AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.4.1.4

Oxidation and reduction in terms of electrons (HT only)

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**27**
Available paper years	**2007–2022**

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.

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 01 · Mark scheme

November 2007 | CHY1A | Original Q3 | Legacy

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

Answer 02 · Mark scheme

November 2007 | CHY1A | Original Q7 | Legacy

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

Answer 03 · Mark scheme

November 2007 | CHY1A | Original Q9 | Legacy

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

Answer 04 · Mark scheme

January 2008 | CHY2H | Original Q6 | Legacy

The full source mark scheme begins on page 34. Follow original question 6 in that document.

Answer 05 · Mark scheme

November 2008 | CHY1AP | Original Q7 | Legacy

Seven	**4**	**1**	**2**	**3**

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 06 · Mark scheme

March 2009 | CHY1AP | Original Q9 | Legacy

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

Answer 07 · Mark scheme

March 2009 | CHY1BP | Original Q5 | Legacy

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

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 08 · 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**

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 08 · Mark scheme

June 2009 | CHY1H | Original Q4 | Legacy

CHY1H

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 09 · Mark scheme June 2009 | CHY2H | Original Q5 | Legacy

Question 5

question	answers	extra information	mark
5(a)(i)	any **one** from: • they are positive / cations • they are H^+ • opposite charges attract	ignore atom	1
5(a)(ii)	potassium is more reactive (or reverse)	assume 'it' refers to hydrogen allow potassium reacts with water allow potassium is very reactive **or** most reactive metal / element allow hydrogen gains electrons more easily / is reduced more easily accept potassium is higher up the reactivity series	1
5(b)	6 **and** 2	accept correct multiples and fractions	1
5(c)(i)	the reaction / it is reversible **or** a description of a reversible reaction	allow 'it is an equilibrium' allow reversible symbol drawn correctly allow 'the reverse / back reaction'	1

Question 5 continues on the next page…

CHY2H

Question 5 Continued

question	answers	extra information	mark
5(c)(ii)	**lithium nitride** assume that 'it' or if they do not specify means lithium nitride assume lithium / lithium nitrate refers to lithium nitride • hydrogen is bonded / held / absorbed / has formed a compound / reacted with lithium nitride plus **one** of: • does not explode / cause a fire • is not free / less hydrogen • is not under pressure • does not leak • is only released slowly • compound of hydrogen with lithium nitride / product is (more) stable / less reactive / less chance of a reaction	accept converse for hydrogen as below assume that gas / hydrogen means gas in the cylinder • hydrogen (in cylinder) / gas is not bonded / held / absorbed / in a compound / reacted with lithium nitride plus **one** of: • can explode / cause a fire • is free • is under pressure • can leak • releases quickly	1 1
5(d)(i)	smaller **or** correct indication of size **or** higher surface area	allow very / really small **or** tiny accept few (100) atoms in size allow 1 to 100 nanometres or 10^{-9} metres allow absorption and / or release of hydrogen more quickly allow have different properties allow 'more particles in each volume / area' do not allow reacts more quickly	1

Question 5 continues on the next page…

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

CHY2H

Question 5 Continued

question	answers	extra information	mark
5(d)(ii)	greater surface area		1
5(e)(i)	loss of an electron **or** loses electrons	do not accept any ref. to oxygen	1
5(e)(ii)	full outer shell of 8 electrons on circle	need not be paired can be ×, dot or e do **not** accept if extra electrons added to inner shell	1
Total			**10**

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 09 · Mark scheme June 2009 | CHY2H | Original Q5 | Legacy

CHY2H

Answer 10 · Mark scheme March 2010 | CHY1AP | Original Q2 | Legacy

Two	**A** reduction **4** **B** combustion **2** **C** thermal decomposition **1** **D** corrosion **3**			
	A	**B**	**C**	**D**

