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 1H

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	
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 This question is about the periodic table.

0 1 . 1 **Figure 1** shows part of Mendeleev's version of the periodic table.

Figure 1

H							
Li	Be	B	C	N	O	F	
Na	Mg	Al	Si	P	S	Cl	
K Cu	Ca Zn		Ti	V As	Cr Se	Mn Br	Fe Co Ni
Rb Ag	Sr Cd	Y In	Zr Sn	Nb Sb	Mo Te	I	Ru Rh Pd

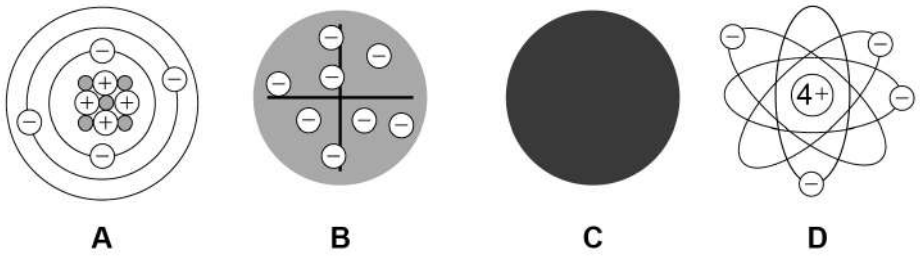
Which group of elements had **not** been discovered when Mendeleev's version of the periodic table was published?

[1 mark]

Do not write outside the box

Figure 2 represents different models of the atom.

Figure 2



0 1 . 2 Which model represents the plum pudding model?

[1 mark]

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

0 1 . 3 Which model resulted from Chadwick's experimental work?

[1 mark]

Tick (✓) **one** box.

A ☐ **B** ☐ **C** ☐ **D** ☐

Question 1 continues on the next page

Do not write outside the box

Potassium has different isotopes.

0 1 . 4 What is meant by 'isotopes'?

You should refer to subatomic particles.

[2 marks]

0 1 . 5 **Table 1** shows the mass numbers and the percentage abundance of two isotopes of potassium.

Table 1

Mass number	Percentage abundance
39	93.1
41	6.9

Calculate the relative atomic mass (A_r) of potassium.

Give your answer to 1 decimal place.

[3 marks]

Relative atomic mass (1 decimal place) = _____

8

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 2 Acids react to produce salts.

Universal indicator is added to water and then nitric acid is added to the mixture.

0 2 . 1 Give the colour change when nitric acid is added to the mixture of universal indicator and water.

[1 mark]

Tick (✓) **one** box.

Blue to red ☐

Green to purple ☐

Green to red ☐

Red to purple ☐

0 2 . 2 What happens to the pH of water when nitric acid is added?

[1 mark]

Tick (✓) **one** box.

Decreases ☐

Stays the same ☐

Increases ☐

0 2 . 3 What is the state symbol for nitric acid?

[1 mark]

_____

Do not write outside the box

Zinc carbonate reacts with nitric acid.

The word equation for the reaction is:

zinc carbonate + nitric acid → zinc nitrate + water + carbon dioxide

white solid — colourless solution

0 2 . 4 Give **two** observations that would be made when zinc carbonate is added to nitric acid until the zinc carbonate is in excess.

[2 marks]

1 _____

_____

2 _____

_____

0 2 . 5 The formula of the zinc ion is Zn^{2+}

The formula of the nitrate ion is NO_3^-

What is the formula for zinc nitrate?

[1 mark]

Tick (✓) **one** box.

$ZnNO_3$ ☐

$Zn(NO_3)_2$ ☐

Zn_2NO_3 ☐

$Zn_2(NO_3)_2$ ☐

Question 2 continues on the next page

Do not write outside the box

0 2 . 6 Acids react with insoluble metal oxides to produce salts.

Plan a method to produce a pure, dry sample of the soluble salt copper chloride from an acid and a metal oxide.

[6 marks]

12

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 3 This question is about energy change.

A student investigated the temperature change when 10 g of ammonium nitrate was added to 100 cm^3 of water.

This is the method used.

