AQA GCSE Chemistry | 8462

SPECIFICATION POINT 4.4.1.2

The reactivity series

Mark schemes and examiner comments

Tier	**Higher**
Question groups	**47**
Available paper years	**2008–2025**

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.

4.4.1.2 The reactivity series

Answer 01 · Mark scheme June 2008 | CHY1AP | Original Q3 | Legacy

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

Answer 02 · Mark scheme June 2008 | CHY1AP | Original Q7 | Legacy

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

4.4.1.2 The reactivity series

Answer 03 · Mark scheme

June 2008 | CHY3H | Original Q4 | Legacy

question	answers	extra information	mark
4(a)	acts as barrier between sodium and air / oxygen / water (vapour)	accept because they are reactive ignore oil will not react	1
4(b)	**2**Na + **2**H_2O → **2**NaOH + H_2	allow multiples / fractions	1
4(c)	these metals react with water producing an alkaline solution **or** produce solution with pH greater than 7 / high pH	owtte allow produce OH^- ions **not** these metals are / form alkalis ignore 'strong' pH	1
4(d)		it = potassium <u>outer</u> electron must be mentioned once for all **3** marks	
	bigger atom **or** outer shell electron further from nucleus **or** more shells	**or** converse argument for sodium less reactive provided sodium is specified	1
	less attraction to nucleus **or** more shielding	**not** less magnetic attraction	1
	outer electron more easily lost	**ignore** potassium reacts more easily	1
Total			**6**

4.4.1.2 The reactivity series

Answer 03 · Mark scheme June 2008 | CHY3H | Original Q4 | Legacy

COMPONENT NUMBER: CHY3H

COMPONENT NAME: Chemistry

STATUS: Final

DATE: June 2008

Answer 04 · Mark scheme November 2008 | CHY1AP | Original Q7 | Legacy

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

Answer 05 · 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 06 · Mark scheme March 2009 | CHY1AP | Original Q9 | Legacy

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

Answer 07 · Mark scheme June 2009 | CHY1AP | Original Q7 | Legacy

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

4.4.1.2 The reactivity series

Answer 08 · Mark scheme November 2009 | CHY1AP | Original Q1 | Legacy

Question	Key		
One	**A**	Calcium (Ca)	**2**
	B	Lithium (Li)	**3**
	C	Gold (Au)	**1**
	D	Iron (Fe)	**4**

Answer 09 · Mark scheme November 2009 | CHY1AP | Original Q8 | Legacy

Eight	**1**	**1**	**3**	**4**

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 June 2010 | CHY1AP | Original Q9 | Legacy

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

4.4.1.2 The reactivity series

Answer 13 · 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 14 · Mark scheme

November 2010 | CHY1AP | Original Q8 | Legacy

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

4.4.1.2 The reactivity series

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**

4.4.1.2 The reactivity series

Answer 15 · Mark scheme

January 2011 | CHY1H | Original Q4 | Legacy

CHY1H

4.4.1.2 The reactivity series

Answer 16 · Mark scheme

Question 4

question	answers	extra information	mark
4(a)(i)	a correct link between any two named elements eg same group / column same properties / number of outer electrons	allow some link between any two elements in the same group (in both Newlands' and **or** the modern periodic table)	1
4(a)(ii)	any **two** from: • elements still being discovered **or** no gaps for undiscovered elements • some boxes have 2 elements in them • metals and non-metals in same column / mixed up • pattern for first 16 or so elements only	ignore statements about lack of evidence / proof accept some elements in same column have different properties. allow any sensible suggestion about misplaced elements eg copper in group 1 elements allow did not work for all elements	2
4(b)(i)	Cl > Br > I **or** I < Br < Cl Cl has 2 reactions, Br has 1 reaction, I doesn't react	accept reactivity / it decreases down the group owtte allow Cl has most / more reactions and I has least / less reactions (must be clear about where Br fits in)	1 1

Question 4 continues on the next page

CHY3H

Question 4 contd

question	answers	extra information	mark
4(b)(ii)	Br_2	allow multiples / fractions if correctly completed and balanced	1
4(b)(iii)	(they) have 7 outer electrons	allow (they) have 7 electrons in highest occupied (energy) level / shells / rings	1
4(c)	down group (atom / elements) bigger **or** outer electrons (level / shell / ring) further from nucleus / centre **or** more shells / level / rings	outer / last / final must be mentioned once in correct context, otherwise max **2** marks comparative required on all three points accept converse ie less reactive up group ignore more electrons do **not** accept more outer shells for this mark	1
	force(s) / attraction(s) are weaker **or** more shielding **or** attracts less	allow electron(s) attracted less easily allow electron(s) less under influence (of nucleus) do **not** accept magnetic / gravitational / intermolecular forces	1
	electron(s) lost more easily	allow electron(s) more likely to be lost allow easier to give away	1
Total			**10**

4.4.1.2 The reactivity series

Answer 16 · Mark scheme January 2011 | CHY3H | Original Q4 | Legacy

CHY3H

Answer 17 · 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 18 · Mark scheme March 2011 | CHY1AP | Original Q8 | Legacy

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

Answer 19 · Mark scheme June 2011 | CHY1AP | Original Q5 | Legacy

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

Answer 20 · 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

4.4.1.2 The reactivity series

Answer 21 · 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**

4.4.1.2 The reactivity series

Answer 21 · Mark scheme June 2011 | CHY2H | Original Q5 | Legacy

CHY2H

Answer 22 · Mark scheme November 2011 | CHY1AP | Original Q7 | Legacy

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

Answer 23 · Mark scheme November 2011 | CHY1BP | Original Q1 | Legacy

Question	Key		
One	**A**	abundance	**4**
	B	colour	**2**
	C	density	**3**
	D	reactivity	**1**

4.4.1.2 The reactivity series

Answer 24 · Mark scheme

January 2013 | CH1HP | Original Q7 | Legacy

question	answers	extra information	mark
7(a)	(because to produce low-carbon steel) oxygen is needed to react with / oxidise carbon	accept (to produce low-carbon steel) oxygen removes carbon as carbon dioxide	1
	(to produce titanium) an atmosphere of argon is used because it is unreactive		1
	any oxygen / air would react with / oxidise magnesium or titanium	ignore magnesium chloride / titanium chloride reacts with oxygen	1
7(b)		it = titanium ignore references to abundance / usefulness / temperature / amounts / relative reactivity / equipment	
	for titanium:	allow converse arguments for iron	
	• there are more stages in its manufacture	accept slower rate of production **or** is more labour intensive **or** a batch process is used or the process used is not continuous	1
	• larger amounts of energy are needed	accept the titanium chloride is cooled and reheated which is not energy efficient	1
	• magnesium / chlorine / argon have to be produced **or** are expensive **or** are used		1

4.4.1.2 The reactivity series

Answer 24 · Mark scheme

CH1HP

question	answers	extra information	mark
7(c)	titanium is below magnesium and above iron (in the reactivity series of metals)	allow similar position to aluminium **or** carbon **or** zinc	1
	because magnesium removes chlorine from titanium chloride **and** titanium removes oxygen from iron oxide **OR** magnesium more reactive than titanium because it removes chlorine from titanium chloride (1) titanium more reactive than iron because it removes oxygen from iron oxide (1)	allow magnesium displaces titanium **and** titanium displaces iron accept magnesium more reactive than titanium because it displaces titanium accept titanium more reactive than iron because it displaces iron	1
Total			**8**