Answer 11 · Mark scheme March 2010 | CHY1AP | Original Q6 | Legacy

Six	**4**	**1**	**3**	**4**

Answer 12 · Mark scheme March 2010 | CHY1BP | Original Q8 | Legacy

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

Answer 13 · Mark scheme June 2010 | CHY1AP | Original Q2 | Legacy

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

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 14 · Mark scheme

June 2010 | CHY1BP | Original Q9 | Legacy

Nine	**4**	**3**	**2**	**1**

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 15 · Mark scheme

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**

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 15 · Mark scheme January 2011 | CHY1H | Original Q4 | Legacy

CHY1H

Answer 16 · Mark scheme June 2011 | CHY1AP | Original Q5 | Legacy

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

Answer 17 · 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

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 18 · Mark scheme

June 2011 | CHY2H | Original Q5 | Legacy

Question 5

question	answers	extra information	mark
5(a)(i)	electron(s)	allow free / delocalised / negative electrons do **not** accept additional particles	1
5(a)(ii)	ion(s)	allow named ions from table ignore positive or negative do **not** accept additional particles	1
5(b)(i)	copper	accept Cu do **not** accept Cu^{2+}	1
5(b)(ii)	it is / they are positive (ions) and it is the least reactive	accept formula of positive ion	1 1
5(c)(i)	loss of electron(s)	ignore numbers	1
5(c)(ii)	$\mathbf{2H^+} + \mathbf{2e^-} \rightarrow H_2$	accept correct multiples / fractions accept e / e^- allow $\mathbf{2H^+} \rightarrow H_2 - \mathbf{2e^-}$	1
Total			**7**

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 18 · Mark scheme June 2011 | CHY2H | Original Q5 | Legacy

CHY2H

Answer 19 · Mark scheme November 2011 | CHY1AP | Original Q4 | Legacy

Four	3	2	1	2

Answer 20 · Mark scheme November 2011 | CHY1AP | Original Q5 | Legacy

Five	4	2	2	2

Answer 21 · Mark scheme November 2011 | CHY1BP | Original Q7 | Legacy

Seven	4	1	1	3

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 22 · Mark scheme June 2014 | CH1HP | Original Q1 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
1(a)(i)	2,4 drawn (as dots / crosses / e^-)		1	2 / 1.1.1h	E
1(a)(ii)	Water (vapour) / steam	allow hydrogen oxide / H_2O *do **not** accept hydroxide*	1	1 / 1.4.3b	G
1(b)	any **two** pairs from: carbon dioxide (1) causes global warming (1) **or** carbon (particles) / *soot* (1) causes global dimming (1) **or** carbon monoxide (1) is toxic (1) **or** sulfur dioxide (1) causes acid rain (1)	*allow greenhouse effect / climate change / sea level rise / melting of polar ice caps* *allow particulates* *allow blocks out sunlight / smog / prevents plant growth / causes breathing difficulties* *allow kills plants / erosion / acidifies water*	4	1 / 1.4.3a/c	E
Total			**6**		

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 22 · Mark scheme

June 2014 | CH1HP | Original Q1 | Legacy



4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 23 · 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

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 23 · Mark scheme

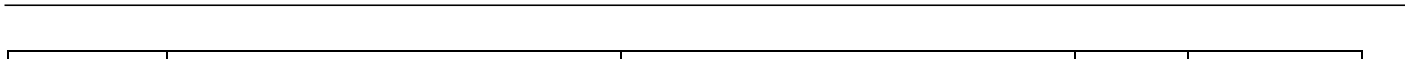
June 2018 | 8462/1H | Original Q2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.4	carbon is more reactive (than nickel) (so) carbon will displace / replace nickel (from nickel oxide) **or** (so) carbon will remove oxygen (from nickel oxide)	allow converse allow (so) nickel ions gain electrons allow (so) carbon transfers electrons to nickel (ions)	1 1	AO1 4.4.1.2 4.4.1.3
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**	

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 23 · Mark scheme

June 2018 | 8462/1H | Original Q2



4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 24 · 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

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 24 · 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