1. Measure the temperature of 100 cm^3 of water.

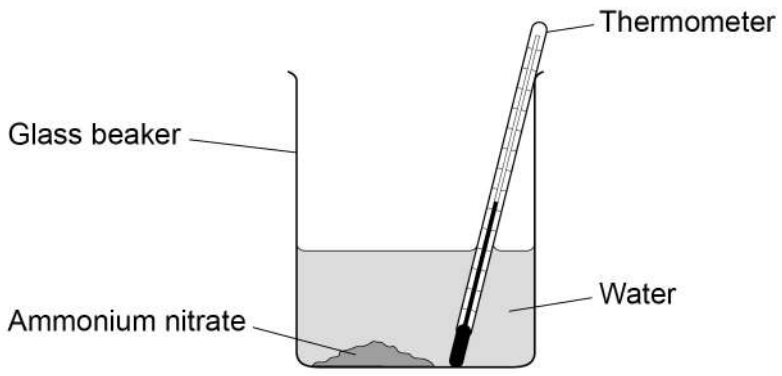
2. Add 10 g of ammonium nitrate.

3. Stir once.

4. Measure the temperature of the solution every minute for 7 minutes.

Figure 3 shows the apparatus.

Figure 3



0 3 . 1 What is the dependent variable in this investigation?

[1 mark]

0 3 . 2 Give **three** improvements to the investigation to make the results more accurate.

[3 marks]

1

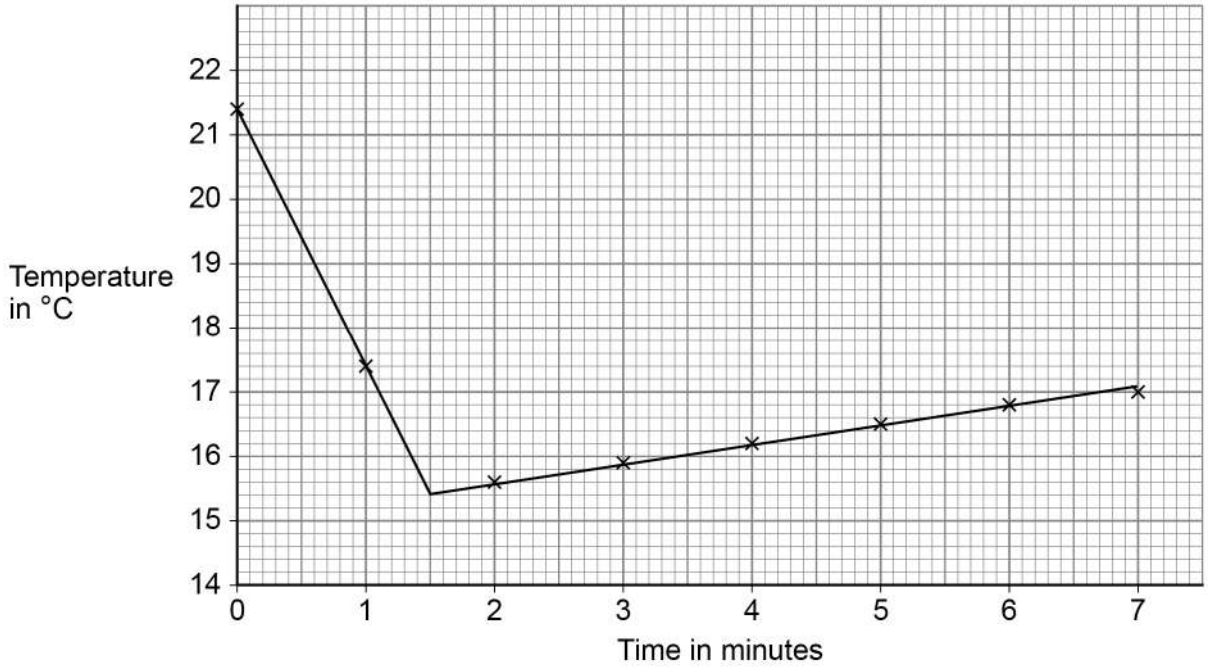
2

3

Do not write outside the box

0 3 . 3 **Figure 4** shows the results.

Figure 4



Explain the results.