4.4.1.2 The reactivity series

Answer 24 · Mark scheme

January 2013 | CH1HP | Original Q7 | Legacy

CH1HP

4.4.1.2 The reactivity series

Answer 25 · Mark scheme

June 2013 | CH2HP | Original Q4 | Legacy

Question 4

question	Answers	extra information	Mark
4(a)(i)	current / charge couldn't flow	allow could not conduct (electricity)	1
	because the ions / particles couldn't move	do **not** accept electrons/ molecules / atoms	1
	or		
	(salt) needs to be molten / dissolved (to conduct electricity) (1)		
	so that the ions / particles can move (1)	do **not** accept electrons / molecules / atoms	
4(a)(ii)	he had status **or** he had evidence / proof	accept he had authority **or** experience accept the experiment could be repeated	1
4(b)	hydrogen / H_2	do **not** allow hydrogen ions	1
	the ions are positive	accept because opposite (charges) attract	1
	potassium is more reactive (than hydrogen)	accept potassium ions are less easily discharged (than hydrogen) **or** potassium ions are less easily reduced (than hydrogen)	1
4(c)(i)	gain electron(s)	accept fully balanced correct equation for **2** marks	1
	one electron	if no other marks awarded allow (potassium ions) reduced for **1** mark	1
4(c)(ii)	$\mathbf{2}Cl^- \rightarrow Cl_2 + \mathbf{2e^-}$	must be completely correct, including charge on electron accept correct multiples	1
4(c)(iii)	2, 8, 8	accept any combination of dots, crosses, "e" or any other relevant symbol ignore any charges if given	1
Total			**10**

4.4.1.2 The reactivity series

Answer 26 · Mark scheme

June 2013 | CH3HP | Original Q1 | Legacy

Question 1

question	Answers	extra information	Mark
1(a)(i)	hydrogen	accept H_2 allow H	1
1(a)(ii)	hydroxide	accept OH^- allow OH do **not** accept lithium hydroxide	1
1(b)	any **two** from: potassium: • reacts / dissolves faster • bubbles / fizzes faster • moves faster (on the surface) • melts • produces (lilac / purple) flame	'it' = potassium accept converse for lithium allow reacts more vigorously / quickly / violently / explodes ignore reacts more allow fizzes more allow more gas allow moves more allow forms a sphere allow catches fire / ignites do **not** accept other colours	2
Total			**4**

4.4.1.2 The reactivity series

Answer 27 · 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** $CuO + C \rightarrow$ **2** $Cu + CO_2$	*allow* $2\ CuO + C \rightarrow Cu_2 + CO_2$ *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**		

4.4.1.2 The reactivity series

Answer 27 · Mark scheme

June 2014 | CH1HP | Original Q4 | Legacy



4.4.1.2 The reactivity series

Answer 28 · Mark scheme June 2014 | CH3HP | Original Q3 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.	ID
3(a)	similar properties	*allow same properties* allow correct example of property ignore answers in terms of atomic structure	1	1 / 3.1.1a	E
3(b)(i)	in order of atomic / *proton* number	*allow increasing number (of protons)*	1	1 / 3.1.2a	E
3(b)(ii)	elements in same group have same number *(of electrons)* in outer shell **or** *highest energy level*	*allow number (of electrons) increases across a period*	1	1 / 3.1.2b	E
3(c)	any **two** from: • stronger / harder • less reactive • higher melting points	*statements must be comparative* *ignore higher densities* *ignore boiling point*	2	2 / 3.1.3c	E
3(d)	*reactivity increases down group* *outer electron is further from nucleus* *less attraction between outer electron and nucleus* *therefore outer electron lost more easily*	*allow converse throughout* *for next three marks, outer electron needs to be mentioned once otherwise max = **2*** *allow more energy levels / shells* *allow larger atoms* *allow more shielding*	1 1 1 1	1 / 3.1.3b/h	E
Total			**9**		

4.4.1.2 The reactivity series

Answer 28 · Mark scheme

June 2014 | CH3HP | Original Q3 | Legacy



4.4.1.2 The reactivity series

Answer 29 · Mark scheme

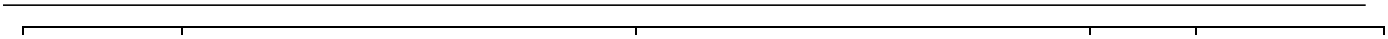
June 2015 | CH3HP | Original Q3 | Legacy

Question	Answers	Extra information	Mark	AO / Spec. Ref.
3(a)	increase		1	**AO1** 3.1.3.f
3(b)(i)	Na^+ **and** Br^-	both required	1	**AO1** 3.1.3.a/e
3(b)(ii)	sodium chloride	allow NaCl do **not** allow sodium chlorine	1	**AO2** 3.1.3.g
3(b)(iii)	chlorine is more reactive than bromine	allow converse argument allow symbols Cl, Cl_2, Br and Br_2 allow chlorine / it is more reactive. do **not** allow chloride **or** bromide	1	**AO1** 3.1.3.g
3(b)(iv)	fluorine	allow F / F_2. do **not** allow fluoride.	1	**AO2** 3.1.3.g
Total			**5**	

4.4.1.2 The reactivity series

Answer 29 · Mark scheme

June 2015 | CH3HP | Original Q3 | Legacy



4.4.1.2 The reactivity series

Answer 30 · 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

4.4.1.2 The reactivity series

Answer 30 · Mark scheme

June 2016 | CH1HP | Original Q3 | Legacy

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**	

4.4.1.2 The reactivity series

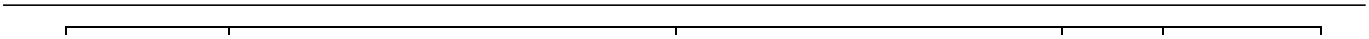
Answer 31 · Mark scheme June 2016 | CH3HP | Original Q3 | Legacy

Question	Answers	Extra information	Mark	AO / SpecRef
3(a)(i)	atomic weights	allow atomic masses	1	AO1 3.1.1a
3(a)(ii)	proton	allow proton number	1	AO1 3.1.2a
3(b)(i)	F/fluorine	allow F_2	1	AO3 3.1.3a,b,f
3(b)(ii)	any **one** from: • copper has a higher density • copper is stronger • copper is harder • copper is less reactive	allow converse for potassium allow named property ignore colour, conductivity, melting point and boiling point	1	AO1 3.1.3c
3(b)(iii)	relative distance from nucleus relative attraction to nucleus relative ease of gain or loss of electron opposite explanation of ease of gain or loss of electron for other group	max 3 marks if 'outer' not mentioned allow more / fewer energy levels / shells or larger / smaller atom allow more / less shielding	1 1 1 1	2AO1 / 1AO2 / 1AO3 3.1.3b,f,h
Total			**8**	