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 24 · Mark scheme

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

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 24 · Mark scheme

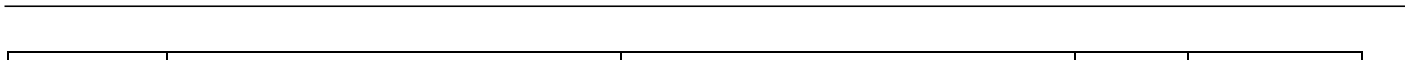
June 2018 | 8462/1H | Original Q8

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**	

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 24 · Mark scheme

June 2018 | 8462/1H | Original Q8



4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 25 · Mark scheme

November 2020 | 8462/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	the (minimum) energy needed for particles to react **or** the (minimum) energy needed for a reaction to occur	allow the (minimum) energy needed to start a reaction	1	AO1 4.5.1.2
06.2	(M_r of Fe_2O_3 =) 160		1	AO2 4.3.1.2 4.3.2.1 4.3.2.2 4.3.2.4
	(moles $Fe_2O_3 = \frac{3000}{160}$ =) 18.75 (mol)	allow correct use of incorrectly calculated M_r	1	
	(moles Al $= \frac{1000}{27}$ =) 37.0 (mol)	allow 37.037037 (mol) correctly rounded to at least 2 significant figures if both MP2 and MP3 are not awarded allow **1** mark for 0.01875 mol Fe_2O_3 **and** 0.037 mol Al	1	
	(aluminium is limiting because) 37.0 mol is less than the (2 x 18.75 =) 37.5 mol (aluminium needed) **or** iron oxide is in excess because 18.75 mol is more than the ($\frac{37.0}{2}$ =) 18.5 mol (iron oxide needed)	allow correct use of incorrect number of moles from steps 2 and/or 3	1	

Question 6 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2 ctd	**alternative approaches:** **approach 1:** **(finding required mass of aluminium by moles method)** (M_r of Fe_2O_3 =) 160 (1) (moles $Fe_2O_3 = \frac{3000}{160}$ =) 18.75 (mol) (1) (moles Al needed =18.75 × 2 =) 37.5 (mol) **and** (mass Al needed = 37.5 × 27 =) 1012.5 (g) **or** 1.0125 kg (1) (so) 1.00 kg of aluminium is not enough (1) **approach 2:** **(finding required mass of aluminium by proportion method)** (M_r of Fe_2O_3 =) 160 (1) (3.00 kg Fe_2O_3 needs) $\frac{3.00}{160}$ × 2 × 27 (kg Al) (1) (=) 1.0125 (kg) (1) (so) 1.00 kg of aluminium is not enough (1)	 allow correct use of incorrectly calculated M_r allow correct use of incorrectly calculated moles of iron oxide allow correct use of incorrectly calculated moles of aluminium needed dependent on calculated mass of aluminium needed being greater than 1.00 (kg) allow correct use of incorrectly calculated M_r dependent on calculated mass of aluminium needed being greater than 1.00 (kg)		AO2 4.3.1.2 4.3.2.1 4.3.2.2 4.3.2.4

Question 6 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2 ctd	**alternative approaches:** **approach 3:** **(finding required mass of iron oxide by moles method)** M_r of Fe_2O_3 =) 160 (1) (moles Al $= \frac{1000}{27}$ =) 37.0 (mol) (1) (moles Fe_2O_3 needed) $= \frac{37.0}{2}$) = 18.5 (mol) **and** (mass Fe_2O_3 needed = 18.5 × 160 =) 2960 (g) **or** 2.96 (kg) (1) (so) 3.00 kg of iron oxide is an excess (1) **approach 4:** **(finding required mass of iron oxide by proportion method)** (M_r of Fe_2O_3 =) 160 (1) (1.00 kg Al needs) $\frac{1.00}{2 \times 27} \times 160$ (kg Fe_2O_3) (1) (=) 2.96 (kg) (1) (so) 3.00 kg of iron oxide is an excess (1)	allow 37.037037 (mol) correctly rounded to at least 2 significant figures allow correct use of incorrectly calculated moles of aluminium allow correct use of incorrectly calculated moles of iron oxide needed allow correct use of incorrectly calculated M_r dependent on calculated mass of iron oxide needed being less than 3.00 (kg) allow correct use of incorrectly calculated M_r dependent on calculated mass of iron oxide needed being less than 3.00 (kg)		AO2 4.3.1.2 4.3.2.1 4.3.2.2 4.3.2.4