[4 marks]

Question 3 continues on the next page

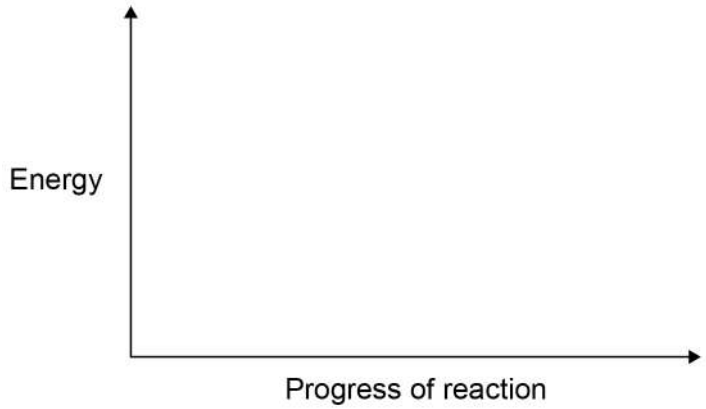
Do not write outside the box

0 3 . 4 Draw a reaction profile for an exothermic reaction.

You should label:

- the energy level of the reactants and of the products
- the activation energy
- the overall energy change.

[4 marks]



12

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 Carbon can exist in a number of different structures.

0 4 . 1 The first fullerene to be discovered was Buckminsterfullerene.

What is the formula of Buckminsterfullerene?

[1 mark]

Tick (✓) **one** box.

C_{40} ☐

C_{50} ☐

C_{60} ☐

C_{70} ☐

0 4 . 2 Graphite is a form of carbon.

Explain why graphite conducts electricity.

[2 marks]

Do not write outside the box

Steel is an alloy of iron and carbon.

0 4 . 3 Explain why steel is harder than iron.

[3 marks]

0 4 . 4 Iron is alloyed with carbon and other metals to make stainless steel.

A stainless steel fork contains 71.92% iron.

Table 2 shows the mass of each element in the fork.

Table 2

Element	Iron	Carbon	Chromium	Nickel
Mass of element in g	**X**	0.05	10.44	5.80

Calculate the mass of iron (**X**) in the fork.

[4 marks]

X = _____ g

10

Turn over ►

Do not write outside the box

0 5 This question is about the electrolysis of aqueous solutions.

Hydrogen gas and chlorine gas are produced when sodium chloride solution is electrolysed.

0 5 . 1 Hydrogen ions (H^+) are attracted to the negative electrode.

The half equation for the reaction at the negative electrode is:

$$2H^+ + 2e^- \rightarrow H_2$$

What type of reaction happens at the negative electrode?

Give the reason for your answer.

[2 marks]

Type of reaction _____

Reason _____

_____

0 5 . 2 Chloride ions are attracted to the positive electrode.

Complete the half equation for the production of chlorine gas (Cl_2).

[2 marks]

$$\_\_\_\ Cl^- \rightarrow \_\_\_\_\_ + \_\_\_\_\_$$

Do not write outside the box

0 5 . 3 Hydrogen gas and oxygen gas are produced when sodium sulfate solution is electrolysed.

Explain how oxygen gas is produced in the electrolysis of sodium sulfate solution.

[4 marks]

8

Turn over for the next question

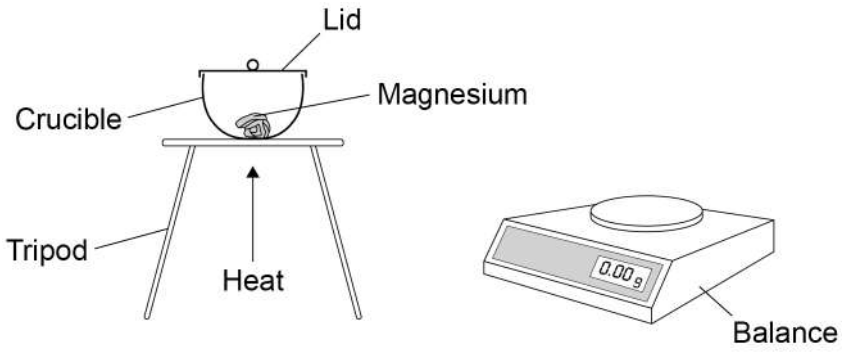
Do not write outside the box

0 6 Metal oxides are produced when metals are heated in air.

A student investigated the change in mass when 0.12 g of magnesium was heated in air.

Figure 5 shows the apparatus.

Figure 5



The student measured the mass of magnesium oxide produced.

0 6 . 1 0.12 g of magnesium reacted to produce 0.20 g of magnesium oxide.

Calculate the number of moles of oxygen gas (O_2) that reacted.

Relative atomic mass (A_r): O = 16

[3 marks]

Moles of oxygen gas = _____

Do not write outside the box

0 6 . 2 The student repeated the experiment **without** a lid on the crucible.