4.4.1.2 The reactivity series

Answer 31 · Mark scheme

June 2016 | CH3HP | Original Q3 | Legacy



4.4.1.2 The reactivity series

Answer 32 · Mark scheme

June 2018 | 8462/1H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	all 4 metals labelled and suitable scale on *y*-axis	magnesium value must be at least half the height of the grid	1	AO2 4.4.1.2 4.5.1.1
	all bars correctly plotted	allow a tolerance of ± ½ a small square ignore width and spacing of bars allow **1** mark if copper not included and other 3 bars plotted correctly	1	
05.2		ignore because it is exothermic ignore references to copper		AO3 4.5.1.1
	temperature increases	allow (because) energy / 'heat' is transferred to the surroundings allow energy / 'heat' is given out	1	
	or			
	temperature does not decrease	allow energy / 'heat' is not taken in (from the surroundings) allow the energy of the products is less than the energy of the reactants		

4.4.1.2 The reactivity series

Answer 32 · Mark scheme

June 2018 | 8462/1H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	suitable method described		1	AO3 4.4.1.2 4.5.1.1
	the observations / measurements required to place in order	dependent on a suitable method	1	
	an indication of how results would be used to place the unknown metal in the reactivity series		1	
	a control variable to give a valid result		1	
	approaches that could be used **approach 1:** add the unknown metal to copper sulfate solution (1) measure temperature change (1) place the metals in order of temperature change (1) any **one** from (1): • same volume of solution • same concentration of solution • same mass / moles of metal • same state of division of metal **approach 2:** add the metal to salt solutions of the other metals **or** heat the metal with oxides of the other metals (1) measure temperature change (only if salt solutions used) **or** observe whether a chemical change occurs (1) place the metals in order of temperature change **or** compare whether there is a reaction to place in correct order (1) any **one** from (1): • same volume of salt solutions • same concentration of salt solutions • same (initial) temperature of salt solutions • same mass / moles of metal **or** metal oxide • same state of division of metal **or** metal oxide			

4.4.1.2 The reactivity series

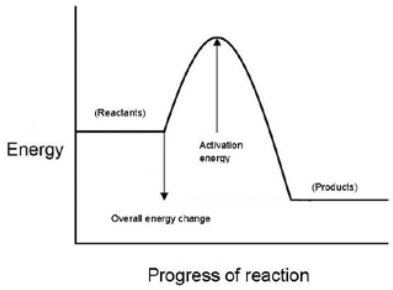
Answer 32 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3 cont.	**approach 3:** add all of the metals to an acid (1) measure temperature change or means of comparing rate of reaction (1) place the metals in order of temperature change or rate of reaction (1) any **one** from (1): • same volume of acid • same concentration of acid • same (initial) temperature of acid • same mass / moles of metal • same state of division of metal **approach 4:** set up electrochemical cells with the unknown metal as one electrode and each of the other metals as the other electrode (1) measure the voltage of the cell (1) place the metals in order of voltage (1) any **one** from (1): • same electrolyte • same concentration of electrolyte • same temperature of electrolyte			

4.4.1.2 The reactivity series

Answer 32 · Mark scheme

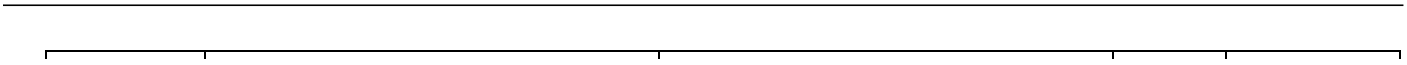
June 2018 | 8462/1H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4		an answer of:  scores **3** marks		AO1 4.5.1.2
	correct shape for exothermic reaction	the reactant and product lines needed not be labelled do **not** accept incorrectly labelled reactant and product lines	1	
	labelled activation energy		1	
	labelled (overall) energy change	ignore arrow heads	1	
Total			**10**	

4.4.1.2 The reactivity series

Answer 32 · Mark scheme

June 2018 | 8462/1H | Original Q5



4.4.1.2 The reactivity series

Answer 33 · 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

4.4.1.2 The reactivity series

Answer 33 · 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

Answer 33 · Mark scheme

June 2018 | 8462/1H | Original Q8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.7		an incorrect answer for one step does **not** prevent allocation of marks for subsequent steps		AO2 4.3.1.2 4.3.2.1 4.3.2.2 4.3.2.4
	(M_r of $TiCl_4$ =) 190		1	
	(moles Na) = $\frac{20\,000}{23}$ =) 870 (mol	allow **1** mark for 0.870 mol Na **and** 0.211 mol $TiCl_4$	1	
	$\left(\text{moles } TiCl_4 = \frac{40\,000}{190} =\right)$ 211 (mol)	allow use of incorrectly calculated M_r from step 1	1	
	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	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	

4.4.1.2 The reactivity series

Answer 33 · Mark scheme

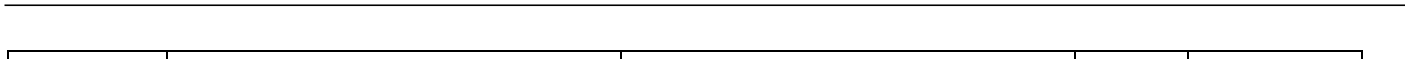
June 2018 | 8462/1H | Original Q8

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**	

4.4.1.2 The reactivity series

Answer 33 · Mark scheme

June 2018 | 8462/1H | Original Q8



4.4.1.2 The reactivity series

Answer 34 · Mark scheme

June 2019 | 8462/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	any **two** from: • temperature (of solution) • concentration of electrolyte / solution • compound / ions in electrolyte / solution	ignore room temperature allow volume of electrolyte / solution allow size of electrode allow distance between electrodes do **not** accept electrode **X** unqualified do **not** accept (measured) voltage	2	AO3 4.5.2.1
06.2	order: (most reactive) magnesium cobalt nickel tin copper (least reactive) silver justification: the higher the (positive) voltage, the more reactive (the metal) silver has a negative voltage because silver is less reactive than copper	allow **1** mark for magnesium, cobalt, nickel, tin in order at top allow **1** mark for copper and silver in order at the bottom allow the most reactive (metal) has the highest voltage	2 1 1	AO3 4.4.1.2 4.5.2.1
06.3	magnesium and tin		1	AO3 4.5.2.1

4.4.1.2 The reactivity series

Answer 34 · Mark scheme

June 2019 | 8462/1H | Original Q6

06.4	(in a fuel cell) hydrogen is oxidised (to produce water) water is produced / released as gas / vapour / steam	allow (in a fuel cell) hydrogen reacts with oxygen (to produce water) if no other mark awarded, allow **1** mark for fuel cells produce water	1 1	AO3 4.5.2.2
Total			**9**	

4.4.1.2 The reactivity series

Answer 35 · 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		1	AO1 4.1.3.1 4.1.3.2
	they have high melting points		1	
02.2	the (grey) crystals are silver		1	AO3 4.4.1.2
	the copper ions (produced) are blue	allow the copper nitrate / compound (produced) is blue	1	
	(because) copper displaces silver		1	

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)		

4.4.1.2 The reactivity series

Answer 35 · 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** $\frac{6090 + 14\,350}{100}$ = 204.4	 ignore units	1 1	AO2 4.1.1.6
Total			**11**	