Question 6 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	$Mg(s) + Zn^{2+}(aq) \rightarrow Mg^{2+}(aq) + Zn(s)$	allow multiples allow **1** mark for $Mg^{2+} + Zn$ with missing or incorrect state symbols	2	AO2 4.1.1.1 4.2.2.2 4.4.1.4
06.4	magnesium (atoms) are oxidised because they lose electrons (and) zinc (ions) are reduced because they gain electrons	 if no other marks awarded allow **1** mark for magnesium (atoms) lose electrons and zinc (ions) gain electrons	1 1	AO2 4.4.1.4
Total			**9**	

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 26 · 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

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

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**

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 27 · Mark scheme

June 2022 | 8462/1H | Original Q4

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	(zinc oxide) solid remaining	allow (zinc oxide) solid no longer disappears ignore references to colour / effervescence	1	AO1 4.2.2.2 4.4.2.2 4.4.2.3 RPA 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	(excess) zinc oxide can be filtered off	allow converse statements for hydrochloric acid allow separation / removal of (excess) zinc oxide is easier ignore to ensure all the (hydrochloric) acid is used up	1	AO1 4.4.2.2 4.4.2.3 RPA 1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	any **one** from: • zinc hydroxide • zinc carbonate	allow $Zn(OH)_2$ allow $ZnCO_3$	1	AO1 4.4.2.2 4.4.2.3 RPA1

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 27 · Mark scheme

June 2022 | 8462/1H | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	heat (the solution) until crystallisation point is reached	allow heat (the solution) until crystals start to form allow heat (the solution) to reduce the volume allow heat (the solution) to evaporate (some of the water)	1	AO1 4.4.2.3 RPA 1
	leave the solution (to cool / crystallise)		1	
		if no other mark is awarded allow **1** mark for heat the solution to dryness		

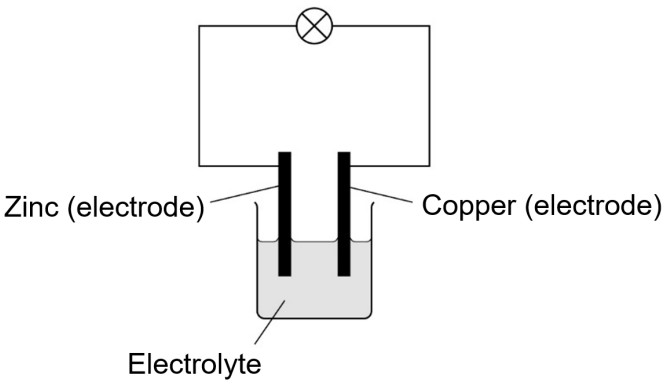
Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5	$Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$	ignore state symbols	1	AO2 4.4.1.2 4.4.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.6	zinc (atoms) lose (2) electrons	do **not** accept references to oxygen	1	AO2 4.4.1.2 4.4.1.4

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 27 · Mark scheme

June 2022 | 8462/1H | Original Q4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.7	(a diagram showing) solution in a container zinc electrode **and** copper electrode both inserted into solution complete circuit that would function as an electrochemical cell including a labelled electrolyte an answer of  scores **3** marks	ignore voltmeter / ammeter regardless of location ignore labels ignore polarities on electrodes allow a named electrolyte in solution allow a named molten electrolyte do **not** accept cell / battery in external circuit do **not** accept a wire between the electrodes	 1 1 1	AO1 4.5.2.1

Total Question 4		10

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Version 1.0: 0108

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Secondary Education

Additional Science 4463 / Chemistry 4421

CHY2H Unit 2 Chemistry

Mark Scheme

2008 examination – January series

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

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.

