AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.4.1.3

Extraction of metals and reduction

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**66**
Available paper years	**2007–2025**

Using this booklet

1. Booklet answer numbers match the question booklet.
2. Use the original question number within marking tables.
3. Examiner comments are included where available.

Name: _____ **Date:** _____

Where a precise marking extract is unavailable, the full source document is included in an appendix. Any missing mark scheme is explicitly identified.

4.4.1.3 Extraction of metals and reduction

Answer 01 · Mark scheme January 2007 | CHY1H | Original Q3 | Legacy

Question 3

	answers	extra information	mark
(a)(i)	contain enough metal to make it economical / worth while to extract		1
(ii)	reduction	accept displacement accept redox	1
(iii)	Fe + CO_2	do **not** accept Fe_2 / Fe_4	1
	correct balancing	accept multiples and halves	1
	2Fe_2O_3 + **3**C → **4**Fe + **3**CO_2	allow Fe_2 / Fe_4 as ecf	
(b)	**Pure Iron** (in pure metal all the atoms are the same size and) able to slip / slide over each other – (property soft)	OWTTE ignore references to molecules / particles. if they say 'move' both times, allow **one** mark but 'crack' or 'split' is wrong.	1
	Cast iron (in cast iron) different sized atoms / larger atoms **or** structure is distorted / disrupted	OWTTE	1
	so it is difficult for layers of atoms to slip / slide over each other	OWTTE	1
(c)	any **three** from: • conserves / saves resources / metal ores • saves energy resources (used for extraction / processing) • decreases waste materials • decreases a named pollution	accept cheaper / saves money do **not** accept acid rain	3
total			10

4.4.1.3 Extraction of metals and reduction

Answer 02 · Mark scheme March 2007 | CHY1A | Original Q6 | Legacy

Six	**A**	calcium carbonate only	**1**
	B	calcium oxide only	**3**
	C	calcium carbonate and calcium oxide	**2**
	D	carbon dioxide only	**4**

	A	**B**	**C**	**D**

Answer 03 · Mark scheme June 2007 | CHY1A | Original Q1 | Legacy

Question	***Key***		
One	**A**	hard	**3**
	B	resistant to corrosion	**4**
	C	easily shaped	**2**
	D	brittle	**1**

Answer 04 · Mark scheme June 2007 | CHY1A | Original Q5 | Legacy

Five	**3**	**2**	**1**	**1**

Answer 05 · Mark scheme June 2007 | CHY1A | Original Q7 | Legacy

Seven	**3**	**2**	**3**	**3**

Answer 06 · Mark scheme June 2007 | CHY1A | Original Q8 | Legacy

Eight	**1**	**3**	**2**	**3**

Answer 07 · Mark scheme June 2007 | CHY1H | Original Q2 | Legacy

The full source mark scheme begins on page 75. Follow original question 2 in that document.

Answer 08 · Mark scheme November 2007 | CHY1A | Original Q3 | Legacy

Three	**1**	**4**	**2**	**3**

Answer 09 · Mark scheme November 2007 | CHY1A | Original Q4 | Legacy

Four	**3**	**3**	**2**	**1**

Answer 10 · Mark scheme November 2007 | CHY1A | Original Q7 | Legacy

Seven	**4**	**4**	**2**	**2**

4.4.1.3 Extraction of metals and reduction

Answer 11 · Mark scheme

November 2007 | CHY1A | Original Q9 | Legacy

Nine	**3**	**4**	**3**	**3**

Answer 12 · Mark scheme

November 2007 | CHY1B | Original Q4 | Legacy

Four	**1**	**2**	**1**	**2**

Answer 13 · Mark scheme

January 2008 | CHY1H | Original Q4 | Legacy

No matching mark scheme was available in the supplied archive for this question.

Answer 14 · Mark scheme

March 2008 | CHY1AP | Original Q5 | Legacy

Five	**1**	**3**	**1**	**1**

Answer 15 · Mark scheme

June 2008 | CHY1AP | Original Q3 | Legacy

Three	**1**	**4**	**3**	**1**

4.4.1.3 Extraction of metals and reduction

Answer 16 · Mark scheme

June 2008 | CHY1H | Original Q4 | Legacy

question	answers	extra information	mark
4(a)	any **one** from: • light(er) / less dense • resistant to acids / alkalis / chemical	 ignore stronger accept resistant to corrosion	1
4(b)	any **two** from: • magnesium is <u>more</u> reactive than titanium • titanium is <u>more</u> reactive than carbon • magnesium is <u>more</u> reactive than carbon • magnesium is <u>most</u> reactive • carbon is <u>least</u> reactive	it must be clear list principle applies allow reverse argument ignore reference to temperature magnesium is above titanium in the reactivity series	2

Question 4 continued on the next page...

4.4.1.3 Extraction of metals and reduction

Answer 16 · Mark scheme

June 2008 | CHY1H | Original Q4 | Legacy

COMPONENT NUMBER: CHY1H

COMPONENT NAME: Science B / Chemistry

STATUS: Final

DATE: June 2008

Question 4 continued...

question	answers	extra information	mark
4(c)	any **three** from: • takes a long time to process • low abundance (of ore) • small amount produced • batch process used **or** blast furnace is continuous • more stages used to manufacture titanium • more energy used (per tonne of titanium) • magnesium / chlorine is expensive • labour intensive	it = titanium ignore references to cost / easier / usefulness alone **or** references to incorrect processes allow ≥ 3 / many / several allow high energy requirement ignore references to temperature	3
Total			**6**

4.4.1.3 Extraction of metals and reduction

Answer 16 · Mark scheme June 2008 | CHY1H | Original Q4 | Legacy

COMPONENT NUMBER: CHY1H

COMPONENT NAME: Science B / Chemistry

STATUS: Final

DATE: June 2008

Answer 17 · Mark scheme November 2008 | CHY1AP | Original Q4 | Legacy

Four	**2**	**3**	**3**	**3**

Answer 18 · Mark scheme March 2009 | CHY1AP | Original Q2 | Legacy

Two	**A**	decomposed	**2**			
	B	acidified	**3**			
	C	reduced	**4**			
	D	extracted	**1**			
	A		**B**	**C**	**D**	

Answer 19 · Mark scheme March 2009 | CHY1AP | Original Q9 | Legacy

Nine	**2**	**2**	**3**	**1**

Answer 20 · Mark scheme June 2009 | CHY1AP | Original Q4 | Legacy

Four	**3**	**3**	**4**	**1**

4.4.1.3 Extraction of metals and reduction

Answer 21 · Mark scheme June 2009 | CHY1AP | Original Q6 | Legacy

Six	**2**	**4**	**2**	**3**

Answer 22 · Mark scheme June 2009 | CHY1AP | Original Q7 | Legacy

Seven	**4**	**1**	**4**	**1**

Answer 23 · Mark scheme June 2009 | CHY1AP | Original Q9 | Legacy

Nine	**3**	**3**	**2**	**3**

4.4.1.3 Extraction of metals and reduction

Answer 24 · Mark scheme June 2009 | CHY1H | Original Q1 | Legacy

Question 1

question	answers	extra information	mark
1(a)(i)	3 / three		1
1(a)(ii)	5 / five		1
1(b)	any **one** from: • less / no transport • less / no (fossil) fuel used	 accept less / no distance ignore references to carbon dioxide / carbon emissions	1
1(c)(i)	carbon dioxide / CO_2 (causes) global warming / climate change / greenhouse gas **or** (cement) particles / smoke (1) (causes) asthma / dust / (global) dimming (1) **or** sulfur dioxide / SO_2 / nitrogen oxides / NO_x (1) (causes) acid rain (1)	for a correct emission explanation must be correct for named emission ignore ozone layer accept breathing problems do **not** accept nitrogen or water vapour for emissions do **not** accept no named emission	1 1

Question 1 continues on the next page…

CHY1H

Question 1 Continued

question	answers	extra information	mark
1(c)(ii)	absorb / trap / capture / filter / pass through water / scrub / electrostatic attraction	ignore condense / off setting / different fuel	1
Total			**6**

4.4.1.3 Extraction of metals and reduction

Answer 24 · Mark scheme

June 2009 | CHY1H | Original Q1 | Legacy

CHY1H

4.4.1.3 Extraction of metals and reduction

Answer 25 · Mark scheme

June 2009 | CHY1H | Original Q4 | Legacy

Question 4

question	answers	extra information	mark
4(a)(i)	reacts with carbon / C carbon dioxide / CO_2 / gas is formed / given off	accept burns / oxidises carbon accept carbon monoxide / CO accept correctly balanced equation for **2** marks ignore state symbols	1 1
4(a)(ii)	change / improve properties	accept any specific property accept to make alloys / special steels ignore brittle	1
4(b)	any **two** from: • to conserve ores / iron • to prevent the use of landfills • to conserve energy / fuel • to reduce carbon / carbon dioxide emissions • to meet EU / International targets	 accept ores / iron are non-renewable / non-sustainable allow less quarrying / mining allow reduce waste accept fossil fuels are non-renewable ignore costs / demand	2
Total			**5**

4.4.1.3 Extraction of metals and reduction

Answer 25 · Mark scheme

June 2009 | CHY1H | Original Q4 | Legacy

CHY1H

4.4.1.3 Extraction of metals and reduction

Answer 26 · Mark scheme

June 2009 | CHY1H | Original Q6 | Legacy

Question 6

question	answers	extra information	mark
6(a)(i)	many ethene / molecules / monomers join to form a long hydrocarbon / chain / large molecule	accept double bonds open / break accept addition polymerisation ignore references to ethane correct equation gains **2** marks	1 1
6(a)(ii)	(can be deformed but) return to their original shape (when heated or cooled)	ignore 'it remembers its shape'	1
6(a)(iii)	cross links / extra bonds in PEX molecules / chains in PEX are held in position molecules / chains in PEX unable to slide past each other / move	it = PEX throughout accept inter-molecular bonds ignore inter-molecular forces accept rigid structure	1 1 1