4.4.1.2 The reactivity series

Answer 36 · 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	

Answer 36 · Mark scheme

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**	

4.4.1.2 The reactivity series

Answer 37 · Mark scheme

November 2020 | 8462/1H | Original Q8

Question 8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.1	liquid gas		1	AO2 4.2.2.1
08.2	(boiling point) increases (down the table / group) (because) the relative formula / molecular mass increases **or** (because) the size of the molecule increases (so) the intermolecular forces increase (in strength) (so) more energy is needed to overcome the intermolecular forces	 allow (so) the forces between molecules increase (in strength) allow (so) more energy is needed to separate the molecules do **not** accept a reference to breaking bonds unless specifically between molecules	1 1 1 1	AO1 4.1.2.6 4.2.2.1 4.2.2.4
08.3	boiling point is a bulk property	allow boiling point is related to intermolecular forces (so more than one molecule is involved)	1	AO1 4.2.2.1
08.4	the gas / halogen is toxic	allow the gas / halogen is poisonous / harmful allow to prevent inhalation of the gas / halogen ignore deadly / lethal	1	AO3 4.1.2.6

4.4.1.2 The reactivity series

Question 8 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
08.5		allow energy level for shell throughout		AO1 4.1.2.6
	(going down the group) the outer electrons / shell become further from the nucleus	allow the atoms become larger allow the number of shells increases ignore the number of outer shells increases	1	
	(so) the nucleus has less attraction for the outer electrons / shell	allow (so) the nucleus has less attraction for the incoming electron allow (so) increased shielding between the nucleus and the outer electrons / shell allow (so) increased shielding between the nucleus and the incoming electron	1	
	(so) an electron is gained less easily		1	

Question 8 continued

08.6	4.48 (g iron) **and** 8.52 (g chlorine) (moles Fe = $\frac{4.48}{56}$ =) 0.08 (moles Cl = $\frac{8.52}{35.5}$ =) 0.24 (Fe : Cl = 0.08 : 0.24 =) 1 : 3 $2\ Fe + 3\ Cl_2 \rightarrow 2\ FeCl_3$	 allow correct calculation using incorrectly calculated mass of iron allow correct calculation using incorrectly calculated mass of chlorine allow (moles Cl_2 = $\frac{8.52}{71}$ =) 0.12 allow correct calculation using incorrectly calculated moles of iron and / or chlorine allow multiples / fractions allow a correctly balanced equation including Fe and Cl_2 from an incorrect ratio of Fe : Cl allow **1** mark for Fe **and** Cl_2 (reactants) **and** $FeCl_3$ (product) **or** allow **1** mark for Fe **and** Cl_2 (reactants) **and** a formula for iron chloride correctly derived from an incorrect ratio of Fe : Cl (product)	1 1 1 1 2	AO2 4.1.1.1 4.1.2.6 4.3.2.3

Total			**16**

4.4.1.2 The reactivity series

Answer 38 · Mark scheme

November 2021 | 8462/1H | Original Q4

Question 4

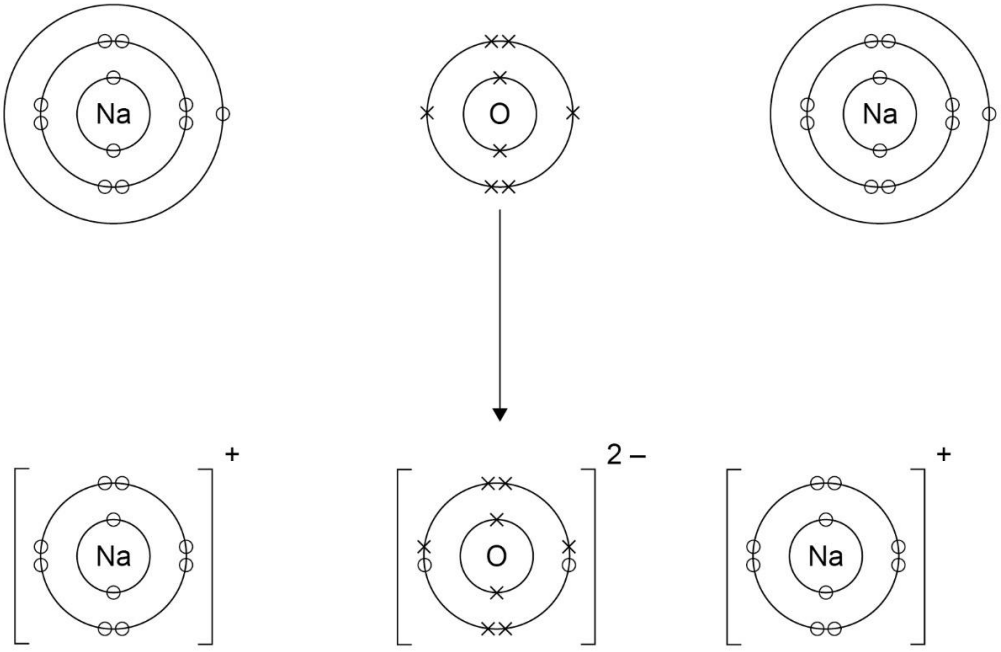
Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	any **two** from: • (potassium) floats • (potassium) melts • (potassium) moves around • potassium becomes smaller • (lilac) flame • effervescence	 allow potassium disappears allow fizzing	2	AO1 4.1.2.5 4.4.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	$2K + 2H_2O \rightarrow 2KOH + H_2$	allow multiples allow **1** mark for KOH **and** H_2	2	AO1 AO2 4.1.1.1 4.1.2.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	reactivity increases (going down the group) (because) the outer electron / shell is further from the nucleus (so) there is less attraction between the nucleus and the outer electron / shell (so) the atom loses an electron more easily	 allow (because) there are more shells allow (because) the atoms get larger allow (so) there is more shielding from the nucleus do **not** accept incorrect attractions	1 1 1 1	AO1 4.1.2.5 4.4.1.2

Answer 38 · Mark scheme

Question 4 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	(dot and cross diagram to show) sodium atom **and** oxygen atom	allow use of outer shells only	1	AO2 4.2.1.1 4.2.1.2
	two sodium atoms to one oxygen atom	allow two sodium ions to one oxide ion	1	
	(to produce) sodium ion with a + charge		1	
	(to produce) oxide ion with a 2– charge		1	
	 scores **4** marks			

Question 4 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5	(oxygen) gains electrons		1	AO1 4.4.1.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.6	giant structure	allow (giant ionic) lattice	1	AO1 4.2.1.3 4.2.2.1
	(with) strong (electrostatic) forces of attraction between (oppositely charged) ions		1	4.2.2.3
	(so) large amounts of energy are needed to break the bonds / forces	allow (so) large amounts of energy are needed to separate the ions	1	

Total			**16**

4.4.1.2 The reactivity series

Answer 39 · Mark scheme

November 2021 | 8462/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	C		1	AO3 4.2.2.7 4.2.2.8

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.2	(in an alloy) the atoms are of different sizes		1	AO1 4.2.2.7
	(so) the layers (of atoms in an alloy) are distorted		1	
	(so in an alloy) the layers slide over each other less easily (than in a pure metal)		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3	measure temperature change	allow measure the temperature before **and** after the reaction	1	AO1
	when each metal is added to silver nitrate solution		1	AO1
	same concentration / volume of solution **or** same mass / moles of metal	allow same initial temperature (of silver nitrate solution)	1	AO2
	the greater the temperature change the more reactive		1	AO3 4.4.1.2 4.5.1.1 RPA4

