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International Education

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CHEMISTRY **0620/43**

Paper 4 Theory (Extended) **May/June 2026**

MARK SCHEME

Maximum Mark: 80

Published

This mark scheme contains the instructions and marking guidance that our examiners used to mark candidate responses for this component.

Before they start marking, examiners complete a standardisation process. They review a range of candidate responses and discuss the mark scheme in detail to agree which answers can and cannot be accepted. Examiners award marks where it is clear that candidate responses have met the requirements of the mark scheme. These requirements may vary between different components or different versions of the same component, depending on the exact requirements of the question and the candidate responses seen during the standardisation process.

Sometimes, our mark schemes may allow marks to be awarded to responses which contain elements that are factually incorrect or for content not covered by the syllabus. We do this in response to the demands of a specific question to support candidates and make sure that our assessments are fair. However, these allowances should not be used as a guide for teaching and learning.

We cannot discuss the mark scheme with schools, and we recommend that schools read the mark scheme together with the assessment material and the Principal Examiner Report for Teachers.

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General marking principles

All examiners must apply these marking principles when marking candidate responses.

1	Examiners must award marks for each response in line with: • the specific **content** defined in the mark scheme • the specific **skills** defined in the mark scheme or in the level descriptions • the **standard of response** required as exemplified by the standardisation scripts.
2	Examiners must award **whole marks** (not half marks, or other fractions).
3	Examiners must award marks **positively**. This means that: • marks are not deducted for errors or omissions • marks are awarded for correct/valid answers as defined in the mark scheme and also for **other valid answers** which go beyond the scope of the syllabus and mark scheme referring to your team leader as appropriate • the quality of spelling, punctuation and grammar are judged **only** when the mark scheme indicates that these features are **specifically assessed** in the question. However, the meaning of all responses must be unambiguous.
4	Examiners must **consistently** apply the requirements of the mark scheme and any rules for what to do when candidates have not followed instructions correctly.
5	Examiners must use the **full range of marks** defined in the mark scheme, unless limited by the quality of the candidate responses seen.
6	Examiners must award marks according to the mark scheme and **must not** award marks with grade thresholds or grade descriptions in mind.

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Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	'List rule' guidance For questions that require ***n*** responses (e.g. State **two** reasons …): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked *ignore* in the mark scheme should not count towards ***n***. • Incorrect responses should not be awarded credit but will still count towards ***n***. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

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6 Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

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Annotations guidance for centres

Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

Annotations

Annotation	Meaning
A	information missing or insufficient for credit
BOD	benefit of doubt given
CON	contradiction in response, mark not awarded
	incorrect point or mark not awarded
	key point attempted / working towards marking point / incomplete answer / response seen but not credited / blank page seen
ECF	error carried forward applied
I	incorrect or insufficient response, mark not awarded
NAQ	response has not answered question
NBOD	benefit of doubt was considered, but the response was decided to not be sufficiently close for benefit of doubt to be applied
R	incorrect point or mark not awarded
SEEN	blank page seen

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Annotation	Meaning
✓	correct point of mark awarded

Mark Scheme Abbreviations:	
;	separates marking points
/	alternative responses for the same marking point
R	reject the response
A	allow/accept the response
I	ignore the response
CON	contradiction in response, no mark
ecf	error carried forward
ora	or reverse argument
AW	alternative wording
underline or **bold**	actual word given must be used by candidate (grammatical variants excepted)
( )	the word / phrase in brackets is not required but sets the context
max	indicates the maximum number of marks that can be given
MP / M	marking point