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4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

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.

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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.

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

CHY2H

Question 1

question	answers	extra information	mark
(a)	sensible line of best fit which goes through or close to all the points **except** the anomalous point	allow wobbly / short double lines ± ½ square	1
(b)	loss of gas / loss of CO_2	idea of gas produced / formed	1
(c)	7		1
(d)(i)	steeper line from around the same starting point and left of the points levelling off at 99	allow crosses if they are fully correct for **1** mark accept short level line at 99 ± ½ square	1 1
(d)(ii)	any **three** from: • particles / molecules / atoms/ ions have more energy • move faster • collide <u>more</u> often **or** <u>more</u> chance of collisions **or** bump into each other <u>more</u> • collide with <u>more</u> force / energy **or** <u>more</u> particles have the activation energy **or** <u>more</u> collisions result in reaction **or** <u>more</u> collisions are successful	 allow given / gain / get energy ignore move about more ignore vibrate more / faster ignore collide quicker / faster	3
total			8

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

CHY2H

Question 2

question	answers	extra information	mark
(a)	any **one** from: • they are made of layers • atoms / ions / particles / layers (of atoms) can slide over each other	 do **not** accept line / rows / lattice	1
(b)	any **one** from: • smaller / tiny **or** very small • correct size range 1 to 100 nanometres • a few hundred atoms in size	 do **not** allow small alone if they state smaller and give a size outside range ignore size if it is less than 20,000	1
(c)	harder plus **one** from: • so does not wear as quickly / erode as quickly • less vulnerable to damage owtte • because they have a high surface area to volume ratio **or** stronger (1) plus **one** from: (1) • less likely to break / do not break • not as vulnerable to damage owtte • do not bend out of shape • because they have a high surface area to volume ratio	 ignore corrode harder to wear down = **1** mark accept withstand pressure harder and stronger alone gains **1** mark	1 1
total			4

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

CHY2H

Question 3

question	answers	extra information	mark
(a)	N_2O		1
(b)	13.8 to 14	gains full marks without working if answer incorrect 13 gains **1** mark **or** 14/101 × 100 gains **1** mark	2
total			3

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

CHY2H

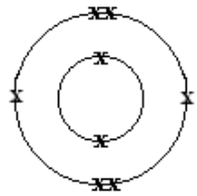
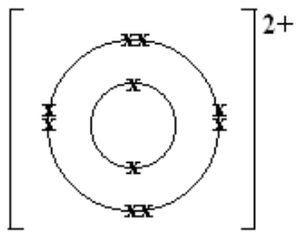
Question 4

question	answers	extra information	mark
(a)	electric current / electricity		1
	plus **one** from:		1
	• is passed through ionic compound / substance / electrolyte • passed through molten/aqueous compound / substance	must be linked to electricity allow liquid compound / substance do **not** allow solution / liquid alone	
	• causing decomposition	accept split up / breakdown / breaking up owtte ignore separated accept elements are formed ignore new substances form	
(b)	hydrogen	accept H_2 do **not** accept H / H^2	1
(c)	one electron from each atom	accept each carbon is bonded to three other carbon atoms leaving one (unbonded) electron owtte	1
	is delocalised / free (to move)	must be linked to electrons answers of delocalised / free electrons only, gains **1** mark accept each carbon is bonded to three other carbon atoms leaving delocalised / free electrons = **2** marks **maximum 1** mark if graphite described as a metal / giant ionic lattice	1
total			5