Question 6 continues on the next page…

CHY1H

Question 6 Continued

question	answers	extra information	mark
6(b)	any **four** from: • less (hydrocarbon) fuels used • less / no electrical energy used • reduce carbon / carbon dioxide emissions • reduce / no pollution by sulfur dioxide / acid rain • continuous process • conserve copper which is running out or only low-grade ores available • reduce the amount of solid waste rock that needs to be disposed • reduce the need to dig large holes (to extract copper ores)	ignore costs / sustainability / non-renewable allow less energy allow no electrolysis allow less global warming allow less / no transportation allow less waste allow less mining	4
Total			**10**

4.4.1.3 Extraction of metals and reduction

Answer 27 · Mark scheme

November 2009 | CHY1AP | Original Q4 | Legacy

Four	**4**	**3**	**2**	**1**

Answer 28 · Mark scheme

November 2009 | CHY1AP | Original Q6 | Legacy

Six	**3**	**3**	**4**	**2**

4.4.1.3 Extraction of metals and reduction

Answer 29 · Mark scheme

January 2010 | CHY1H | Original Q5 | Legacy

Question 5

question	answers	extra information	mark
5(a)(i)	sulfur dioxide (forms) acid rain	allow sulfur oxide accept acidic lakes / seas ignore consequences do **not** accept global warming / global dimming / ozone layer	1 1
5(a)(ii)	electrolysis	allow phonetic spelling ignore electroplating	1
5(b)(i)	alloyed / mixed with other metals / elements / atoms / zinc / tin	allow combined / added ignore make it impure do **not** allow reacted / bonded / joined	1
5(b)(ii)	(in the pure copper) copper / metal / atoms / layers able to slide over each other zinc / tin / other (atoms) change the structure / disrupt pattern / layers **or** zinc / tin (atoms) are a different size	accept zinc / tin / other (atoms) prevent (copper) atoms / layers sliding over each other ignore different shapes	1 1
Total			**6**

4.4.1.3 Extraction of metals and reduction

Answer 29 · Mark scheme January 2010 | CHY1H | Original Q5 | Legacy

CHY1H

Answer 30 · Mark scheme March 2010 | CHY1AP | Original Q6 | Legacy

Six	4	1	3	4

Answer 31 · Mark scheme March 2010 | CHY1AP | Original Q8 | Legacy

Eight	4	3	3	3

Answer 32 · Mark scheme March 2010 | CHY1BP | Original Q8 | Legacy

Eight	2	1	2	1

Answer 33 · Mark scheme June 2010 | CHY1AP | Original Q3 | Legacy

Three	2	1	1	2

Answer 34 · Mark scheme June 2010 | CHY1AP | Original Q9 | Legacy

Nine	2	4	4	3

4.4.1.3 Extraction of metals and reduction

Answer 35 · Mark scheme

June 2010 | CHY1H | Original Q3 | Legacy

Question 3

question	answers	extra information	mark
3(a)(i)	C	must be correct symbol do **not** accept carbon any balancing must be correct	1
3(a)(ii)	$Fe + CO_2$ 2…. + 3….	correct formulae correct balancing allow $Fe_2 + 3CO_2$ for this mark	1 1
3(a)(iii)	layers / atoms in pure iron are able to slide over each other **or** layers / atoms in cast iron are unable to slide over each other (easily)	it = pure iron accept ions for atoms ignore molecules / particles	1

Question 3 continues on the next page

CHY1H

Question 3 continued

question	answers	extra information	mark
3(b)	any **three** from: • less iron ore used • less other metals extracted / used to make different steels • less fuel used • less specified pollution • less / no landfill space needed • less / no mining needed **or** fewer specified effects of mining	mention of ozone = max **2** accept the idea that ores would be conserved but not unspecified conservation accept the idea that ores would be conserved but not unspecified conservation accept the idea that fuels would be conserved ignore reduces energy requirements accept global warming / greenhouse effect / CO_2 / CO / carbon emissions / acid rain / SO_2 / global dimming / do **not** accept ozone layer ignore reduces waste accept effect such as eyesore / loss of habitat eg 'less mining iron ore' = **2** marks	3
Total			**7**

4.4.1.3 Extraction of metals and reduction

Answer 35 · Mark scheme June 2010 | CHY1H | Original Q3 | Legacy

CHY1H

Answer 36 · Mark scheme November 2010 | CHY1AP | Original Q1 | Legacy

Question	Key		
One	**A**	uses another metal	**3**
	B	does **not** use a chemical reaction	**2**
	C	could be done in a blast furnace	**4**
	D	is called electrolysis	**1**

Answer 37 · Mark scheme November 2010 | CHY1AP | Original Q4 | Legacy

Four	**3**	**2**	**1**	**2**

Answer 38 · Mark scheme November 2010 | CHY1AP | Original Q8 | Legacy

Eight	**3**	**2**	**2**	**2**

4.4.1.3 Extraction of metals and reduction

Answer 39 · Mark scheme

January 2011 | CHY1H | Original Q1 | Legacy

Question 1

question	answers	extra information	mark
1(a)(i)	very little / low percentage of metal (in the ore)	accept only 0.5% metal in the ore **or** over 99% waste in the ore **or** nearly 100% waste in the ore ignore reference to percentage of metal in the Earth's crust **or** energy used or pollution	1
1(a)(ii)	any **one** from • iron uses less energy / fuel for extraction • iron has more uses • more demand for iron • iron is stronger • cheaper / costs less • easier to extract	(it = iron) ignore electrolysis / uses electricity / reactivity ignore high abundance in the Earth's crust / high percentage of metal in ore ignore harder	1
1(b)(i)	has melting point lower than 950°C	(it = aluminium) allow has a low melting point ignore boiling point	1
1(b)(ii)	electrode(s) made of carbon oxygen reacts with electrode(s) / carbon	 accept C + O_2 (→ CO_2) NB oxygen reacts with the carbon electrode(s) = **2** marks	1 1

Question 1 continues on the next page

CHY1H

Question 1 contd

question	answers	extra information	mark
1(b)(iii)	any **two** from: • saves resources / non renewable • landfill problem • saves energy / fuel / electricity • less carbon dioxide / carbon emissions or reduces carbon footprint • less quarrying / mining	accept aluminium / ore will run out or conserves aluminium accept aluminium does not corrode ignore global warming ignore consequences of quarrying / mining ignore pollution / harms environment / costs / easy to recycle	2
Total			**7**

4.4.1.3 Extraction of metals and reduction

Answer 39 · Mark scheme

January 2011 | CHY1H | Original Q1 | Legacy

CHY1H

4.4.1.3 Extraction of metals and reduction

Answer 40 · Mark scheme

January 2011 | CHY1H | Original Q4 | Legacy

Question 4

question	answers	extra information	mark
4(a)(i)	removal of oxygen	accept definition in terms of electrons **or** oxidation numbers ignore oxides	1
4(a)(ii)	2 (Cl_2)	allow correct multiples	1
4(a)(iii)	no atoms are lost / made (during a chemical reaction) **or** the atoms are rearranged (during a chemical reaction)	accept because of (the law of) conservation of mass / matter	1
4(b)(i)	sodium is more reactive (than titanium)	accept sodium is very reactive **or** titanium is less reactive do **not** accept sodium is more reactive than argon	1
4(b)(ii)	any **one** from: • sodium / titanium would react with oxygen / air • sodium / titanium does not react with argon	 accept air / oxygen is reactive accept argon is unreactive / inert / a noble gas / in group O	1
4(c)(i)	all atoms are the same / it only contains one type of atom	accept all ions are the same do **not** accept only got one atom do **not** accept all atoms are the same size ignore particles	1
4(c)(ii)	two different / types atoms / elements / ions bonded / joined together	accept more than one type of atom / ion / element do **not** accept different size accept definite proportions do **not** accept mixture	1 1
Total			**8**

4.4.1.3 Extraction of metals and reduction

Answer 40 · Mark scheme January 2011 | CHY1H | Original Q4 | Legacy

CHY1H

Answer 41 · Mark scheme March 2011 | CHY1AP | Original Q2 | Legacy

Two	**A** Metal **A**		**2**	
	B Metal **B**		**3**	
	C Metal **C**		**4**	
	D Metal **D**		**1**	
	A	**B**	**C**	**D**

Answer 42 · Mark scheme March 2011 | CHY1AP | Original Q4 | Legacy

Four	**4**	**3**	**2**	**2**

Answer 43 · Mark scheme March 2011 | CHY1AP | Original Q8 | Legacy

Eight	**2**	**2**	**1**	**2**

Answer 44 · Mark scheme June 2011 | CHY1AP | Original Q5 | Legacy

Five	**2**	**2**	**1**	**3**

Answer 45 · Mark scheme June 2011 | CHY1AP | Original Q9 | Legacy

Nine	**1**	**2**	**2**	**3**

The AQA UMS Conversion Calculator can be found at the following web address:

http://www.aqa.org.uk/umsconversion

Answer 46 · Mark scheme November 2011 | CHY1AP | Original Q4 | Legacy

Four	**3**	**2**	**1**	**2**

4.4.1.3 Extraction of metals and reduction

Answer 47 · Mark scheme

November 2011 | CHY1AP | Original Q5 | Legacy

Five	**4**	**2**	**2**	**2**

Answer 48 · Mark scheme

November 2011 | CHY1BP | Original Q7 | Legacy

Seven	**4**	**1**	**1**	**3**

4.4.1.3 Extraction of metals and reduction

Answer 49 · Mark scheme

January 2012 | CH1HP | Original Q4 | Legacy

Question 4

question	answers	extra information	mark
4(a)(i)	reduction	accept redox / smelting	1
4(a)(ii)	3 4 3		1
4(b)(i)	55	ignore other units	1
4(b)(ii)	water	accept sodium hydroxide accept correct formulae H_2O or NaOH	1
4(b)(iii)	any **one** from: • save energy / fuel for transporting the ore • (old) quarries nearby for waste/red mud	accept less (cost of) transport allow transported quickly	1

Question 4 continues on the next page …….