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Question	Answer	Marks	Guidance
			For equations throughout: unless stated otherwise, **A** multiples **I** state symbols
			1(a) to **(g)** **A** equations instead of letters but letter takes precedence **I** errors in equations as long as it is clear which equation the candidate is referring to.
1(a)	G	**1**	**A** $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$
1(b)	A	**1**	**A** $CH_2{=}CH_2 + H_2 \rightarrow C_2H_6$ **A** F **A** nitrogen + hydrogen → ammonia
1(c)	A	**1**	**A** $CH_2{=}CH_2 + H_2 \rightarrow C_2H_6$
1(d)	E	**1**	**A** carbon dioxide + water → glucose + oxygen
1(e)	F	**1**	**A** nitrogen + hydrogen → ammonia
1(f)	B	**1**	**A** ethane + chlorine → chloroethane + hydrogen chloride
1(g)	H	**1**	**A** $2C_8H_{18} + 17O_2 \rightarrow 16CO + 18H_2O$

Question	Answer	Marks	Guidance
			R incorrect names / incorrect formulas for 2a
2(a)(i)	oxygen / O	**1**	**A** O_2
2(a)(ii)	potassium / K	**1**	
2(a)(iii)	chromium / Cr	**1**	**I** chrome
2(a)(iv)	carbon / C	**1**	**I** graphite

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Question	Answer	Marks	Guidance
2(a)(v)	carbon / C	1	**R** graphite
2(a)(vi)	silver / Ag **OR** lead / Pb	1	**A** mercury / Hg **A** Ag^+ / Pb^{2+} / Hg^+ / Hg_2^{2+} **A** silver chloride / lead(II) chloride / mercury(I) chloride **A** $AgCl$ / $PbCl_2$ / Hg_2Cl_2 / $HgCl$ **A** correct ionic equations **A** names of elements or symbols of elements with correct oxidation states e.g. lead(II) or Pb(II) **I** correct oxidation states in names of compounds e.g. 'silver(I) chloride' **R** incorrect oxidation states in names of compounds **R** oxidation states in formulas e.g. $Pb(II)Cl_2$
2(b)(i)	**M1** different **atoms** of the same element that have the same number of protons **M2** but different numbers of neutrons	2	The word 'number' need only be used once in the answer number = amount = quantity = sum = total **'atom'** or '**atoms'** must be seen for M1 to score **A 'atom(s)** of the same element' / '**atom(s)** of an element' / '**atom(s)** of the element' **A** '**atom(s)** with the same number of protons' / '**atom(s)** with the same atomic number' / '**atom(s)** with the same proton number' **A** 'same number of protons **in nucleus'** for M1 **I** 'ions of the same element' etc **R** 'same atoms' / 'different element' / 'elements of an atom' for M1 **A '**different mass number' / 'different nucleon number' **I** 'different (relative) atomic mass / A_r' **I '**same number of electrons' for M1 and M2 **R '**different number of electrons' for M2 **A** 1 salvage mark for '**atoms** with same protons but different neutrons' (i.e. no 'numbers' in answer)

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Question	Answer	Marks	Guidance
2(b)(ii)	20	**1**	

Question	Answer	Marks	Guidance
3(a)(i)	**M1** 8 crosses in second shell of each sodium ion **M2** 6 dots and 2 crosses in second shell of oxide ion **M3** '+' charge on both sodium ions on correct answer lines **and** '2^{-}' charge on oxide ion on correct answer line	**3**	**I** empty third shell of Na **R** M1 If cross / dot appears in Na 3rd shell and O 2nd shell (usually with transfer arrows) **A** M2 as ECF if each Na have 8 dots in 2nd shell and O has 8 dots in 2nd shell **A** 'Na^{+}' and 'O^{2-}' as charges on answer lines **A** '+1' / '1+' for charge on sodium ion **A** '– –' / '–2' for charge on oxide ions
3(a)(ii)	**M1** (strong) (electrostatic) attraction between ions **M2** ions have opposite charges	**2**	**A** alternative wording for attraction e.g. '(strong electrostatic) force **holding** ions **together**' For M1 **I** 'force' alone. e.g. 'strong electrostatic force between ions' would not score M1 but 'strong force of attraction between ions' / 'strong force of attraction in an ionic lattice' would. **A** alternate wording for 'ions' for M1 e.g. 'cations **and** anions' **A** formulas of specific ions from the question for M1 i.e. Na^{+} **and** O^{2-} (charges need not be correct but must be opposite) **I** 'electromagnetic' **I** 'bonds held together by forces' / 'attraction between bonds' **I** 'charged atoms' for 'ions' **I** 'attraction between charged particles' for M1 **I** the number of ions e.g. **A** 'attraction between 2 (or more) ions' **R** 'weak attraction' / 'intermolecular forces' / 'covalent bonding' / 'metallic bonding' for M1 **R** 'attraction between molecules / atoms / electrons' for M1