Total			8

Answer 40 · Mark scheme

November 2021 | 8462/2H | Original Q9

Question 9

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.1	(delivery) tube is in (sulfuric) acid		1	AO3 4.6.1.2 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.2	reaction has stopped (because a) reactant is used up	allow no more gas produced allow named reactants	1 1	AO2 4.6.1.1 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.3	any **one** from: • the line (for 0.05 mol/dm^3 sulfuric acid) is less steep • (0.05 mol/dm^3 sulfuric acid) produces less gas in a fixed time • the reaction (using 0.05 mol/dm^3 sulfuric acid) takes longer to finish	allow converse statements about 0.10 mol/dm^3 sulfuric acid ignore produces less gas do **not** accept produces less gas in total	1	AO1 4.6.1.1 RPA5

Question 9 continued

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.4	tangent drawn at 80 s on 0.05 mol/dm^3 curve (from tangent) value for *x*-step **and** value for *y*-step (rate =) $\frac{\text{value for } y\text{-step}}{\text{value for } x\text{-step}}$ calculation of rate answer to 2 significant figures	 allow a tolerance of ± ½ a small square allow correct use of incorrectly determined values from tangent for *x*-step and/or *y*-step allow an answer correctly calculated to 2 significant figures from an incorrect calculation of rate	1 1 1 1 1	AO2 4.6.1.1 RPA5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.5	Cu^{2+}		1	AO2 4.1.3.2 4.6.1.4

Total			10

4.4.1.2 The reactivity series

Answer 41 · 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

4.4.1.2 The reactivity series

Answer 41 · 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		

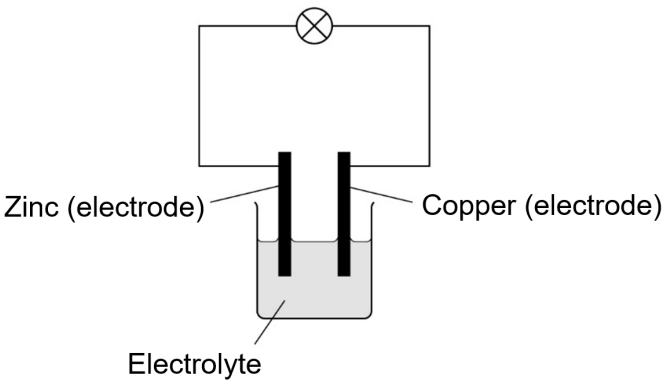
Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5	$Zn + Cu^{2+} \rightarrow Zn^{2+} + Cu$	ignore state symbols	1	AO2 4.4.1.2 4.4.1.4

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

4.4.1.2 The reactivity series

Answer 41 · 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

4.4.1.2 The reactivity series

Answer 42 · Mark scheme

June 2022 | 8462/1H | Original Q5

Question 5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.1	any **one** from: • more vigorous bubbling (for rubidium) • bigger / brighter flame (for rubidium)	allow converse statements for potassium allow (rubidium) catches fire more quickly allow (rubidium) moves around more quickly allow (rubidium) explodes allow (rubidium) disappears more quickly allow (rubidium) melts more quickly	1	AO3 4.1.2.5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.2		allow energy level for shell throughout allow converse argument in terms of potassium		AO1 4.1.2.5 4.4.1.2
	(rubidium's) outer shell / electron is further from the nucleus	allow the (rubidium) atom is larger allow (rubidium) has more shells	1	
	(so) there is less (electrostatic) attraction between the nucleus and the outer electron (in rubidium)	allow (so) there is more shielding between the outer electron and the nucleus (in rubidium)	1	
	(so) the (outer) electron (in rubidium) is more easily lost	allow (so) less energy is needed to remove the (outer) electron (in rubidium)	1	

4.4.1.2 The reactivity series

Answer 42 · Mark scheme

June 2022 | 8462/1H | Original Q5

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.3	$2\ Rb + 2\ H_2O \rightarrow 2\ RbOH + H_2$	ignore state symbols allow multiples allow **1** mark for H_2 allow **1** mark for RbOH	3	AO2 4.1.1.1 4.1.2.5 4.3.1.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.4	the noble gases have boiling points that increase going down the group		1	AO1 4.1.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
05.5	(relative atomic mass =) $\frac{(90.48 \times 20)+(0.27 \times 21)+(9.25 \times 22)}{100}$ = 20.1877 = 20.2	allow (relative atomic mass =) $\frac{1809.6 + 5.67 + 203.5}{100}$ allow (relative atomic mass =) 18.096 + 0.0567 + 2.035 allow an answer correctly rounded to 3 significant figures from an incorrect calculation which uses all of the values in **Table 1** ignore units	1 1 1	AO2 4.1.1.6

Total Question 5		11

4.4.1.2 The reactivity series

Answer 43 · 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	ignore references to hydrogen allow converse allow silicon is below carbon (in the reactivity series)	1	AO3 4.4.1.3
	(because) carbon displaces silicon (from silicon dioxide)	ignore (because) carbon reduces silicon dioxide	1	

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

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

4.4.1.2 The reactivity series

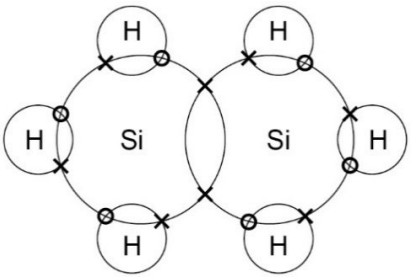
Answer 43 · Mark scheme

June 2022 | 8462/1H | Original Q7

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)			

4.4.1.2 The reactivity series

Answer 43 · Mark scheme

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

4.4.1.2 The reactivity series

Answer 43 · 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

4.4.1.2 The reactivity series

Answer 44 · 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 44 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
09.6	(percentage atom economy =) $\frac{A_rX}{A_rX + 54} \times 100 = 77.3$		1	AO2 4.3.3.2
	100 A_r**X** = 77.3 (A_r**X** + 54)	allow A_r**X** = 0.773 (A_r**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**X** = 4174.2	allow 0.227 A_r**X** = 41.742	1	
	A_r**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**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		

Answer 44 · Mark scheme

	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**

4.4.1.2 The reactivity series

Answer 45 · Mark scheme

June 2024 | 8462/1H | Original Q2

Question 2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.1	(similarity) both have one outer (shell) electron	allow energy level for shell allow same number of outer (shell) electrons	1	AO1 4.1.2.1
	(difference) sodium has 3 shells but potassium has 4 shells	allow potassium has more shells allow (different) number of shells	1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.2	any **two** from: • effervescence / bubbles / fizzing • (potassium) floats • (potassium) moves around • (potassium) becomes smaller • (potassium) melts • flame • explosion	ignore gas produced allow (potassium) forms a ball ignore colour of flame	2	AO1 4.1.2.5 4.4.1.2

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.3	blue / violet / purple		1	AO2
	(the solution is) alkaline	allow (the solution) contains OH^- (ions) allow (the solution) contains hydroxide ions allow the solution is basic	1	AO1 4.1.2.5 4.4.2.4

4.4.1.2 The reactivity series

Answer 45 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.4	all five points correctly plotted	allow a tolerance of ± ½ a small square allow **1** mark for three or four points correctly plotted	2	AO2 4.1.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.5	3.4 (mg/cm^3)	allow a value in the range 3.0 to 3.8 (mg/cm^3)	1	AO3 4.1.2.4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.6	chlorine and potassium bromide		1	AO2 4.1.2.6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
02.7	relative molecular mass increases and boiling point increases		1	AO1 4.1.2.6