CH1HP

Question 4 cont'd…

question	answers	extra information	mark
4(c)	**Environmental** any **one** from: • less mining / quarrying (of bauxite) • less landfill space needed / used • less use of fossil fuels / energy • less carbon dioxide produced **Ethical or social** any **one** from: • saves resources • creates (local) employment • more people aware of the need for recycling	 allow loss of habitat / less qualified noise pollution allow less red mud / waste allow using resources more than once if answers reversed and both correct award **1** mark allow less qualified noise pollution if not given in environmental	1 1
Total			**7**

4.4.1.3 Extraction of metals and reduction

Answer 49 · Mark scheme

January 2012 | CH1HP | Original Q4 | Legacy

CH1HP

4.4.1.3 Extraction of metals and reduction

Answer 50 · Mark scheme

June 2012 | CH1HP | Original Q2 | Legacy

Question 2

question	answers	extra information	mark
2(a)	any **one** from: • there are many stages needed (to extract titanium) • more energy / materials are needed (to extract titanium) • titanium cannot be extracted by using carbon	ignore references to cost / mining / availability allow longer / slower / more complicated process / batch process ignore higher temperature ignore reference to electrolysis do **not** accept titanium extracted by electrolysis	1
2(b)	carbon dioxide	allow CO_2	1
2(c)	magnesium chloride is electrolysed / used / decomposed magnesium and / or chlorine are recycled / reused	 allow the products of electrolysis are recycled word / symbol equation = **1** mark	1 1
2(d)	 because oxygen / nitrogen (in air) would react with the magnesium **or** would produce magnesium oxide / nitride whereas argon is inert / unreactive **or** argon does not react (with magnesium)	accept titanium for magnesium ignore argon is in Group 0 / noble gas	 1 1
2(e)	240		1
2(f)	250	allow range 245 to 250	1
Total			**8**

4.4.1.3 Extraction of metals and reduction

Answer 50 · Mark scheme

June 2012 | CH1HP | Original Q2 | Legacy

CH1HP

Answer 51 · Mark scheme

June 2013 | CH1HP | Original Q2 | Legacy

Question 2

question	answers	extra information	Mark
2(a)	any **two** from: • copper / ores are running out / harder to find • there are no / very small amounts of high-grade copper ores left • copper metal is in demand • copper is expensive • now economical to extract copper from low-grade ores	it = copper allow new methods of extraction e.g. bioleaching and phytomining allow high-grade ores are running out for **2** marks	2
2(b)(i)	large amounts / 98% of rock to dispose of as waste **or** waste rock takes up a lot of space	accept contains toxic (metal) compounds / bioleacher	1
2(b)(ii)	(copper sulfide reacts with oxygen to) produce sulfur dioxide / SO_2 that causes acid rain	allow (sulfur reacts with oxygen to) produce sulfur dioxide / SO_2 allow description of effects of acid rain **or** sulfur dioxide if no other mark awarded allow CO_2 produced which causes global warming **or** CO_2 produced by burning fuel or heating the furnace for **1** mark	1 1
2(b)(iii)	any **one** from: • large amounts of fuels / energy used (for the furnace and electrolysis) • (the extraction has) many steps / stages / processes • large amounts of ore / material have to be mined	allow large amounts of electricity needed ignore high temperature / electrolysis unqualified allow (extraction) is a long process / takes a lot of time allow ores contain a low percentage of copper	1

Question 2 continues on the next page

4.4.1.3 Extraction of metals and reduction

Answer 51 · Mark scheme

June 2013 | CH1HP | Original Q2 | Legacy

Question 2 continued

question	answers	extra information	Mark
2(b)(iv)	(copper ions move towards) the negative electrode / *cathode* because copper ions / Cu^{2+} are positively charged **or** are oppositely charged **or** copper ions need to gain electrons	 allow because metal ions are positive **or** opposites attract	1 1
2(b)(v)	(growing) plants		1
Total			**9**

4.4.1.3 Extraction of metals and reduction

Answer 52 · Mark scheme June 2014 | CH1HP | Original Q4 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
4(a)(i)	phytomining		1	1 / 1.3.1g	G
4(a)(ii)	*(the land contains)* very little copper	*allow low grade ore **or** large amounts of waste* *ignore quarrying / benefits of using plants*	1	3 / 1.3.1f/g	E
	uneconomical	*accept (smelting) uses a lot of energy / fossil fuels* *allow expensive*	1		
4(a)(iii)	Cu **2** CuO + C → **2** Cu + CO_2	*allow 2 CuO + C → Cu_2 + CO_2 for **1** mark*	1 1	2 / 1.3.1f	E
4(b)(i)	iron is more reactive (than copper) iron is cheap(er than copper)	*allow cheaper **or** uses less energy than electrolysis*	1 1	1 + 2 / 1.3.1h	E
4(b)(ii)	*any **two** from:* • copper / ions move **or** are attracted to the negative electrode / *cathode* • where they are reduced **or** gain (two) electrons • *where they form copper (metal / atoms)*		2	1 / 1.3.1h	E
Total			**9**		

4.4.1.3 Extraction of metals and reduction

Answer 52 · Mark scheme

June 2014 | CH1HP | Original Q4 | Legacy



4.4.1.3 Extraction of metals and reduction

Answer 53 · Mark scheme June 2015 | CH1HP | Original Q4 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
4(a)	The ore is not pure or contains impurities or the ore does not contain 100% of the metal compound rock / other compounds need to be removed / separated	allow to concentrate the metal or metal compound	1 1	2+3 / 1.3.1b
4(b)(i)	(cast iron is) brittle	allow not strong ignore weak	1	1 / 1.3.2a
4(b)(ii)	the oxygen reacts with carbon reducing the percentage of carbon in the mixture **or** producing carbon dioxide	allow carbon burns in oxygen or is oxidised	1 1	2 / 1.3.2b
4(c)(i)	aluminium has a low density		1	2 / 1.3.3c
4(c)(ii)	(because copper) is in the central/middle (block of the periodic table) whereas aluminium is in Group 3 (of the periodic table)		1 1	1 / 1.3.3a
4(c)(iii)	iron is more reactive (than copper) so copper is displaced/reduced	ignore cost	1 1	1+2 / 1.3.1h/i
Total			10	

4.4.1.3 Extraction of metals and reduction

Answer 53 · Mark scheme

June 2015 | CH1HP | Original Q4 | Legacy



4.4.1.3 Extraction of metals and reduction

Answer 54 · Mark scheme

June 2016 | CH1HP | Original Q3 | Legacy

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
3(a)(i)	(thermal) decomposition	allow decomposes or endothermic	1	AO1 1.2.1b/c
3(a)(ii)	copper oxide		1	AO2 1.2.1b/c
3(b)(i)	the (potassium) carbonate did not decompose/change/react (when heated) the mass did not change or the limewater did not go cloudy because no carbon dioxide produced	allow temperature not high enough do **not** allow potassium did not decompose ignore references to reactivity	1 1 1	AO1+AO2 +AO3 1.2.1c/e; 4.5.4a
3(b)(ii)	the less reactive the metal the more (easily) its carbonate will decompose/react or vice versa	needs to be a relative comparison allow max **1** mark where the distinction between a metal and its carbonate is not clear allow **1** mark for carbonates of reactive metals do not decompose or vice versa	2	AO3 1.2.1 c; 1.3
3(c)(i)	make it economical (to extract the metal/iron)	allow make it worth extracting allow so they can make money/profit	1	AO1 1.3.1a
3(c)(ii)	Fe balanced correctly (2,3,4,3)	 not ecf allow correct balanced equation but with $2Fe_2$ on right for one mark	1 1	AO2 1.1.3b; 1.3.2c

4.4.1.3 Extraction of metals and reduction

Answer 54 · Mark scheme

3(c)(iii)	**iron** from the blast furnace is brittle **steel** produced is strong / flexible	"it" = iron allow steel has more/specific uses allow steel is rust-resistant	1 1	AO1 1.3.2a/b/c
3(c)(iv)	(recycling) is used to conserve iron (ore) **or** energy **or** resources **or** minimise pollution **or** reduce the need to quarry (not reuse) because of damage, paint removal, rusting/corrosion, metal fatigue/weaker (not landfill) because sites have limited space **or** loss of habitats	allow reverse arguments. allow to reduce the use of landfill	1 1 1	AO1+AO2 1.3.1j
Total			**15**	

4.4.1.3 Extraction of metals and reduction

Answer 55 · Mark scheme June 2017 | CH1HP | Original Q5 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
5(a)(i)	any **one** from: • all these gases / hydrogen / methane / water vapour / ammonia may not have been in the Earth's early atmosphere • the conditions of the reaction were not like those on early Earth • many different amino acids are needed for life processes	ignore no proof / evidence **or** no one was there **or** references to religion **or** meteorites / comets. allow nobody knows what was in the Earth's early atmosphere allow very little (0.5%) in the Earth's early atmosphere allow nobody knows what the conditions were on early Earth allow only simple amino acids **/** glycine were produced	1	**AO3** 1.7.2d;e
5(a)(ii)	any **three** from: • used by plants / algae **or** for photosynthesis • absorbed / dissolved by oceans • locked up in sedimentary rocks / carbonates / limestone • locked up in fossil fuels	ignore volcanoes allow stored in for locked up allow stored in for locked up mention of respiration: maximum two marks	3	**AO1** 1.7.2f;g;h
5(b)(i)	helium / He **and** neon / Ne	both needed	1	**AO2** 1.7.2j