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Question	Answer	Marks	Guidance
3(a)(ii)		2	**A** 'cations **and** anions' / 'positive **and** negative ions' / '+ve **and** –ve ions' **A** 'particles' for ions i.e. 'strong electrostatic attraction between oppositely charged particles' scores M2 (but not M1) **A** specific ions Na^+ **and** O^{2-} (charges need not be correct – just opposite) **I** named ions other than those of Na and O **A** 'metals form positive ions **and** non–metals form negative ions' for M2 **A** incorrect statements 'cations are negative **and** anions positive' / 'metals form negative ions **and** non–metals form positive ions' **I** references to transfer of electrons (correct or incorrect) **I** 'metal ions' and 'non–metal ions' (alone) for 'oppositely charged ions' **I** 'oppositely charged atoms' **R** 'molecules' / 'oppositely charged electrons' for M2 **A** 1 salvage mark for 'intermolecular attraction between oppositely charged ions' for M2
3(a)(iii)	a regular arrangement of alternating positive and negative ions	1	**A** 'alternating (arrangement) of particles' (as 'ionic' appears in the question) for 'alternating': **A** 'regular' / 'repeating' / 'pattern' / 'uniform' / 'ordered / 'organised' / 'rows **and** columns' / 'opposite charged ions next to each other'

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Question	Answer	Marks	Guidance
3(a)(iii)			**I** 'alternative' for 'alternating' **I** 'fixed' **I** 'arrangement' alone **I** 'straight rows' / 'straight lines' for 'arrangement': **A** 'structure' / '3D shape' **I** 'shape' (alone) for 'particles': **A** 'ions' (alone) / 'charged atoms' / 'charged particles' / 'positive and negative ions' **A** 'oppositely–charged ions' / 'anions **and** cations' / 'Na^+ **and** O^{2-}'(allow incorrect charges but must be opposite e.g. **A** Na^- **and** O^{2+}) **I** 'atoms' (alone) **R** 'molecules' / 'electrons' **I** references to forces of attraction / bonding between ions / forces holding ions together, whether correct or incorrect **A** diagram showing regular alternating arrangement of + and – symbols, with more than 1 row (allow any charges as long as opposite)
3(b)(i)	**M1** double bond of 2 dots and 2 crosses **M2** 4 non-bonding dots on one oxygen atom **and** 4 non–bonding crosses on the other oxygen atom	**2**	**I** inner shells **A** use of 'o' to represent careless dots **R** use of symbols other than dots or crosses for M1 octets must be correct for M2 non–bonding electrons need not be drawn in pairs **A** 1 mark only for otherwise–correct diagram of all dots or all crosses or an incorrect mixture or use of a different symbol

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Question	Answer	Marks	Guidance
3(b)(ii)	Intermolecular (forces of attraction)	**1**	**A** 'intermolecular bonds' / 'intermolecular attractions' **I** descriptions of the term e.g. 'attraction (forces) between molecules' / '(forces (of attraction) holding molecules together' **A** 'intermolecular forces between particles' **A** 'London (forces)' / 'van der Waals (forces)' / 'dispersion (forces)' / 'dipole–dipole (forces)' / 'induced dipole–induced dipole (forces)' **I** IMF / VDW / LDF / dipole forces / 'id–id (forces)' **I** 'intermolecular forces *between bonds*' (does not score) **I** 'weak' **R** 'strong' (as 'weak' is given in the question) **R** 'intermolecular forces between atoms' **A** 'intermolecular forces between oxygen (particles)' **R** 'int**ra**molecular forces' / 'covalent bonds' between molecules but **I** if between atoms **R** 'ionic bonds' / 'metallic bonds' **A** 'oxygen / covalent molecules have intermolecular forces' but **I** 'covalent bonds have intermolecular forces'