Suggest why the mass of magnesium oxide produced would be different without a lid on the crucible.

[2 marks]

0 6 . 3 Copper reacts with oxygen to produce copper oxide.

63.5 g of copper produces 79.5 g of copper oxide.

Calculate the mass of copper oxide produced when 0.50 g of copper reacts with oxygen.

Give your answer to 3 significant figures.

[3 marks]

Mass (3 significant figures) = _____ g

Question 6 continues on the next page

Do not write outside the box

0 6 . 4 Iron reacts with oxygen to produce an oxide of iron.

0.015 moles of iron reacts with 0.010 moles of oxygen gas (O_2).

Determine:

- the formula of the iron oxide produced
- the balanced symbol equation for the reaction.

[4 marks]

Formula of iron oxide = _____

Balanced symbol equation

_____

12

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 7 Methane, ethane, propane and butane all react with oxygen to produce carbon dioxide and water.

0 7 . 1 Suggest why a mixture of methane and oxygen does **not** react at room temperature.

Answer in terms of particles.

[2 marks]

0 7 . 2 **Table 3** shows the energy released when methane, ethane and propane react with oxygen to produce carbon dioxide and water.

Table 3

	Compound reacted with oxygen		
	Methane	Ethane	Propane
Formula of compound	CH_4	C_2H_6	C_3H_8
Energy released in kJ/mol	680	1160	1640

Predict the energy released when butane (C_4H_{10}) reacts with oxygen to produce carbon dioxide and water.

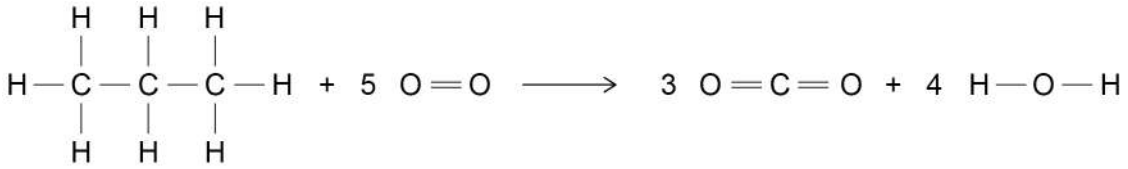
[1 mark]

Energy released = _____ kJ/mol

Do not write outside the box

0 7 . 3 Propane reacts with oxygen to produce carbon dioxide and water.

The displayed formula equation for the reaction is:



The reaction is exothermic.

In the reaction, the energy released when forming new bonds is 1640 kJ/mol greater than the energy needed when breaking bonds.

Table 4 shows bond energies.

Table 4

Bond	**H–C**	**C–C**	**O=O**	**C=O**	**O–H**
Bond energy in kJ/mol	410	**X**	500	740	460

Calculate the C—C bond energy (**X**).

[5 marks]

X = _____ kJ/mol

8

END OF QUESTIONS

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

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

Do not write outside the box

Do not write outside the box

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

Do not write outside the box

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

Do not write outside the box

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

GCSE
COMBINED SCIENCE: TRILOGY
8464/C/1H

Chemistry Paper 1H

Mark scheme

June 2021

Version: 1.0 Final Mark Scheme

2 1 6 G 8 4 6 4 C 1 H / M S

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 his or her judgement
- the Assessment Objectives, level of demand 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.

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**. Different terms in the mark scheme are shown by a / ; 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 error / 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 planets in the solar system.

[2 marks]

Student	Response	Marks awarded
1	Neptune, Mars, Moon	1
2	Neptune, Sun, Mars, Moon	0

3.2 Use of chemical symbols / formulae

If a student writes a chemical symbol / formula instead of a required chemical name, 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. Full marks can, however, be given for a correct numerical answer, without any working shown.

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

Any error in the answers to a structured question should be penalised once only.

Papers should be constructed in such a way that the number of times errors can be carried forward is kept to a minimum. Allowances for errors carried forward are most likely to be restricted to calculation questions and should be shown by the abbreviation ecf in the marking scheme.

3.6 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited **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.

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 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.

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.