4.4.1.3 Extraction of metals and reduction

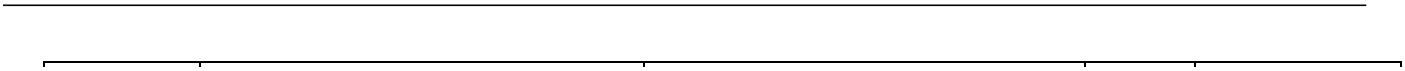
Answer 55 · Mark scheme

5(b)(ii)	carbon dioxide would be solid **or** would block pipes	ignore freezes allow forms dry ice	1	**AO3** 1.7.2j
5(b)(iii)	 the other gas is argon / Ar because they have similar boiling points **or** there is only 3 °C difference in boiling points	mark independently	 1 1	**AO2** 1.7.2j
5(c)	 **stage 1:** oxygen reacts with carbon so carbon content decreases **or** carbon forms carbon dioxide **stage 2:** (other metals added) to form an alloy so the steel has a specific property / specific use	mark independently allow because cast iron is (too) brittle allow to stop layers sliding allow because pure iron is (too) soft	 1 1 1 1	**AO1** **AO2** 1.3.2a;b;c
Total			**12**	

4.4.1.3 Extraction of metals and reduction

Answer 55 · Mark scheme

June 2017 | CH1HP | Original Q5 | Legacy



4.4.1.3 Extraction of metals and reduction

Answer 56 · Mark scheme

June 2018 | 8462/1H | Original Q2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	FeS_2	do **not** accept equations	1	AO2 4.2.1.3
02.2	26 30 26	must be this order	1 1 1	AO2 4.1.1.4 4.1.1.5
02.3	any **two** from: • iron has a high(er) melting / boiling point • iron is dense(r) • iron is hard(er) • iron is strong(er) • iron is less reactive • iron has ions with different charges • iron forms coloured compounds • iron can be a catalyst	allow the converse statements for sodium allow transition metal for iron allow Group 1 metal for sodium ignore references to atomic structure ignore iron rusts allow iron is less malleable / ductile allow specific reactions showing difference in reactivity allow iron is magnetic	2	AO1 4.1.2.5 4.1.3.1 4.1.3.2

4.4.1.3 Extraction of metals and reduction

Answer 56 · Mark scheme

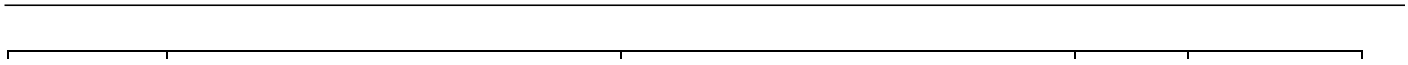
June 2018 | 8462/1H | Original Q2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.4	carbon is more reactive (than nickel)	allow converse	1	AO1 4.4.1.2 4.4.1.3
	(so) carbon will displace / replace nickel (from nickel oxide) **or** (so) carbon will remove oxygen (from nickel oxide)	allow (so) nickel ions gain electrons allow (so) carbon transfers electrons to nickel (ions)	1	
02.5		an answer of 67.8 (%) scores **3** marks an answer of 67.8160919 (%) or correctly rounded answer to 2, 4 or more sig figs scores **2** marks an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps		AO2 4.3.3.2
	(total M_r of reactants =) 87		1	
	(percentage atom economy) $= \frac{59}{87} \times 100$	allow (percentage atom economy) $= \frac{59}{\text{incorrectly calculated } M_r} \times 100$	1	
	= 67.8 (%)	allow an answer from an incorrect calculation to 3 sig figs	1	
Total			**11**	

4.4.1.3 Extraction of metals and reduction

Answer 56 · Mark scheme

June 2018 | 8462/1H | Original Q2



4.4.1.3 Extraction of metals and reduction

Answer 57 · Mark scheme June 2018 | 8462/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	chlorine is toxic	allow carbon monoxide is toxic allow poisonous for toxic ignore harmful / deadly / dangerous allow a poisonous gas is used / produced allow titanium chloride is corrosive	1	AO3 4.1.2.6 4.4.1.3
08.2	any **one** from: • very exothermic reaction • produces a corrosive solution • produces hydrogen, which is explosive / flammable	 allow explosive allow violent reaction ignore vigorous reaction ignore sodium is very reactive allow caustic for corrosive ignore alkaline allow flames produced ignore sodium burns	1	AO3 4.1.2.5 4.4.1.3
08.3	argon is unreactive / inert oxygen (from air) would react with sodium / titanium **or** water vapour (from air) would react with sodium / titanium	allow argon will not react (with reactants / products / elements) allow elements / reactants / products for sodium / titanium	1 1	AO3 4.1.2.4 4.1.2.5 4.4.1.1 4.4.1.3

4.4.1.3 Extraction of metals and reduction

Answer 57 · Mark scheme

June 2018 | 8462/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.4	metal chlorides are usually ionic	allow titanium chloride is ionic	1	AO1 4.1.2.6 4.1.3.1
	(so)(metal chlorides) are solid at room temperature **or** (so)(metal chlorides) have high melting points	allow titanium chloride for metal chlorides	1	4.2.1.2 4.2.2.3 4.2.2.4
	(because) they have strong (electrostatic) forces between the ions **or** (but) must be a small molecule or covalent	ignore strong ionic bonds allow molecular allow alternative approach: titanium chloride must be covalent **or** has small molecules (1) with weak forces between molecules do **not** accept bonds unless intermolecular bonds(1) (but) metal chlorides are usually ionic (1)	1	
08.5	sodium (atoms) lose electrons	do **not** accept references to oxygen	1	AO1 4.4.1.4
08.6	Na → $Na^+ + e^-$	do **not** accept e for e^-	1	AO2 4.1.1.1 4.4.1.4

4.4.1.3 Extraction of metals and reduction

Answer 57 · Mark scheme

June 2018 | 8462/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.7	(M_r of $TiCl_4$ =) 190 (moles Na) = $\frac{20\,000}{23}$ =) 870 (mol $\left(\text{moles } TiCl_4 = \frac{40\,000}{190} =\right)$ 211 (mol) **either** (sodium is in excess because) 870 mol Na is more than the 844 mol needed **or** (because) 211 mol $TiCl_4$ is less than the 217.5 mol needed	an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps allow **1** mark for 0.870 mol Na **and** 0.211 mol $TiCl_4$ allow use of incorrectly calculated M_r from step 1 the mark is for correct application of the factor of 4 other correct reasoning showing, with values of moles or mass, an excess of sodium or insufficient $TiCl_4$ is acceptable allow use of incorrect number of moles from steps 2 and / or 3 alternative approaches: **approach 1:** (M_r of $TiCl_4$ =) 190(1) (40 kg $TiCl_4$ needs) $\frac{40}{190} \times 4 \times 23$ (kg Na) (1) (=) 19.4 (kg) (1) so 20 kg is an excess (1) **approach 2:** (M_r of $TiCl_4$ =) 190(1) (20 kg Na needs) $\frac{20}{4 \times 23} \times 190$ (kg $TiCl_4$) (1) (=) 41.3 (kg) (1) so 40 kg is not enough (1)	1 1 1 1	AO2 4.3.1.2 4.3.2.1 4.3.2.2 4.3.2.4

4.4.1.3 Extraction of metals and reduction

Answer 57 · Mark scheme

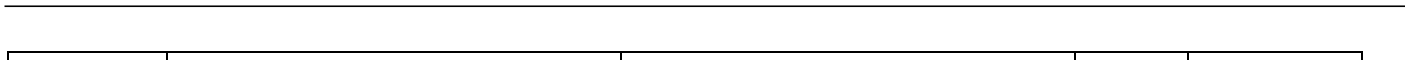
June 2018 | 8462/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.8	(actual mass =) $\frac{92.3}{100} \times 13.5$ **or** (actual mass =) 0.923×13.5 = 12.5 (kg)	an answer 12.5 (kg) scores **2** marks allow 12 / 12.46 / 12.461 / 12.4605 (kg)	1 1	AO2 4.3.3.1
Total			**15**	

4.4.1.3 Extraction of metals and reduction

Answer 57 · Mark scheme

June 2018 | 8462/1H | Original Q8



4.4.1.3 Extraction of metals and reduction

Answer 58 · Mark scheme

November 2020 | 8462/1H | Original Q2

Question 2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	they form ions with different charges they have high melting points		1 1	AO1 4.1.3.1 4.1.3.2
02.2	the (grey) crystals are silver the copper ions (produced) are blue (because) copper displaces silver	 allow the copper nitrate / compound (produced) is blue 	1 1 1	AO3 4.4.1.2

Question 2 continued

Question	Answers	Mark	AO/ Spec. Ref
02.3	**Level 2:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	3–4	AO1 AO3 4.4.1.2 4.5.1.1 RPA 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 **Key steps** • add the metals to (dilute) hydrochloric acid • measure temperature change **or** compare rate of bubbling **or** compare colour of resulting solution for copper: • no reaction • shown by no temperature change **or** shown by no bubbles for magnesium and iron: • magnesium increases in temperature more than iron **or** magnesium bubbles faster than iron **or** magnesium forms a colourless solution and iron forms a coloured solution **Control variables** • same concentration / volume of hydrochloric acid • same mass / moles of metal • same particle size of metal • same temperature (of acid if comparing rate of bubbling)		

4.4.1.3 Extraction of metals and reduction

Answer 58 · Mark scheme

November 2020 | 8462/1H | Original Q2

Question 2 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.4	$\frac{(203 \times 30) + (205 \times 70)}{100}$ **or** $\frac{6090 + 14\,350}{100}$		1	AO2 4.1.1.6
	= 204.4	ignore units	1	

Total			11

4.4.1.3 Extraction of metals and reduction

Answer 59 · Mark scheme

November 2020 | 8462/2H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1		max **1** mark if soot wrongly identified		AO1 4.9.3.1
	incomplete combustion		1	
	(because of) insufficient oxygen		1	
06.2		allow SO_2 for sulfur dioxide		
	sulfur reacts with oxygen to form sulfur dioxide	allow sulfur burns to form sulfur dioxide	1	AO1
	(so) less sulfur dioxide emitted		1	AO1
	(so) less acid rain		1	AO2
	(so less) limestone reacts with acid rain		1	AO2 4.9.3.1 4.9.3.2
06.3	(car engines work at) high temperatures		1	AO1 4.9.3.1
	(so in the engine) nitrogen (from air) reacts with oxygen (from air)		1	
Total			**8**	