Total Question 2	**11**

4.4.1.2 The reactivity series

Answer 46 · Mark scheme

June 2024 | 8462/1H | Original Q6

Question 6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.1	(most reactive) Mg Zn Ni Cu Ag (least reactive)	allow name of metal for symbol allow **1** mark for (most reactive) Mg Zn Ni **or** Ni Cu Ag (least reactive)	2	AO3 4.4.1.2 4.5.2.1
	(justification) the higher the (positive) voltage the more reactive the metal	allow the most reactive (metal) has the highest (positive) voltage allow the least reactive (metal) has the most negative voltage allow the greater the difference in reactivity the greater the (magnitude of the) voltage	1	

4.4.1.2 The reactivity series

Answer 46 · Mark scheme

June 2024 | 8462/1H | Original Q6

Question	Answers	Mark	AO / Spec. Ref.
06.2	**Level 3:** The method would lead to the production of a valid outcome. The key steps are identified and logically sequenced.	5–6	AO3 4.3.4 4.5.2.1
	Level 2: The method would not necessarily lead to a valid outcome. Most steps are identified, but the method is not fully logically sequenced.	3–4	
	Level 1: The method would not lead to a valid outcome. Some relevant steps are identified, but links are not made clear.	1–2	
	No relevant content	0	
	Indicative content • **set up cell with sodium chloride solution as the electrolyte** • **use two different metals as electrodes** • **measure voltage** • **repeat at different concentrations of electrolyte solution** • **by diluting the sodium chloride solution with water** • using measured volumes of sodium chloride solution and water • measure volumes with a measuring cylinder (allow pipette / burette) • use the same two metals each time • use the same volume of electrolyte solution		

Question	Answers	Extra information	Mark	AO / Spec. Ref.
06.3		ignore references to electrodes		AO1 4.5.2.2
	hydrogen is oxidised (electrochemically)	allow hydrogen loses electrons	1	
	to produce water		1	

Total Question 6	11

4.4.1.2 The reactivity series

Answer 47 · Mark scheme

June 2025 | 8462/1H | Original Q4

Question 4

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.1	–34 °C	allow a value in the range –70 to –20 °C	1	AO3 4.1.2.6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.2	solid	allow (s)	1	AO3 4.1.2.6 4.2.2.1

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.3	7		1	AO1 4.1.2.1 4.1.2.6

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.4	HAt		1	AO2 4.1.2.1 4.1.2.6

Answer 47 · Mark scheme

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.5		allow energy level for shell		
	reactivity decreases (going down the group)		1	AO1 4.1.2.6
	(because) the outer shell / electrons become further from the nucleus	allow (because) the atoms become larger allow (because) the atoms have more shells	1	
	(so) there is less (electrostatic) attraction between the nucleus and the outer electron(s)	allow (so) there is more shielding between the outer electron(s) and the nucleus	1	
	(so) gaining an electron is more difficult		1	

Question	Answers	Extra information	Mark	AO / Spec. Ref.
04.6	$Br_2 + 2KI \longrightarrow I_2 + 2KBr$	allow multiples allow **1** mark for Br_2 **and** I_2 allow **1** mark for KI **and** KBr ignore state symbols	3	AO2 4.1.1.1 4.1.2.6

Total Question 4	11

Answer 32 · Examiner comments

June 2018 | 8462/1H | Original Q5

Question 5 (standard and standard / high demand)

05.1 This question was done very well, with 94 % of students achieving both marks. The few that did not score both marks usually omitted to label their bars.

05.2 This question was very well answered, with 77% of students achieving both marks. The most common error was suggesting that the reactions were not endothermic because the copper experiment did not increase in temperature. This seems to suggest an unclear understanding of exothermic and endothermic reactions. Other common errors were in the use of language, such as the 'heat increases' (for temperature), or 'temperature is given out'.

05.3 It was expected that students would simply repeat the same experiment with the unknown metal, giving details of variables to be controlled in order to produce valid results. However, many students decided to go down a different track, and full marks could be achieved from methods involving:

- adding all of the five metals to an acid
- adding the unknown metal to salt solutions of the other four
- measuring either the temperature change or some measure of the rate of reaction
- heating the unknown metal with oxides of the other four
- using the unknown metal as one electrode in a series of electrochemical cells and measuring the voltage produced.

8% of students achieved full marks, and 53% achieved two or more.

The most common missed mark was for the control variable. Though some realised that a control variable was necessary, use of the ubiquitous 'amount' was all too frequently seen and did not gain credit.

The method involving displacement reactions was very common but not very successful, with vague references to adding the metal to unspecified solutions, or to metal oxides without heating, or to other metals. Some students wanted to add the metals to water, without recognising that these four metals would not react with water, so they would only be able to place the unknown if it were the most reactive. Other students placed the metal in relation to carbon or hydrogen rather than to the other four metals as required by the question.

There was some confusion between making results valid (by using control variables to give a fair test) as opposed to accurate (by cutting down energy exchange with the surroundings), which did not gain credit.

4.4.1.2 The reactivity series

Answer 32 · Examiner comments

June 2018 | 8462/1H | Original Q5

05.4 Many excellent answers were seen, although there were some very sloppy diagrams. 54% of students achieved two or three marks.

- A significant number had drawn an endothermic curve, but then went on to label it correctly so were able to access two of the three available marks.
- A small number drew the correct curve, but then did not put on the labels.
- Some labelled reactant and product lines incorrectly as start and end temperature.
- Some attempted labels by, for example, drawing a line / arrow from the right to point at the top of the curve and labelling it incorrectly as activation energy.

Answer 33 · 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.

4.4.1.2 The reactivity series

Answer 33 · 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.

4.4.1.2 The reactivity series

Answer 34 · Examiner comments

June 2019 | 8462/1H | Original Q6

Question 6 (standard and standard / high demand)

06.1 Students found this question difficult and were quite often imprecise in their description of the control variables. The use of the word amount is unlikely to gain credit and students should be encouraged to use scientific terminology such as ‘volume’.

The most common control variables given were volume of solution and concentration of solution.

Common responses seen that were not credited included:

- amount of solution
- the electrolyte
- the copper electrode.

06.2 Most students scored the 2 marks for the order of reactivity of the top four metals and the justification for this order.

The most common error was then to put silver above copper in the order of reactivity.

However, only a small proportion of students were able to explain the negative voltage for silver in terms of its reactivity compared with copper.

06.3 Approximately half of students correctly identified ‘magnesium and tin’ as the pair of metals to produce the greatest voltage.

‘Magnesium and cobalt’ was a strong distractor, presumably because it also contained the most reactive metal.

4.4.1.2 The reactivity series

Answer 34 · Examiner comments June 2019 | 8462/1H | Original Q6

06.4 Only a small proportion of students scored both marks. The mark for describing the reaction that produces water in a hydrogen fuel cell was the least frequently scored.

Often, students gained the compensation mark for the idea that hydrogen fuel cells produce water.

However a significant number of students gave incomplete responses indicating that hydrogen fuel cells produce steam (with no reference to water).

Some common misconceptions seen were:

- Hydrogen fuel cells release hydrogen gas.
- Hydrogen burns in a hydrogen fuel cell.