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

CHY2H

Question 5

question	answers	extra information	mark
(a)	any **one** from: • gives out heat / energy • transfers energy from a substance to the surroundings • ΔH / energy change / enthalpy change is negative	accept releases / gives off owtte ignore references to light	1
(b)	$2Mg + O_2 \rightarrow 2MgO$	accept correct multiples / fractions	1
(c)		electrons do not need to be paired accept dots / circles / e instead of crosses do **not** allow 2.6 without diagram	1
(d)		electrons do not need to be paired allow without brackets must have the charge accept dots / circles / e instead of crosses ignore extra empty outer shells ignore nucleus do **not** allow $[2.8]^{2+}$ without diagram	1

continued…

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

CHY2H

Question 5 continued…

question	answers	extra information	mark
(e)	oppositely charged (ions / atoms)	allow positive and negative(ions / atoms)	1
	(they) attract	must be in correct context accept held by electrostatic forces ignore ionic bonding **maximum 1** if they refer to intermolecular forces / attractions / covalent bonds	1
(f)	magnesium chloride	accept $MgCl_2$ (if correctly written)	1
total			7

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

CHY2H

Question 6

question	answers	extra information	mark
(a)	**Compound A** any **one** from: • sodium bromide • potassium bromide • ammonium bromide • hydrogen bromide • any metal bromide except silver and lead. **Compound B** silver nitrate	accept correct formulae accept silver sulfate	1 1
(b)	the silver compound will decompose / silver ions be reduced to silver (owtte)	accept film would darken owtte accept any idea of light changing silver bromide / silver ions / silver nitrate / silver sulfate allow 'forms a black solid' / it would turn black	1
(c)	precipitation	accept descriptions of precipitation reactions accept double decomposition accept precipitate do **not** allow displacement	1
(d)	electrons are gained	 the second mark **must** be linked to electrons accept it / silver / silver ions gains electrons for **both** marks ignore references to oxygen	1 1
total			6

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

CHY2H

Question 7

question	answers	extra information	mark
(a)	1213.8 to 1214.3 correct answer not given then check working 1) moles of N_2 = $\frac{1000}{28}$ = 35.7 mol 2) moles of NH_3 = 2 × (answer from (1)) = 71.4 mol 3) mass of NH_3 = (answer from 2) × 17 = 71.4 × 17 = 1214 g **or** • 28g of N_2 → 34g of NH_3 • 1g of N_2 → $\frac{34}{28}$ = 1.214g NH_3 • 1000 g of N_2 → 1000 × 1.214 = 1214g **or** • 1000 × $\frac{34}{28}$ **or** **other correct methods**	gains **3** marks without working **1** mark for each correct step do **not** penalise rounding errors in this part **1** mark for each correct step do **not** penalise rounding errors in this part allow error carried forward eg gains **2** marks if correct answer not given 1000 × $\frac{28}{34}$ gains **1** mark, **2** marks if correctly calculated (823.5g) 1000 × $\frac{28}{17}$ gains **1** mark if calculated correctly (1647.05g) look for the key ideas in the methods above	3

continued…

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

CHY2H

Question 7 continued…

question	answers	extra information	mark
(b)	25 / 25.035 **or** ecf from (a)	gains **2** marks even when there is no working incorrect answer then 304/(their answer from (a)) × 100 gains **1** mark	2
	or using figures from part (b) **27.6 / 28**	gains **2** marks even when there is no working accept 27 for **1** mark if answers incorrect then304/1100 × 100 gains **1** mark	
(c)(i)	increase yield reaction is exothermic **or** allow decreased yield because rate of reaction is slower / fewer collisions for **2** marks	**must** get both points for **2** marks	1 1
(c)(ii)	increase yield plus **one** from: • more (gaseous) reactant molecules than (gaseous) product molecules (owtte) • increased rate of reaction / more collisions	accept greater volume on the left than the right owtte	1 1

continued…

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

CHY2H

Question 7 continued…

question	answers	extra information	mark
(d)	any **one** from: **economic** • large town provides workforce • workers do not have to travel far to the factory. (owtte) • transport infrastructure already in place for large town. (owtte) • factory brings prosperity to town (owtte) • factory provides employment • reduced tourism • reduction in local house prices • any other sensible economic factor linked to town		1
	any **one** from: **safety** • escape of dangerous / harmful chemicals / gases (owtte) • danger of increased traffic • risk of explosion.(owtte) /danger of high pressure • consequences of an accident could be severe if the town is close • any other sensible safety idea	do **not** allow polluting gases unqualified	1