Answer 60 · Mark scheme

November 2021 | 8462/1H | Original Q3

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	(3 × M_r H_2O = 3 × (2 + 16) =) 54 (A_r **R** = 150 – 54 =) 96 **alternative approach**: (M_r **R**O_3 = 150 – 6 =) 144 (1) (A_r **R** = 144 – (3 × 16) =) 96 (1)	 ignore units ignore units	1 1	AO2 4.3.1.1 4.3.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	**(R** =) molybdenum / Mo	allow ecf from question **03.1**	1	AO3 4.1.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	(total M_r of reactants) = 163 (% atom economy =) $\frac{119}{163}$ (×100) = 73 (%)	 allow correct use of an incorrectly calculated value of total M_r allow 73.00613 (%) correctly rounded to at least 2 significant figures	1 1 1	AO2 4.3.1.2 4.3.3.2

Question 3 continued

Question	Answers	Mark	AO/ Spec. Ref
03.4	**Level 2:** Some logically linked reasons are given. There may also be a simple judgement.	3-4	AO3 4.4.1.3
	Level 1: Relevant points are made. They are not logically linked.	1–2	
	No relevant content	0	
	Indicative content • carbon and iron are the cheapest reactants • hydrogen is the most expensive reactant • separating solid products is expensive • separating solid products is time consuming • in method 1, tungsten needs to be separated from tungsten carbide • in method 1, some tungsten is lost as tungsten carbide • in method 1, the carbon dioxide produced will escape • in method 2, the water vapour produced will escape • in method 2, no separation of solids is needed • in method 3, tungsten needs to be separated from iron oxide		

Total			**10**

Answer 61 · Mark scheme

November 2021 | 8462/2H | Original Q8

Question 8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	(lead is) toxic / poisonous	allow (lead is) harmful ignore (lead is) dangerous / deadly / lethal	1	AO3 4.10.3.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.2	the proportions (of metals) are different		1	AO3 4.10.3.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.3	any **three** from: • recycling conserves copper ores • recycling uses less energy • recycling reduces waste • mining / quarrying cause environmental impacts	ignore references to cost allow copper ores are finite allow recycling reduces use of landfill allow description of environmental impact caused by mining / quarrying	3	AO1 AO2 AO3 4.10.1.1 4.10.1.4 4.10.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.4	grow plants (on land containing copper ores) plants are burnt (to produce ash) ash dissolved in acid (to produce a solution of a copper compound) electrolysis of solution (containing a copper compound) **or** displacement (of copper) from solution (containing a copper compound)	allow named plant allow addition of scrap iron to the solution (of a copper compound)	1 1 1 1	AO1 4.10.1.4

Question 8 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.5	any **two** from: • high grade ores still available • land not available • phytomining takes a long time • new technology	allow demand not high enough	2	AO3 4.10.1.4

Total			**11**

4.4.1.3 Extraction of metals and reduction

Answer 62 · Mark scheme

June 2022 | 8462/1H | Original Q7

Question 7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.1	silicon is less reactive than carbon (because) carbon displaces silicon (from silicon dioxide)	ignore references to hydrogen allow converse allow silicon is below carbon (in the reactivity series) ignore (because) carbon reduces silicon dioxide	1 1	AO3 4.4.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.2	more energy is needed (to obtain aluminium) (because) aluminium is obtained (from aluminium oxide) by electrolysis	ignore references to electricity	1 1	AO3 4.4.1.3 4.4.3.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.3	both products are solid		1	AO3 4.4.1.3

4.4.1.3 Extraction of metals and reduction

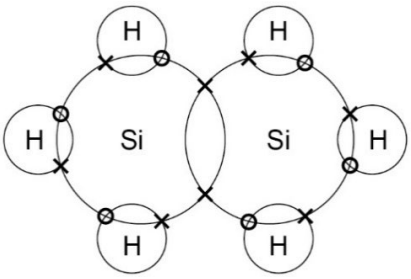
Answer 62 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.4	(M_r of SiO_2 = 28 + (2 × 16)) = 60		1	AO2 4.3.1.2 4.3.2.1 4.3.2.2
	(conversion 1.2 kg =) 1200 (g)		1	
	(number of moles of SiO_2 = $\frac{1200}{60}$) = 20	allow correct use of an incorrectly converted or unconverted mass of SiO_2 allow correct use of an incorrectly calculated M_r of SiO_2	1	
	(number of moles of Mg = 20 × 2) = 40	allow correct use of an incorrectly calculated number of moles of SiO_2	1	
	(mass of Mg = 40 × 24) = 960 (g)	allow correct use of an incorrectly calculated number of moles of Mg	1	
	alternative approach:			
	(M_r of SiO_2 = 28 + (2 × 16)) = 60 (1)			
	48 g Mg reacts with 60 g SiO_2 (1)	allow correct use of an incorrectly calculated M_r of SiO_2		
	(conversion 1.2 kg =) 1200 (g) (1)			
	48 × $\frac{1200}{60}$ (g Mg reacts with 1200 g SiO_2) (1)	allow correct use of an incorrectly calculated mass of Mg and / or incorrectly converted or unconverted mass of SiO_2		
	= 960 (g) (1)			

4.4.1.3 Extraction of metals and reduction

Answer 62 · Mark scheme

June 2022 | 8462/1H | Original Q7

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.5		allow any combination of x, •, o, $e^{(-)}$ for electrons	1	AO2 4.2.1.4

4.4.1.3 Extraction of metals and reduction

Answer 62 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
07.6	(volume of oxygen for 30 cm^3 Si_2H_6 = 3.5 × 30) = 105 (cm^3)		1	AO2 4.3.2.4 4.3.5
	(volume of excess oxygen = 150 – 105) = 45 (cm^3)	allow correct use of an incorrectly calculated volume of oxygen for 30 cm^3 Si_2H_6	1	
	(volume of water (vapour) = 3 × 30) = 90 (cm^3)		1	
	(volume of gases = 45 + 90) = 135 (cm^3)	allow correct use of incorrectly calculated volumes of excess oxygen and / or water vapour	1	
	allowed alternative approach: (moles Si_2H_6 = $\frac{0.03}{24}$ =) 0.00125 (1)			
	(moles water vapour formed = 3 × 0.00125 =) 0.00375 **and** (moles oxygen used = 3.5 × 0.00125 =) 0.004375 (1)	allow correct use of an incorrectly calculated number of moles of Si_2H_6		
	(moles excess oxygen = $\frac{0.15}{24}$ - 0.004375 =) 0.001875 (1)	allow correct use of an incorrectly calculated number of moles of oxygen used		
	(volume of gases = 24 × (0.00375 + 0.001875) = 0.135 dm^3 =) 135 (cm^3) (1)	allow correct use of an incorrectly calculated number of moles of excess oxygen and / or moles of water vapour formed		

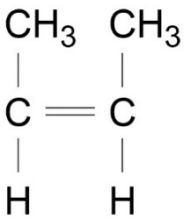
Total Question 7		15

4.4.1.3 Extraction of metals and reduction

Answer 63 · Mark scheme

June 2022 | 8462/2H | Original Q1

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 • (otherwise) the copper (produced) would be a mixture • (otherwise) the insulation would burn / melt (during recycling) • copper and poly(butene) are recycled by different methods	allow (otherwise) the copper (produced) would be contaminated allow (otherwise) poly(butene) could produce toxic fumes	1	AO3 4.10.2.2

4.4.1.3 Extraction of metals and reduction

Answer 63 · Mark scheme

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

4.4.1.3 Extraction of metals and reduction

Answer 63 · Mark scheme

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

Answer 64 · Mark scheme

June 2023 | 8462/1H | Original Q9

Question 9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.1	(substance reduced) Fe_2O_3 (reason) (Fe_2O_3) loses oxygen	allow iron oxide MP2 is dependent upon MP1 being awarded ignore Fe^{3+} gains electrons	1 1	AO2 4.4.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.2	$\frac{3}{2}$ × 12g		1	AO2 4.3.1.1 4.3.2.1 4.3.2.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.3	**A** loses electrons and $\mathbf{B}^+$ gains electrons		1	AO2 4.4.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.4	**D**		1	AO3 4.4.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.5	(metal) **C** (explanation) aluminium forms ions with a charge 3+ (so) 3 nitrate ions are needed for 1 aluminium ion	 allow aluminium forms Al^{3+} (ions) allow (so) 3 nitrate ions are needed to balance the 3+ charge on 1 aluminium (ion)	1 1 1	AO3 4.4.1.2 4.4.3.3

Answer 64 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.6	(percentage atom economy =) $\frac{A_r\mathbf{X}}{A_r\mathbf{X} + 54} \times 100 = 77.3$		1	AO2 4.3.3.2
	100 $A_r\mathbf{X}$ = 77.3 ($A_r\mathbf{X}$ + 54)	allow $A_r\mathbf{X}$ = 0.773 ($A_r\mathbf{X}$ + 54) allow correct use of an incorrectly determined value of the M_r of the non-useful reactant atoms	1	
	22.7 $A_r\mathbf{X}$ = 4174.2	allow 0.227 $A_r\mathbf{X}$ = 41.742	1	
	$A_r\mathbf{X}$ = 184	allow 183.8854626 correctly rounded to at least three significant figures	1	
	alternative approach 1: ($3M_r$ H_2O = (3 × 16) + (6 × 1) =) 54 **and** (percentage = 100 – 77.3 =) 22.7% (1)			
	(total M_r of reactants =) $\frac{100}{22.7} \times 54$ (1)	allow correct use of an incorrectly determined value for $3M_r$ H_2O and/or percentage of unwanted products		
	= 238 (1)			
	($A_r\mathbf{X}$ = 238 – 54) **or** $\left(A_r\mathbf{X} = 238 \times \frac{77.3}{100}\right)$ = 184 (1)	allow correct use of an incorrectly determined value of total M_r of reactants and/or value for $3M_r$ H_2O allow 183.8854626 correctly rounded to at least three significant figures		

	alternative approach 2: ($3M_r$ H_2O = (3 × 16) + (6 × 1) =) 54 **and** (percentage = 100 – 77.3 =) 22.7% (1) $\left(\frac{1}{22.7} \times 54 =\right)$ 2.3788546 (1) 2.3788546 × 77.3 (1) = 184 (1)	 allow correct use of an incorrectly determined value for $3M_r$ H_2O and/or percentage of unwanted products allow correct use of an incorrectly determined value for 1% of the total M_r of reactants allow 183.8854626 correctly rounded to at least three significant figures		