Answer 35 · 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 36 · 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 37 · Examiner comments

November 2020 | 8462/1H | Original Q8

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

08.1 The majority scored the mark, but many thought bromine is a solid at 0 ºC.

08.2 This question was not well answered. Most students stated that the boiling point increased going down the group, although some were evidently confused by the negative values in the table and stated the opposite trend. However, many students then confused boiling point with reactivity and tried to explain the trend using forces within the atom rather than forces between molecules. Students should refer to intermolecular forces rather than intermolecular bonds, to avoid any confusion about which 'bonds' they are referring to in terms of breaking them to make the substance change state.

08.3 This was very poorly answered. The idea of a bulk property was very rarely seen. There was considerable confusion between the terms atom and molecule, with many stating that bromine was diatomic so there are always two molecules. The best answers referred to the fact that boiling point relates to intermolecular forces, which cannot exist if there is only one molecule.

08.4 Many students realised that the fume cupboard would prevent inhalation of the gas, which is toxic. However, some students regard a fume cupboard as insulation to prevent the escape of heat energy, or thought it was to trap and retain the gas.

08.5 Most students knew and were able to express, that the atoms get larger going down the group. Some, however, referred incorrectly to the number of outer shells increasing. Fewer were able to express that there was a reducing attraction between the nucleus and the outer electrons or the incoming electron, with many vague references to shielding without mentioning the nucleus or the relevant electrons. Even fewer were able to express the increase in difficulty of gaining (rather than merely attracting) an electron.

Answer 37 · Examiner comments

November 2020 | 8462/1H | Original Q8

08.6 Very few students scored full marks. Most students were able to calculate the mass of iron, but some calculated the mass of iron chloride instead of chlorine. They sometimes then assumed a formula of iron chloride and tried to work backwards. Of those who did calculate the masses of both iron and chlorine, most were then able to calculate the number of moles of each, but many then failed to find the simplest ratio as 1:3, instead leaving it as 0.08:0.24. Some calculated the number of moles of chlorine molecules instead of atoms; these students almost always failed to multiply by 2 to obtain the number of moles of atoms, giving a ratio of 2:3 instead of 1:3. Very few were then able to give a balanced equation; most did not use their ratio to give the formula of iron chloride as $FeCl_3$. It was rare to see the formula of chlorine written correctly as Cl_2, and iron was sometimes seen as Fe_2.

Answer 38 · Examiner comments

November 2021 | 8462/1H | Original Q4

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

04.1 Many students remembered that effervescence would be seen, but there were many vague descriptions such as ‘vigorous reaction’ which did not gain credit. Students often gave the same observation twice, eg, ‘effervescence’ and ‘bubbles’. Many students incorrectly mentioned a colour change, perhaps remembering a demonstration where an indicator had been added. Very few mentioned the potassium melting.

04.2 Very few students could write the formulae for the correct products. Those who could were usually able to balance the equation. Many students approached the question from the wrong direction, trying to balance the equation by inventing fictitious products.

04.3 This was not well answered, with only a small number of students scoring full marks. Many incorrectly tried to link reactivity to melting and boiling point. Many referred to the distance and / or attraction between the nucleus and electrons in general, rather than the outer electrons. Others failed to mention the nucleus at all.

04.4 The electron arrangements of both atoms and ions were required for full marks, as well as the ratio of sodium ions to oxide ions and the correct charges on the ions. Few students scored all the marks as they did not draw the atoms of sodium and oxygen before reaction. Many tried to draw covalent structures. The ratio of 2 atoms of sodium to one of oxygen was well known. Students should be aware that electrons cannot be in two places at the same time and should not be drawn as if they are. Some students drew both ionic and covalent structures, thereby contradicting themselves and losing the marks for a correct ionic structure. A great deal of time and effort would be saved by drawing the outer electrons only, as in the specification.

04.6 Students found this question very difficult, with many referring incorrectly to intermolecular forces, even when mentioning ions. Many also referred to covalent bonds or forces between atoms. Of those who did refer correctly to the large amounts of energy required to break the strong attractions between ions, very few referred to the giant structure of the compound.

4.4.1.2 The reactivity series

Answer 39 · Examiner comments November 2021 | 8462/1H | Original Q6

Question 6 (standard and standard / high demand)

06.2 This was poorly answered, with many instances of incorrect use of scientific terms. Some referred to molecules instead of atoms, different shapes instead of different sizes, and rows instead of layers. Many did not refer to the layers in a metal at all, merely referring to atoms, or a vague 'they' not being able to slide. Even those who did refer to layers rarely said those layers were distorted. There were many incorrect answers in terms of an incorrect type of bonding, and many thought that alloys are compounds.

06.3 Students were expected to do a simple comparison of the temperature change when each metal was added separately to silver nitrate solution. A control variable was needed for full marks to be awarded, as well as how the results would show which metal was the more reactive. Some students did not appear to know how to progress, with some trying to measure a temperature change while heating with a Bunsen burner, and some appearing to confuse reactivity with melting or boiling point. Of those students who did realise what was required, many spoiled their control variable by referring to the same 'amount' of a substance instead of volume, or concentration, or mass, as appropriate to the substance. Many students referred to temperature rather than temperature change. A few students tried to get round the fact that no other chemicals were available by making zinc nitrate and then seeing if Q would react with it. This approach could have worked but only if they had taken steps to ensure that all the silver nitrate had reacted before adding Q.

Answer 40 · Examiner comments November 2021 | 8462/2H | Original Q9

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

09.1 Only around a third of students knew this, which may reflect a lack of practical experience.

09.2 Many students were able to say that the reaction had stopped but only a much smaller number could explain why.

09.3 Around half of the students were able to explain this in a valid way, usually by reference to the slope of the line.

09.4 There was a wide spread of marks here. There is still confusion between mean and instantaneous rate of reaction, so students who approached this as a mean reaction rate usually only scored one mark for giving an answer to 2 significant figures. Amongst the better responses, the first mark was sometimes dropped because the tangent was not close enough to 80 seconds. Some students were able to obtain all 5 marks.

09.5 Around one-third of students identified copper(II) as the only transition metal amongst the choices and therefore more likely to have a catalytic effect.

4.4.1.2 The reactivity series

Answer 41 · 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 41 · 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.

4.4.1.2 The reactivity series

Answer 42 · Examiner comments

June 2022 | 8462/1H | Original Q5

Question 5 (Standard, standard/high and high demand)

05.1 Nearly half of students described how a specific observation would differ. Vague comments about a more violent reaction, with no specific visual observation, did not gain credit.

05.2 Most students scored at least two marks. They knew that rubidium would lose an electron more easily, and that it was the larger size of the atom that was responsible (often expressed as the rubidium atom having more shells). The description of the weaker attraction of the rubidium nucleus for the outer electron was less well expressed; some students omitted to say that the attraction was for the outer electron or that the attraction was between the outer electron and the nucleus. Some gave an inappropriate description of the attraction, such as intermolecular or magnetic. Some contradicted their attraction argument by saying that the outer electron in rubidium is less shielded from the nucleus, rather than more shielded.

05.3 Only about a sixth of students scored full marks. Many knew that one of the products was hydrogen, and could write its formula correctly. However, far fewer knew that RbOH was the other product. Of those who did, most managed to balance the equation correctly.

