step **and** *y* step from tangent (rate =) $\frac{\text{value for } y \text{ step}}{\text{value for } x \text{ step}}$ correct calculation of rate s dm^3/mol	 allow correct use of an incorrectly determined value from tangent for *x* step and/or *y* step	1 1 1 1	AO2 5.6.1.1 RPA11

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.5	(as reaction proceeds) fewer (sodium thiosulfate) particles per unit volume (so) frequency of (particle) collisions decreases	allow (as reaction proceeds) concentration (of sodium thiosulfate) decreases allow (so) probability of collision decreases	1 1	AO2 5.6.1.2 5.6.1.3 RPA11

Total Question 3		**12**

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Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	butane		1	AO2 5.7.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	(molecule) made up of carbon and hydrogen (atoms) only		1	AO1 5.7.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	$C_{11}H_{24} \rightarrow C_5H_{10} + 2\,C_2H_4 + C_2H_6$	allow **1** mark for $2\,C_2H_4$ allow **1** mark for C_2H_6	2	AO2 5.1.1.1 5.3.1.1 5.7.1.4
	OR $C_{11}H_{24} \rightarrow C_5H_{10} + 2\,C_3H_6 + H_2$ (2)	allow **1** mark for $2\,C_3H_6$ allow **1** mark for H_2		
	OR $C_{11}H_{24} \rightarrow C_5H_{10} + 2\,C_2H_6 + C_2H_2$ (2)	allow **1** mark for $2\,C_2H_6$ allow **1** mark for C_2H_2		

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	C_2H_6 is useful as a fuel	allow smaller molecule so useful as a fuel	1	AO1 5.7.1.3 5.7.1.4
	(because more) flammable (than larger molecules)		1	
	OR			
	C_2H_4 / C_3H_6 / C_5H_{10} is used to make polymers (1)	allow C_2H_4 / C_3H_6 / C_5H_{10} is used to make plastics allow C_2H_4 / C_3H_6 / C_5H_{10} is used to make other chemicals		
	(because more) reactive (than alkanes) (1)			
		if a named product is given, allow **1** mark for a correct use and **1** mark for a correct linked reason		

Question	Answers	Mark	AO / Spec. Ref.
04.5	**Level 3:** A judgement, strongly linked and logically supported by a sufficient range of correct reasons is given.	5–6	AO3 5.9.2.2 5.10.1.1 5.10.2.1
	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 • production of plastic uses more hydrocarbons which are from non-renewable crude oil • production of plastic produces more greenhouse gases in the atmosphere which contributes to global warming • production of plastic produces more sulfur dioxide which causes acid rain • production of plastic produces more oxides of nitrogen which cause acid rain and respiratory problems • disposal of plastic produces more waste which increases landfill • burning plastic produces fumes which are toxic so cause respiratory problems • lifetime cost of plastic frames is less • plastic frames have lower costs for maintaining • the total energy consumption for plastic frames is greater than for wooden frames • judgement		

Total Question 4		12

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	nitrogen increased		1	AO1 5.9.1.2
	(because of) emission from volcanoes	allow (because of) denitrifying bacteria	1	5.9.1.3
	oxygen increased		1	
	(because of) photosynthesis		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	carbon dioxide is used during photosynthesis		1	AO1 5.9.1.4
	in trees		1	
	(which) die and are compressed		1	
	over millions of years		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	coal has a higher proportion / percentage of carbon		1	AO2 5.9.3.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	uses bacteria		1	AO1 5.10.1.4
	to produce solutions containing copper compounds	allow to produce leachate solutions	1	
	from which copper is obtained by displacement / electrolysis		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	1000 (kg of plants) gives 7.92 (kg of nickel)		1	AO2 5.10.1.4
	(mass = $\frac{7.92}{4.8}$ × 100 =) 165 (kg)		1	
	(conversion 165 kg =) 165 000 (g)	allow correct conversion of an incorrectly determined mass in kg	1	
	= 1.65 × 10^5 (g)	allow a correctly calculated and rounded conversion to standard form of an incorrect calculation of mass in grams	1	
	OR			
	(mass =) $\frac{0.792}{4.8}$ × 1000 (1)			
	= 165 (kg) (1)			
	(conversion 165 kg =) 165 000 (g) (1)	allow correct conversion of an incorrectly determined mass in kg		
	= 1.65 × 10^5 (g) (1)	allow a correctly calculated and rounded conversion to standard form of an incorrect calculation of mass in grams		

Total Question 5		**16**

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	enzyme		1	AO1 5.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	provides a different reaction pathway (which) has a lower activation energy		1 1	AO1 5.6.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	the effects of changing conditions on the position of an equilibrium (in a closed system)	allow the effects of changing conditions on the yield of an equilibrium reaction (in a closed system)	1	AO1 5.6.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.4	(when) the forward and reverse reactions have the same rate in apparatus which prevents the escape of reactants and products	 allow in a closed system	1 1	AO1 5.6.2.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.5	yield increases (because) there are more moles (of gas) on the left hand side	 allow (because) there are fewer moles (of gas) on the right hand side	1 1	AO2 5.6.2.1 5.6.2.2 5.6.2.3 5.6.2.4 5.6.2.7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.6	yield decreases (because) the system shifts in the endothermic direction		1 1	AO2 5.6.2.1 5.6.2.2 5.6.2.3 5.6.2.4 5.6.2.6

Total Question 6		**10**