Total Question 9	**12**

4.4.1.3 Extraction of metals and reduction

Answer 65 · Mark scheme

June 2023 | 8462/2H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	$CuFeS_2$ + **$4O_2$** → $CuSO_4$+$FeSO_4$	allow multiples allow O_2 for **1** mark	2	AO2 4.1.1.1 4.3.1.1 4.10.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2	(M_r = 63.5 + 56 + (2 x 32) =) 183.5		1	AO2 4.3.1.2 4.10.1.4
	(% of copper =) $\frac{63.5}{183.5}$ × 100	allow correct use of incorrectly determined M_r	1	
	= 34.6 (%)	allow 34.60490 correctly rounded to at least 2 significant figures	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3		MP2 is dependent upon MP1 being awarded		AO1 4.8.3.2 RPA7
	(test) (add) sodium hydroxide (solution)		1	
	(result) blue precipitate		1	
	OR			
	(test) flame test (1)			
	(result) green (flame) (1)	allow blue-green (flame)		

4.4.1.3 Extraction of metals and reduction

Answer 65 · Mark scheme

June 2023 | 8462/2H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	(the use of) bacteria to produce leachate solutions (that contain metal / copper compounds)		1 1	AO1 4.10.1.4

Total Question 5	**9**

Question 3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.1	(substance reduced) SnO_2	allow tin oxide	1	AO2 4.4.1.1 4.4.1.3
	(reason) (SnO_2) loses oxygen	allow (tin oxide) loses oxygen MP2 is dependent upon MP1 being awarded	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.2	carbon is more reactive than tin	allow tin is less reactive than carbon	1	AO3 4.4.1.2 4.4.1.3

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.3	(total M_r = 128 + 12 =) 140	allow (total M_r = 112 + 12 + 16 =) 140	1	AO2 4.3.3.2
	(% atom economy =) $\frac{112}{140} \times 100$	allow correct use of an incorrectly determined total M_r	1	
	= 80 (%)		1	

4.4.1.3 Extraction of metals and reduction

Answer 66 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.4		allow the converse for potassium allow the transition metal for tungsten allow the Group 1 metal for potassium ignore references to atomic structure		
	any **two** from: tungsten • has a higher melting / boiling point • is denser • is harder • is stronger • is less reactive • has ions with different charges • forms coloured compounds • can be a catalyst	 allow is less malleable / ductile allow specific reactions showing difference in reactivity	2	AO1 4.1.2.5 4.1.3.1 4.1.3.2

4.4.1.3 Extraction of metals and reduction

Answer 66 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.5	(sum of relative formula masses on left hand side =) 232 + (3 × 2) = 238 (is equal to sum of relative formula masses on right hand side =) 184 + (3 × 18) = 238	allow (sum of relative formula masses on left hand side =) 232 + 6 = 238 allow (is equal to sum of relative formula masses on right hand side =) 184 + 54 = 238 if no other mark awarded, allow **1** mark for 232 + (3 × 2) = 184 + (3 × 18) **or** 232 + 6 = 184 + 54 **or** allow **1** mark for both sides = 238	1 1	AO2 4.3.1.1 4.3.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
03.6	for sustainable development **or** for economic reasons	allow to minimise use of limited resources allow to minimise use of energy allow to minimise waste ignore references to yield	1	AO1 4.3.3.2

Total Question 3	**11**

Version 1.0: 0707

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Secondary Education

Science B 4462 / Chemistry 4421

CHY1H Unit Chemistry 1

Mark Scheme

2007 examination - June series

4.4.1.3 Extraction of metals and reduction

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' 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 to download from the AQA Website: www.aqa.org.uk

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Dr Michael Cresswell, Director General.

4.4.1.3 Extraction of metals and reduction

MARK SCHEME

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 and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded.

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

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 lines 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.)

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which candidates 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)

Candidate	Response	Marks awarded
1	4,8	0
2	green, 5	0
3	red*, 5	1
4	red*, 8	0

Example 2: Name two planets in the solar system. (2 marks)

Candidate	Response	Marks awarded
1	Pluto, Mars, Moon	1
2	Pluto, Sun, Mars, Moon	0

3.2 Use of chemical symbols / formulae

If a candidate 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

Full marks can be given for a correct numerical answer, as shown in the column 'answers', without any working shown.

However if the answer is incorrect, mark(s) can be gained by correct substitution / working and this is shown in the 'extra information' column;

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 are 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 e.c.f. 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 Unexpected Correct Answers not in the Mark Scheme

The Examiner should use professional judgement to award credit where a candidate has given an unexpected correct answer which is not covered by the mark scheme. The Examiner should consult with the Team Leader to confirm the judgement. The Team Leader should pass this answer on to the Principal Examiner with a view to informing all examiners.

4.4.1.3 Extraction of metals and reduction

CHY1H Question 1

	answers	extra information	mark
(a)	any **two** from: • nitrogen • carbon dioxide • water (vapour) / steam	 accept formulae N / N_2 accept formula CO_2 ignore CO accept formula H_2O	2
(b)	any **three** from: <u>limestone</u> • abundant / local • natural material **or** no 'processing' needed • relatively easy to cut • appearance better <u>concrete</u> • <u>raw materials</u> are abundant • can be reinforced (by steel rods) / strong(er) / supported (by steel rods) • concrete mixture can be poured / moulded / constructed on site • less reactive with acid rain / weathering / erosion	no mark for 'limestone' or 'concrete' on first line – mark advantages only ignore ideas of speed of production or easier to use accept 'can build higher' ignore density / extraction / quarrying / pollution / cost	3
total			5

4.4.1.3 Extraction of metals and reduction

CHY1H Question 2

	answers	extra information	mark
(a)(i)	$Cu_2S + 2O_2 \rightarrow 2CuO + SO_2$	accept fractions and multiples	1
(ii)	any **two** from: • sulfur dioxide • causes acid rain • consequence of acid rain eg kills fish / plants	 accept sulphur dioxide / sulphur oxide / SO_2 ignore other comments eg global warming / ozone / global dimming / greenhouse effect	2
(b)	any **two** from: • heat (copper oxide with carbon) • oxygen is removed by carbon **or** carbon monoxide / carbon dioxide is produced **or** carbon displaces copper • because carbon is more reactive than copper	 accept copper (oxide) loses oxygen **or** carbon gains oxygen accept carbon oxide accept a correct word or balanced symbol equation allow a correct comparison of reactivity	2
(c)(i)	electrolysis	accept electroplating	1
(ii)	(electrical) wiring / appliances / coins / pipes / cladding for buildings / jewellery / making alloys **or** named alloys		1

Continued on next page

4.4.1.3 Extraction of metals and reduction

Question 2 continued

	answers	extra information	mark
(d)	any **three** explanations from: <u>for recycling</u> • less acid rain (pollution) • copper reserves last longer / conserved **or** do not run out • energy for extraction (saved) **or** less energy required • less mining / quarrying • less waste (copper) / electrical appliances dumped **or** less landfill <u>against recycling</u> • collection problems • transport problems • difficult to separate copper from appliances • energy used to melt the collected copper	ignore electrolysis / pollution ignore ideas about less machinery / plant ignore idea of cost	3
total			10

4.4.1.3 Extraction of metals and reduction

CHY1H Question 3

	answers	extra information	mark
(a)(i)	core		1
(ii)	plate (boundaries)	accept parts of the crust ignore crust alone	1
	sudden movement / colliding **or** normally move a few centimetres per year	accept movement but ignore movement apart accept continental drift	1
	convection currents / driven by heat from radioactive processes / decay	idea of source of energy for the movement	1
	the idea of uncertainty with an explanation eg scientists do not know (with any certainty) • what happens under the crust • where the forces / pressure are building up • we cannot measure the forces • when the forces reach their limit	ignore references to volcanoes	1
(b)(i)	78		1

Continued on next page

4.4.1.3 Extraction of metals and reduction

Question 3 continued

	answers	extra information	mark
(ii)	marks awarded for any 2 gases from the following 3 gases	max **3** marks from CO_2	
	any **four** from: carbon dioxide has decreased: • used by plants / bacteria (stromatolites) • during photosynthesis (must be linked to CO_2 decrease) • 'locked up' in (sedimentary) rocks / carbonates / fossil fuels • dissolved in oceans **and / or** oxygen has increased because: • released by plants / bacteria (stromatolites) • during photosynthesis (must be linked to O_2 increase) **and / or** nitrogen has increased because • ammonia reacted with oxygen (to release nitrogen) • nitrogen is released by bacteria	ignore references to respiration	4
total			10

4.4.1.3 Extraction of metals and reduction

CHY1H Question 4

	answers	extra information	mark
(a)	permitted additive / (added) chemicals **or** names / types of additives	accept the chemical name ignore food additive alone	1
(b)(i)	water and oil do not mix / are immiscible **or** don't dissolve each other	ignore density ignore emulsifier alone	1
(ii)	any **two** from: • emulsifier • forms an emulsion • holds the two components together • by lowering the surface tension	 accept description of an emulsion accept stops them separating / they mix allow bonds / binds for holds accept a description of how an emulsifier works for **two** marks eg 'tadpole' diagram or dispersal of oil drops	2
(c)(i)	(because they contain) a double (carbon carbon) bond	accept unsaturated ignore poly or mono	1
(ii)	results suggest sunflower oil is best **or** 'the one that took the least time' because (sunflower oil) has the highest amount of unsaturation / most double bonds / least saturated	 ignore uses up I_2 most quickly second mark is dependent on first	1 1