05.4 Fewer than half of students gave the correct answer. Nearly as many, though, stated that the noble gases all have eight outer shell electrons, appearing to forget about helium.

05.5 More than half of students completed the calculation successfully and rounded to the appropriate 3 significant figures. Common errors were to divide by 63 (sum of the mass numbers) or 3 (number of isotopes) rather than by 100.

Answer 43 · 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.

4.4.1.2 The reactivity series

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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 44 · 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.

4.4.1.2 The reactivity series

Answer 45 · Examiner comments

June 2024 | 8462/1H | Original Q2

Question 2 (standard demand)

02.1 This was very well answered by the majority of students, with nearly two thirds scoring both marks. Most stated that both atoms have one outer shell electron and that potassium has one more shell than sodium. Sometimes the wrong number of shells was given for the two elements; usually 2 shells for sodium and 3 for potassium. Some stated that potassium has more outer shells than sodium. This is not correct as the phrase 'outer shell' is always taken to mean the single outermost shell. Some students gave consequences of the electronic structure rather than referring to the electronic structure itself; this was not given credit. Simply stating that the number of electrons is different did not answer the question; the number of electrons is not the electronic configuration.

02.2 More than two thirds of students gave two correct observations, with bubbling and a flame being the most popular. 'Gas produced' did not gain credit as it is not an observation but a deduction from the observation of bubbling. 'Fizzing' is taken to mean effervescence, so fizzing and bubbling are the same thing rather than two different observations. Credit was not given for any observation requiring extra equipment such as a thermometer or an indicator.

02.3 Well over half of students gave a correct colour and a correct reason, either in terms of the solution being alkaline or containing hydroxide ions. Nearly three quarters of students gained one mark. Some students had evidently seen, and remembered, the experiment done with phenolphthalein in the water, and therefore stated the indicator colour to be pink even though they knew the solution to be alkaline. Some answers were not clearly expressed; 'potassium is an alkali' did not gain credit as it is the potassium hydroxide solution that is alkaline. There were

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also, however, some excellent answers in terms of the hydroxide ion produced causing the solution to be alkaline.

02.4 More than four fifths of students plotted all of their points accurately. Many also drew a line of best fit although this was not required. A few drew their points as small dots instead of crosses, making it very difficult for the examiners to see them on a scanned image. Points do need to be visible, albeit sharp.

02.5 Students could nearly always estimate the density of krypton to within the tolerance allowed. Many used a line of best fit to do so although this was not necessary. In some cases inappropriate methods were used, such as finding the mean of all the other values; this did not gain credit even if it gave a value withing the range allowed.

02.6 Three quarters of students identified the correct pair of solutions, with the spread of incorrect responses being approximately equal.

02.7 Over two thirds of students identified the correct pair of trends. Most of the incorrect responses thought that boiling point decreases down the group.

4.4.1.2 The reactivity series

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

06.1 Over three fifths of students scored all three marks. Most students could list the metals in order of decreasing reactivity, although some ignored the sign and ordered the metals in order of absolute magnitude of voltage. A few tried to remember the reactivity series, even though nickel and silver are not listed in the specification. The best answers justified the order not only in terms of the most reactive metal producing the most positive voltage, but also that the negative voltages were produced by elements less reactive than nickel.

06.2 This extended response plan of a non-required practical discriminated very well. About a third of responses reached Level 3, with more than two thirds reaching level 2.

There were some excellent descriptions of a plan which would work, including details of how the different concentrations to be tested would be made. Some students thought the pure water was to be used as a control rather than for diluting the sodium chloride solution. The top mark in Level 3 was only available if there was detail about how the voltage could be linked quantitatively to the concentration of sodium chloride. This was often poorly expressed using terms such as

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'amount' rather than 'volume,' and did not always mention both the sodium chloride solution provided and the water. The control variable 'use the same two metals each time' was essential to access a Level 3 mark, since the method must lead to a valid outcome. This was often implied in responses where a student named different metals, or stated they must be different, and then said, 'repeat using different concentrations of sodium chloride.' Many students, however, specified that all of the different metals should be used, which was completely unnecessary and possibly rendered the outcome invalid.

A common error was to use two electrodes of the same metal, or to refer simply to 'the electrodes' without specifying what type of electrodes to use. This restricted the answer to Level 2.

It was not uncommon to see reference to a power supply, which restricted the answer to Level 1; there is some confusion between an electrolytic cell and an electrochemical cell.

06.3 Only 1 in 25 students scored both marks by repeating the statement in the specification that hydrogen is oxidised electrochemically to produce water, and only a quarter of students scored one mark. There were a few excellent answers showing the half equations at both electrodes; as long as these showed hydrogen losing electrons, and water being a product, they gained full credit. Those who referred to hydrogen losing electrons in the fuel cell gained credit; however, students often thought that hydrogen ions were reacting, rather than hydrogen molecules. Other types of oxidation, such as combustion, were not accepted. Some students appear to believe that the water is produced as steam, which then drives a turbine generating electricity.

4.4.1.2 The reactivity series

Answer 47 · Examiner comments

June 2025 | 8462/1H | Original Q4

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

04.1 More than two thirds of students were able to estimate the boiling point from the bar chart. A generous range was allowed, from -70 °C to -20 °C. A surprising number of students gave 0 °C or a positive value.

04.2 Three quarters of students were able to use the bar chart to deduce that -250 °C is below fluorine's melting point, so fluorine must be a solid at that temperature. Many stated fluorine to be a gas at that temperature, preferring to rely on what they 'knew' about fluorine than to analyse the data.

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04.3 Nearly all students gave the correct answer. Some produced an answer of 3, perhaps by trying to work out the detailed electronic configuration instead of simply looking at the group number.

04.4 Fewer than three fifths gave a correct answer. Students were expected to give the formula HAt by analogy with HCl. AtH was also accepted. However, there were many instances of H_2At, HAt_2, H_2At_2 or 2HAt. Some students tried to write an equation, which is never an appropriate response when asked for a formula and did not gain credit.

04.5 This question discriminated well, with nearly all students gaining at least one mark but only one in seven scoring all four. Precise use of language was required. Most students were able to state that reactivity decreases going down Group 7. Many were also able to state that gaining an electron became more difficult going down the group, although some referred incorrectly to likelihood rather than difficulty. Far fewer students were awarded the other two marks. Many said 'they' or 'the elements' become larger or 'they' or 'the elements' have more shells rather than specifically referring to the atom. Others stated that electrons, rather than outer shell electrons, become further from the nucleus. Some stated incorrectly that atoms have more outer shells. All atoms have one outer shell. Many students referred to the attraction between the nucleus and the outer shell, rather than between the nucleus and the electrons in the outer shell. Some incorrectly described this attraction as intermolecular or gravitational. Those who tried to refer to shielding usually found difficulty in expressing the idea correctly. Some brought in trends in melting and boiling points, which were not relevant.

04.6 This question also discriminated well, with nearly two thirds of students gaining at least one mark and one third gaining all three. Most students who could write the correct formulae could also balance the equation. However, there were many incorrect formulae, with errors such as Br instead of Br_2, KI_2 instead of KI, and even interhalogen compounds as products such as BrI. Compensation marks were available for those who could write the correct formulae for the two halogens and / or the correct formulae for the two potassium halides. There was no credit for balancing incorrect formulae.