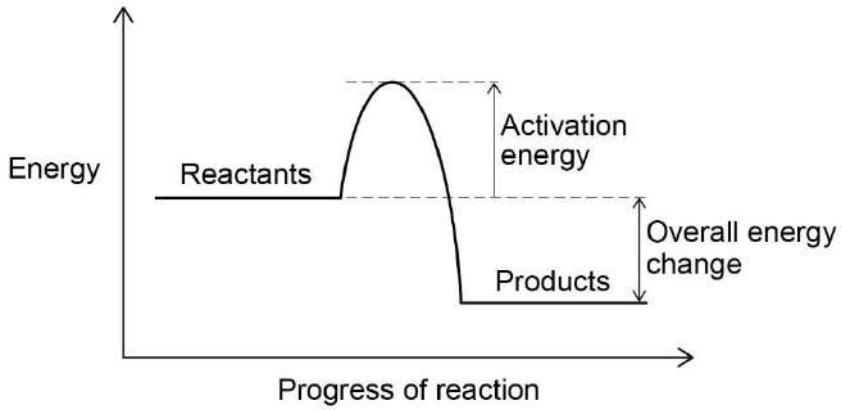
An answer which contains nothing of relevance to the question must be awarded no marks.

Question	Answers	Extra information	Mark	AO / Spec. Ref.
01.1	(Group) 0 **or** noble gases		1	AO2 5.1.2.2
01.2	B		1	AO2 5.1.1.3
01.3	A		1	AO3 5.1.1.3
01.4	(atoms with the) same number of protons	allow atoms with the same atomic number allow atoms of the same element ignore the same number of electrons	1	AO1 5.1.1.5
	(but with) different numbers of neutrons	ignore (but with) different mass numbers do **not** accept (but with) different relative atomic mass	1	
01.5	$\frac{(39 \times 93.1) + (41 \times 6.9)}{100}$		1	AO2 5.1.1.6
	= 39.138		1	
	= 39.1	allow correctly rounded answer to **1** decimal place from an incorrect calculation using all the values given in the question	1	
Total			**8**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	green to red		1	AO1 5.4.2.4
02.2	decreases		1	AO1 5.4.2.4
02.3	(aq)	allow aq ignore aqueous ignore HNO_3	1	AO1 5.2.2.2
02.4	any **two** from: • (white) solid disappears • fizzing **/** bubbles / effervescence • (then) stops fizzing • (white) solid left at the end / bottom	allow a gas is produced ignore colourless solution	2	AO3 5.4.2.2 5.4.2.3
02.5	$Zn(NO_3)_2$		1	AO2 5.1.1.1 5.4.2.2

Question	Answers	Mark	AO / Spec. Ref.
02.6	**Level 3:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	5–6	AO1 5.4.2.2 5.4.2.3 RPA8
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.	3–4	
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative Content: • react hydrochloric acid • (with) copper oxide • in a suitable container • warm (hydrochloric) acid • add copper oxide • until is in excess **or** until solid remains • stir • filter excess copper oxide • pour solution / filtrate into evaporating basin • use of water bath **or** use of electric heater • to heat gently **or** partially evaporate • leave to cool / crystallise For level 3 the correct chemicals must have been selected.		
Total		**12**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	temperature (of solution)	allow temperature change	1	AO1 5.5.1.1
03.2	any **three** from: • insulate the beaker **or** use polystyrene cup • add a lid • stir more (times) • repeat the experiment **and** calculate the mean (ignoring anomalous results) • use smaller volume (of water) • use larger mass of ammonium nitrate • more accurate balance • use digital thermometer **or** use a more accurate thermometer		3	AO3 5.5.1.1
03.3	(from 0 to 1.5 minutes the) temperature decreases (because) ammonium nitrate dissolving is endothermic (then) after 1.5 minutes the temperature increases (because) energy transfers to the solution from the surroundings	allow the temperature decreases (from 21.4 ºC to 15.4 ºC) (then) after 15.4 ºC the temperature increases	1 1 1 1	AO3 5.5.1.1

03.4	labelled horizontal lines for reactants and products, with the product line below the level of the reactant line		1	AO1 5.5.1.2
	reaction pathway	allow curve to start / finish anywhere along reactant / product lines	1	
	line from reactants to maximum labelled activation energy		1	
	line from reactants to products labelled overall energy change		1	
	the diagram below scores 4 marks  			