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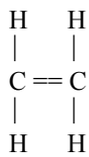
4.4.1.3 Extraction of metals and reduction

Question 4 continued

	answers	extra information	mark
(d)(i)	any **one** from: • have a higher melting point than (vegetable) oil • are solid at (room temperature) / hardened / harder	 accept useful as spreads **or** doesn't soak into bread ignore hard / soft(er)	1
(ii)	any **two** from: • hydrogen added • to carbon carbon double bond / to saturate • (nickel) catalyst / temperature 60 - 150°C	 do **not** accept 'water' wrong catalyst doesn't get this mark ignore high / warm temperature	2
total			10

4.4.1.3 Extraction of metals and reduction

CHY1H Question 5

	answers	extra information	mark
(a)(i)	by (fractional) distillation **or** fractionation	accept a description of the distillation process (heat and how separation works) eg heat **and** condense accept boil / vapourise etc for heat	1
(ii)	CO_2 H_2O	note the order of these products must be correct wrong way round = **1** mark	1 1
(b)(i)	(hexane) has been broken down (into smaller hydrocarbons / molecules)	accept (thermal) decomposition / cracked / split / broken up owtte	1
(ii)		accept $CH_2=CH_2$	1
(iii)	water / hydrogen oxide / steam	accept H_2O	1

Continued on next page

4.4.1.3 Extraction of metals and reduction

Question 5 continued

	answers	extra information	mark
(c)	candidates must include both sugar cane and crude oil in their evaluation **and** both an advantage and a disadvantage to gain full marks. if they do not then the maximum mark is three any **four** from: <u>advantages of using sugar</u> • country has no wealth to buy (large quantities of) crude oil • country has limited technological development **or** underdeveloped / third world country • able / suitable climate to grow sugar cane • enough land to grow sugar cane / land cannot be used to grow food / deforestation • sugar is a renewable source **or** crude oil is a non-renewable resource / finite resource / limited resources • CO_2 / carbon neutral <u>advantages of using alkanes:</u> • economic costs are low • continuous process • country has large oil resources • country has oil refineries / cracking plants • very pure product • faster process	not 'expensive' alone	4
total			10

4.4.1.3 Extraction of metals and reduction

Answer 56 · Examiner comments — June 2018 | 8462/1H | Original Q2

Question 2 (standard demand)

02.1 Because the question asked for the formula rather than the empirical formula, an answer of Fe_9S_{18} was accepted. Even so, 51% of students could not count the atoms and produce a ratio of 1:2. A formula was required, not an equation which some students provided.

02.2 This was very well answered, with 88% of students achieving all three marks.

02.3 57% of students achieved both marks. However, some repeated information in the stem of the question, and some contradicted it by saying sodium is not a metal. Some gave differences in the structure of the atoms instead of differences in properties of the substances.

02.4 This was well answered, with 32% of students achieving one mark, and 57% achieving both.

A common error was to say that carbon is reacting with oxygen (it is not; it is reacting with nickel oxide to remove the oxygen). Those who tried to answer in terms of electron transfer often struggled to gain all the marks.

Answer 56 · Examiner comments — June 2018 | 8462/1H | Original Q2

02.5 This question was well answered, with 60% of students achieving all three marks. However, interpretation of calculator displays did cause a bit of trouble for some students. Some students lost the final mark because they gave an answer of 67.$\dot{8}$. This answer is neither correct (it is not 67.8888888…) nor to three significant figures (it is to an infinite number of significant figures). Some even recognised this latter point and rounded, incorrectly, to 67.9.

Answer 57 · Examiner comments

June 2018 | 8462/1H | Original Q8

Question 8 (standard / high and high demand)

08.1 42% of students could answer this correctly. A hazard was asked for, and it was expected that students would use the correct chemical term for such a hazard; hence the idea that chlorine or carbon monoxide is **toxic** was required. Many did not use the correct term, referring instead to it being harmful (incorrect – it can kill, not merely make one ill), or dangerous or deadly (in what way?). Some students misread the equation and referred to carbon dioxide.

08.2 40**%** of students achieved the mark here. Many did not realise that their observations of a vigorous reaction with a small piece of sodium in the lab would be magnified enormously on an industrial scale. Hence the reaction would be **very** violent or explosive, not just vigorous.

08.3 There were many good attempts at this question, with 73% of students scoring at least one mark. Many students referred to the lack of reactivity of the metals with argon, but some forgot to refer to air. Then some students did not express themselves clearly, referring to one or both metals reacting with air in general, or even with gases not present in the air, such as hydrogen.

08.4 There were some excellent attempts at this difficult question, which discriminated well. 8% of students achieved full marks with 43% achieving at least one mark. Full credit could be gained by those who started with the premise that titanium chloride must be ionic so should have a high melting point; very few started from the true situation, which is that titanium chloride must exist as small molecules as its melting point is low.

The mark that was scored least often was for the explanation of the bonding and how it leads to the actual, or predicted, melting point. Some spoiled an otherwise good description of ionic bonding by also referring to ‘strong intermolecular forces’. Many referred to ‘strong electrostatic forces’ but failed to mention that those forces were between ions.

A significant number of students answered solely in terms of the separate elements, particularly titanium, rather than the compound.

08.5 51% of students achieved the mark for this question. Whilst the definition of oxidation in terms of electrons is well known, the question asked why **this** reaction is oxidation. So, it was necessary to refer to the sodium atoms losing electrons rather than giving a generalised answer. Some students referred to ‘it’ losing electrons, without specifying what ‘it’ referred to, while others referred to oxygen, which is not present.

08.6 54% of students achieved the mark here. It was not uncommon to see ‘$-e^-$’ on the right hand side. A significant number of incorrect responses showed the formation of a doubly charged sodium ion.

Answer 57 · Examiner comments

08.7 This difficult unstructured calculation tested a new area of the specification, and discriminated very well. 74% of students were able to achieve at least one mark, usually for calculating the M_r of $TiCl_4$. 7% of students achieved all four marks, with 12% achieving at least three marks and there were some valiant efforts.

Common errors were:

- using 92 instead of 23 to calculate the number of moles of Na
- omitting the unit conversion from kg to g for the mole calculations
- using the 1:4 mole ratio incorrectly or not at all.

Also, it is not appropriate to leave answers in the form of a fraction, even if this is the default on their calculator. Answers should always be converted to decimal form.

08.8 This was well answered, with 74% of students achieving both marks. A few forgot the 100 in their expression and didn't realise they were making about 1000 kg more than the theoretical maximum.

4.4.1.3 Extraction of metals and reduction

Answer 58 · Examiner comments November 2020 | 8462/1H | Original Q2

Question 2 (standard demand)

02.1 Nearly all students scored at least one mark. The most commonly seen incorrect response was 'they form colourless compounds'.

02.2 Whilst many students realised that copper was displacing silver, most were unable to deduce that the grey crystals were silver and the blue solution was copper nitrate or a copper compound. There were many poorly worded answers which did not gain credit, such as 'it displaced silver', or 'copper is blue in solution'. It was not uncommon for the grey crystals to be described as copper nitrate crystallising from the solution.

02.3 Whilst many students included a control variable in their plan, few actually said how they would identify each metal as magnesium, iron or copper, so were unable to access the higher levels.

02.4 This calculation was very well done by most students.

Answer 59 · Examiner comments November 2020 | 8462/2H | Original Q6

Question 6 (standard and standard / high demand)

06.1 A number of students knew that this was incomplete combustion but far fewer mentioned insufficient oxygen. Some thought the soot was a product of a reaction involving the limestone.

06.2 This item was poorly answered, with a very small number of students able to access all the marks. Many thought that sulfur itself is released to the atmosphere, rather than producing sulfur dioxide in the engine, which is then released. Of those who did, most got the link to acid rain, but a lot did not say there would be less sulfur dioxide and therefore less acid rain. The last point was rarely scored – many just repeated the word erosion or its variants. Very few stated that acid rain reacts with limestone.

06.3 Not very well answered by most students. Many thought that nitrogen comes from the fuel. Others just stated that nitrogen oxides are a product of combustion. Of those who did realise that oxygen and nitrogen were reacting, some thought that this was happening outside the car rather than in the engine and very few mentioned that a high temperature was needed, some just referring to heat.

4.4.1.3 Extraction of metals and reduction

Answer 60 · Examiner comments

November 2021 | 8462/1H | Original Q3

Question 3 (standard demand)

03.1 This was well answered by many students. A common error was to not multiply the relative formula mass of hydrogen by three, leading to an answer of 100.

03.2 This was well answered. Credit was given to those who applied an incorrect response to question **03.1** correctly. Some students gave an answer which corresponded to their answer to question **03.1** used as atomic number rather than relative atomic mass.

03.3 This was well answered, although a common error was to omit the carbon in calculating the total M_r of the reactants.

03.4 The best answers gave the pros and cons of each method and then gave a judgement. One misconception was that the iron oxide in method 3 could be sold. Many concentrated only on cost, and the number of by-products, rather than what those products were and how difficult or costly further separation would be. Few students used the information provided, that solid products have to be separated. A few very good students commented on the low atom economy that method 1 would give because of some tungsten being lost as tungsten carbide.

Answer 61 · Examiner comments

November 2021 | 8462/2H | Original Q8

Question 8 (standard, standard / high and high demand)

08.1 The likely toxicity of lead was identified by approximately half of the students.

08.2 Nearly half of the students gained this mark.

08.3 A good spread of marks were seen here, with around 70% giving at least one creditworthy response, usually linked to energy or waste. However very few were able to gain all 3 marks.

08.4 Approximately one-third of students were able to gain the first two marking points. However, very few scored beyond marking point 2 as the need to add the resulting ash to acid was almost never given.