continued…

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

CHY2H

Question 7(d) continued…

question	answers	extra information	mark
	any **one** from: **environmental** • factory might be unsightly (owtte) • screening of factory (owtte) • loss of habitats (owtte) • plant trees/ hedges etc on and around plant site • pollution of water / air / soil could harm plants / animals **or** noise pollution • CO_2 is produced by burning fuels / heating • CO_2 causes global warming / any effect of global warming • eye sore • any other sensible environmental factor	must be explained	1
total			12

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 23 · 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 23 · 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 24 · Examiner comments

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.

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 24 · 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.

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 25 · Examiner comments

November 2020 | 8462/1H | Original Q6

Question 6 (standard, standard / high and high demand)

06.1 Most students were able to express the idea that activation energy is the minimum energy required to start a reaction. One common error was to say that it is the energy needed to make particles collide.

06.2 A variety of approaches was seen. The majority of students calculated the number of moles of both aluminium and of iron oxide and then attempted with varying degrees of success to explain why the number of moles of aluminium was insufficient for the iron oxide. Common errors were to omit to convert the mass from kilograms to grams, and/or using 54 as the 'M_r' of aluminium. Of those who did correctly calculate the number of moles of each reactant, some had difficulty in expressing clearly the idea of 2 moles of aluminium being needed to react with 1 mole of iron oxide, and therefore 37.0 moles of aluminium is less than the 37.5 moles required, or that 18.75 moles of iron oxide is more than the 18.5 moles required. Other students started with the mass of one reagent and calculated the required mass of the other, either by the moles method or by proportion. These students found it easier to express why there was insufficient aluminium or excess iron oxide.

06.3 Few students scored both marks. Aqueous zinc was often seen as a response. Many students did not understand the idea of an ionic equation and tried to include the sulfate ion.

06.4 Only a third of students scored both marks, but a lot of students were confused about which species gained electrons and which lost them. Definitions of oxidation and reduction in terms of gain and loss of oxygen were not appropriate here and were not credited.

Answer 26 · 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.

4.4.1.4 Oxidation and reduction in terms of electrons (HT only)

Answer 27 · Examiner comments

June 2022 | 8462/1H | Original Q4

Question 4 (Standard, standard/high and high demand)

04.1 Only about 40% of students scored this mark. A visible observation was required, such as solid remaining at the bottom of the beaker, or solid no longer disappearing. Merely rewording the idea that zinc oxide is in excess did not gain credit. Many students referred incorrectly to zinc rather than zinc oxide. The idea of a solid appearing was not given credit, as the solid was added in the first place.

04.2 Few students gained this mark. Many students said the reason was to use up all the acid, without considering why that was necessary - answers in terms of ease of removal of the excess reactant were required. Whilst students seem very familiar with the method for making a salt, they appear to be less familiar with the reasons for each step.

04.3 This was answered correctly by just over half of students. Some suggested zinc or chlorine; whilst zinc would work, it is not a compound. Others suggested using salts such as zinc sulfate.

04.4 Many students correctly described the two-step process of heating to crystallisation point, followed by leaving the solution to cool and crystallise. A few students referred to evaporating the zinc chloride, rather than the water, from the solution. Many students restricted themselves to one mark; either they did not heat the solution, they did not give a reason for heating, or they heated to dryness.

Answer 27 · Examiner comments

June 2022 | 8462/1H | Original Q4

04.5 Fewer than a quarter of students answered correctly. Many students tried to incorporate chloride into their equation. Equations were often not balanced in terms of charge.

04.6 This was well answered, with most students referring specifically to zinc in this reaction rather than to oxidation in general.

04.7 This question was well answered. However, some students drew an electrolytic cell rather than a simple chemical cell, with an electrolyte in a beaker and copper and zinc electrodes dipping into it.