Total		**12**

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	C_{60}		1	AO1 5.2.3.3
04.2	(graphite has) delocalised electrons (so the delocalised electrons) carry electrical charge through the structure	 allow (so the delocalised electrons) move through the structure	1 1	AO1 5.2.3.2
04.3	carbon atoms have different sizes to iron atoms / ions (so carbon atoms) distort the layers of iron atoms / ions (therefore) the layers cannot slide		1 1 1	AO1 5.2.2.7
04.4	(percentage and mass of other elements) 28.08 (%) = 16.29 (g) (mass of fork) = $\frac{16.29}{28.08} \times 100$ (g) = 58.01 (g) (mass of iron = $\frac{71.92}{100} \times 58.01$) = 41.72 (g)	 allow (mass of fork – mass of other elements) = 41.72 (g) allow 41.7 (g) allow correct use of incorrect calculation of mass and / or percentages	 1 1 1 1	AO2 5.2.2.7
Total			**10**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	reduction (as H^+ ions) gain electrons	ignore electrolysis	1 1	AO2 AO1 5.4.1.4 5.4.3.1 5.4.3.4 RPA 9
05.2	$2\,Cl^- \rightarrow Cl_2 + 2\,e^-$	allow $2\,Cl^- - 2\,e^- \rightarrow Cl_2$ ignore state symbols allow **1** mark for $Cl_2 + e^-$ allow **1** mark for $- e^-$ (on lhs) **and** Cl_2 (on rhs)	2	AO2 5.4.1.4 5.4.3.1 5.4.3.4 RPA9
05.3	water molecules break down to produce OH^- ions (which are) attracted to the positive electrode (where OH^- ions are) oxidised **or** (where OH^- ions) lose electrons	 allow dissociate to produce OH^- ions ignore discharged ignore oxygen is produced as no halide is present	1 1 1 1	AO1 5.4.1.4 5.4.3.1 5.4.3.4 5.4.3.5 RPA9
Total			**8**	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	(mass of oxygen = 0.20 – 0.12) = 0.08 (g)		1	AO2 5.1.1.1 5.3.1.1
	(moles of oxygen) = $\frac{0.08}{32}$	allow **1** mark for 0.005 if derived from $\frac{0.08}{16}$	1	5.3.1.3 5.3.2.1 5.4.1.1
	= 0.0025		1	
06.2	(without a lid the) mass of magnesium oxide was less		1	AO3 5.4.1.1
	(because) products escaped	allow magnesium oxide escaped	1	
06.3	(mass of copper oxide =) $\frac{79.5}{63.5}$ × 0.5		1	AO2 5.1.1.1 5.3.1.1 5.3.1.3
	= 0.62598 (g)		1	5.3.2.1 5.3.2.2
	= 0.626 (g)	allow an answer correctly rounded to 3 significant figures from an incorrect calculation which uses all the values in the question	1	5.3.2.3 5.4.1.1

06.4	3:2 ratio Fe : O_2 (molecules) **or** 3:4 ratio Fe : O (atoms)		1	AO2 5.1.1.1 5.3.1.1 5.3.1.3 5.3.2.1
	(formula) Fe_3O_4	allow **1** mark for Fe_3O_2 from 3:2 ratio Fe : O (atoms) (MP2 but not MP1)	1	5.3.2.2 5.3.2.3 5.4.1.1
	$3\,Fe + 2\,O_2 \rightarrow Fe_3O_4$	allow multiples allow correct use of incorrectly determined formula allow **1** mark for Fe, O_2 and Fe_3O_4 **or** allow **1** mark for Fe, O_2 and incorrectly determined formula	2	

Total			**12**

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	particles collide		1	AO3 5.5.1.2
	(but at room temperature) particles have insufficient energy **or** (but) have energy less than the activation energy (so collisions are not successful)		1	
07.2	2120 (kJ/mol)		1	AO3 5.5.1.2 5.5.1.3
07.3		allow C–C for **X**		AO2 5.5.1.3
	(bonds broken = (8 × 410) + 2 **X** + (5 × 500) = 5780 + 2 **X**	allow (bonds broken = (8 × 410) + (5 × 500) = 5780	1	
	(bonds formed = (6 × 740) + (8 × 460) = 8120		1	
	(bonds broken – bonds formed = energy released) (5780 + 2 **X**) – 8120 = – 1640	allow correct use of incorrect values from step 1 and/or step 2	1	
	(2 **X** =) 700	allow correct use of incorrect value from step 3	1	
	(**X** =) 350 (kJ/mol)		1	
Total			**8**	