08.5 Under half of students gave one reason, usually that phytomining is slow. Very few were able to give a second reason.

4.4.1.3 Extraction of metals and reduction

Answer 62 · Examiner comments

June 2022 | 8462/1H | Original Q7

Question 7 (Standard, standard/high and high demand)

07.1 This was well answered, with more than half of students scoring both marks. There was, however, some ambiguous use of the word ‘it’ such as ‘it shows that it is below carbon because it displaces it’. If it was not clear what ‘it’ referred to, credit was not given.

07.2 Only 10% of students were awarded both marks, although nearly 60% scored at least one mark. Many students realised that aluminium is extracted by electrolysis, although some stated that aluminium would be extracted by the use of a more reactive metal. Although many mentioned the high energy cost of electrolysis, few compared electrolysis to the lower energy cost of heating coal to obtain carbon. Other students did state that extracting aluminium requires more energy than forming carbon, but did not explain why.

07.3 Many students realised that the products both being solids would make their physical separation difficult. Some appeared to misunderstandd what ‘separate’ means, and described the difficulty of decomposing magnesium oxide; this did not gain credit. Another common incorrect approach was to say that magnesium is high in the reactivity series. Whilst true, this was not relevant to the question set.

07.4 Those students who adopted a systematic approach, either using moles or reacting masses by proportion, had little difficulty in scoring most or all of the marks. In a multi-step calculation it is essential that each step is shown in the working so that marks for working can be awarded. The most common error was to use 48, instead of 24, for the M_r of Mg, giving an answer that was twice the correct value. Nearly all students carried out the unit conversion correctly. Some students calculated the correct final answer (960 g) but used an incorrect method. Such responses did not score full marks.

Answer 62 · Examiner comments June 2022 | 8462/1H | Original Q7

07.5 This was well answered. However, there were many blank responses.

07.6 This was a high demand calculation, and students found it difficult to analyse the correct approach to take. The gas molar volume was not provided, because it was not needed. Indeed, with the water being formed as a gas, a value of 24 dm^3/mol was not correct. Even so, those students who adopted the approach of converting gas volumes to moles were given full credit if they succeeded. Few did, as a four-step calculation with simple numbers was turned into a seven-step calculation with a unit conversion by electing to follow this approach.

Students needed to use the equation to realise that the SiO_2 formed is a solid, not a gas. They were also told that the oxygen is in excess; that means that the Si_2H_6 is the limiting reactant, and that the gases after reaction would therefore be the water vapour and the remaining oxygen. All that was therefore necessary was to multiply the volume of Si_2H_6 by 3 to find the volume of water vapour formed, and by 7/2 to find the volume of oxygen used. Subtracting that volume from 150 cm^3 would then give the volume of excess oxygen, and adding the volumes of the two appropriate gases together gave the final answer. Only one sixth of students scored at least one mark, which was usually for calculating the volume of water vapour produced.

Answer 63 · Examiner comments June 2022 | 8462/2H | Original Q1

Question 1 (Standard demand)

01.1 This was well answered by many students. The most common errors were to omit the double bond, or to add additional bonds to the carbon atoms. Brackets and/or the inclusion of the letter n were ignored. Around two-thirds of the students scored both marks.

01.2 The majority of responses correctly referred to the insulation being burned or melted or the lack of purity or ‘contamination’ of the copper produced. Around 60% of students scored this mark.

01.3 This was generally well answered as the copper melting and being reformed/moulded into new pipes were commonly seen. Responses referring to ‘heating the wire’ were insufficient to gain credit. Around 70% of the students scored both marks.

01.4 The most common correct responses referred to the conservation of copper and the use of less energy in this process. Relatively few answers identified specified environmental impacts.

Weaker responses referred to ‘pollution’ alone which was insufficient to gain credit. Only around 30% of the students were able to identify two advantages of recycling.

4.4.1.3 Extraction of metals and reduction

Answer 63 · Examiner comments

01.5 The specific correct reagent used and correct result, were not well known.

A variety of tests were chosen, with the most common incorrect response being the use of flame tests.

Acceptable results included shades of blue precipitate, e.g. pale/light blue, but answers giving two colours such as green/blue were not credited. Around a third of students scored both the marks.

01.6 The use of barium chloride or barium nitrate as the reagent for the test was generally followed by the correct result. Again, around a third of the students scored both the marks.

The most common incorrect responses were the use of a flame test or the use of an incorrect reagent.

The mark for the result of the test was dependent upon a mark being being awarded for a correct test.

Answer 64 · Examiner comments

June 2023 | 8462/1H | Original Q9

Question 9 (standard, standard/high and high demand)

09.1 Students found this question difficult, with only a tenth of students scoring both marks and not many more scoring one. Most students gave incorrect responses for the substance reduced: usually iron, but sometimes carbon. Those who gave the correct substance were usually able to give the correct reason in terms of loss of oxygen. It seems that students are so well versed in the definitions of redox in terms of electrons (as in question 09.3) that they have forgotten the simpler definitions in terms of gain or loss of oxygen.

09.2 Fewer than a third of students gave the correct answer, with all three distractors being very popular. This suggests a large degree of guessing rather than using the equation to work out the mole ratio of C:Fe as 3/2 and then multiply by 12 grams.

09.3 Over three-quarters of students could correctly apply their knowledge of redox in terms of electrons. By far the most common incorrect response was **A** gains electrons and $\mathbf{B}^{+}$ loses electrons.

09.4 Fewer than one in seven students answered this high demand question correctly, with the great majority giving metal **A** as the answer. It was necessary to realise that the greatest tendency to form positive ions means the most reactive metal. It was then necessary to work out from the three reactions in the table that **A** is more reactive than **B**, **C** is more reactive than **A**, and **C** is less reactive than **D**, making **D** the most reactive.

09.5 This question discriminated well. Over half of students scored at least one mark, with just over one in ten scoring all three.

Many students tried to answer in terms of the reactivity series. This was not possible, as insufficient detail was provided to identify any of the four metals. The formula of the nitrate ion was provided but was not referenced by the majority of students. The key to answering the question was in the formulae of the nitrates; aluminium forms an ion of charge 3+, so each ion requires three nitrate ions to balance the charge. Even when students got the basic idea, they often did not express themselves clearly enough, using phrases such as ‘aluminium has a 3+ charge’ rather than referring to an aluminium ion.

09.6 Those who understood the concept of atom economy were able to complete this difficult calculation successfully; over a fifth of students scored all four marks and two fifths scored at least one.

There were two main approaches. One was to substitute values into the atom economy expression, followed by successive rearrangements of the expression to give the value of A_r of **X**. A neater solution, used by students who had a good understanding of atom economy, was to realise that the remaining 22.7% was the total M_r of the waste atoms, ie 54, and then scale either to 100% and subtract the 54, or scale straight to 77.3%. Many students misunderstood the M_r of XO_3, thinking it meant the A_r of **X** times 48. Some also misunderstood $3H_2$ or $3H_2O$, giving various values for what should have been a total of 54 for the M_r of the waste atoms. Nevertheless, correct manipulation after these errors allowed access to 3 marks.

Answer 65 · Examiner comments

June 2023 | 8462/2H | Original Q5

Question 5 (standard and standard / high demand)

05.1 Nearly all students correctly identified oxygen as the missing item in the equation and most correctly identified it as a diatomic molecule and were then able to go on to balance it correctly. Four-fifths of students gained both marks.

05.2 This calculation was well done by many students, with more than three-quarters of students scoring the mark. The commonest error was to incorrectly calculate the relative formula mass of the compound due to missing the fact that the compound contained two atoms of sulfur and not one. More than three-quarters of students scored the mark.

05.3 Many students were aware that the test for copper(II) ions produces a blue precipitate. However, there was more trouble in identifying the correct reagent and as a result a number of students scored no marks. A number of students were able to gain credit by the use of a flame test instead. Nearly half of students gained both marks.

05.4 This item was not well answered with many students incorrectly assuming that bioleaching was the same as phytomining. Of those who did know what bioleaching referred to, most were able to identify the use of bacteria, but very few gained the second mark for ‘leachate solutions’, either just referring to ‘leachate’, or by going on to say that the leachate contained copper (rather than copper compounds/ions). Only 10% of students scored both marks, although around half knew that bacteria were involved.

Answer 66 · Examiner comments

June 2025 | 8462/1H | Original Q3

Question 3 (standard demand)

03.1 This was answered less successfully, with the majority of students choosing tin as the substance reduced. Tin is the product of the reduction, not the substance which is reduced. Those who did choose the correct substance, SnO_2, were usually able to give a correct reason; one in seven students were awarded both marks. Some tried to answer in terms of electrons, despite the instruction to answer in terms of oxygen. These answers did not gain credit for the second marking point.

03.2 Nearly three quarters of students managed to state succinctly that carbon is more reactive than tin or that tin is less reactive than carbon. However, some answers were vague and used the word 'it' which is problematic as there are three substances named in the question. 'Carbon is more reactive' is insufficient as we do not know what the reactivity is being compared to.

03.3 More than two thirds of students achieved full marks. Some did not calculate a total M_r but used the M_r of CdO instead; these answers were not creditworthy. Others added up all the M_r of reactants and products instead of just the reactants; these gained partial credit.

03.4 The question asked for two differences in properties, so comparative language was necessary (potassium is softer rather than potassium is soft). Three fifths of students scored both marks, choosing from differences in physical properties and properties exhibited by transition metals only. The most common type of error was to describe differences in atomic structure rather than differences in the properties of the metals in bulk.

03.5 The vast majority of students interpreted the equation correctly and showed that the total M_r on both sides was 238.

03.6 More than two thirds of students gave an acceptable response. Most of those who were awarded the mark answered in terms of economic reasons such as lowering the cost of the operation. Fewer answered in terms of sustainable development; of those who did, most referred to a high atom economy producing less waste. Some students confuse a high atom economy with a high yield; references to yield were ignored.