Question	Answer	Marks	Guidance
4(a)(i)	dissolved in water	**1**	**A** '(solution where) water is the solvent' / 'in a solution with water' **I** 'in solution' (alone) **I** 'in water' (alone) / 'water' / 'dissolved' (alone) / 'dilute' / 'containing water / 'containing water molecules' / 'dissolved in liquid' / 'soluble in water' / 'aq' / 'addition of water' / 'mixed with water'
4(a)(ii)	$\mathbf{2}H_2O_2 \rightarrow \mathbf{2}H_2O + O_2$	**1**	

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Question	Answer	Marks	Guidance
4(a)(iii)	oxygen (produced) escapes from the flask	1	for 'oxygen' **A** O_2 / 'gas' / 'vapour' **I** O **I** 'water vapour' / 'steam' **R** any other named gas for 'escapes from the flask': **A** **'**escapes' / 'is lost' / 'leaves' / 'diffuses **out** (of the flask)' / 'is given off into the air' / 'is evolved into the air' / 'flies away' **A** 'given out **from the flask'** / 'given off **from the flask'** / 'released **from the flask**' for 'flask': **A** apparatus / system / 'through the cotton wool' / 'beaker' or other sensible container **I** **'**oxygen is evolved / given off / given out / released / diffuses' (unqualified) – it must be **from the flask** with these phrases. **I** **'**contents / products have diffused out of the flask' (must be 'oxygen') **I** 'hydrogen peroxide is used up' as part of explanation of oxygen production **R** idea of gas absorbed by cotton wool **R** 'catalyst / manganese(IV) oxide is used up' **R** 'solution / hydrogen peroxide / catalyst / water / liquid splashes / spits out of the flask' **R** idea of evaporation of solution / reactant
4(b)	concentration of **hydrogen peroxide** decreases (as time increases) **OR** number of **hydrogen peroxide** particles per unit volume decreases (as time increases) **OR**	1	for 'hydrogen peroxide': **A** **'**H_2O_2' / **'**reactant' / 'reagent' Answer must be comparative **A** 'number of moles of hydrogen peroxide per unit volume decreases' **A** 'concentration of hydrogen peroxide is highest/higher at start' / 'maximum concentration of hydrogen peroxide at start

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Question	Answer	Marks	Guidance
4(b)	decreased frequency of collisions between **hydrogen peroxide** (particles) (as time increases)		**I** 'mass' / 'amount' / 'volume' / 'moles' (unqualified) instead of concentration **I** 'less hydrogen peroxide' for 'particles', **A** 'molecules' / 'atoms' / 'ions' for 'unit volume', **A** specific examples e.g. 'cm^3' **A** 'fewer hydrogen peroxide particles per unit volume' / 'fewer hydrogen peroxide particles per unit area' / 'fewer hydrogen peroxide particles in the same volume / space' / 'distance between (hydrogen peroxide) particles increases' / 'hydrogen peroxide particles are further apart / less crowded' **A** 'hydrogen peroxide particles closest / closer together at start' / 'shortest / shorter distance between hydrogen peroxide particles at the start' **I** 'fewer hydrogen peroxide particles' (unqualified) **A** 'fewer collisions between hydrogen peroxide (particles) per unit time / per second' / 'hydrogen peroxide (particles) collide less frequently / less often' **A** 'collision frequency of hydrogen peroxide (particles) highest / higher at start' **I** 'less chance / probability of collisions between hydrogen peroxide (particles) **I** 'fewer collisions between hydrogen peroxide (particles)' (unqualified) **I** collisions (of particles) with container or wall **I** 'fruitful' / 'successful' / 'effective' i.e. 'decreased frequency of successful collisions between hydrogen peroxide (particles)' scores **I** 'particles collide slower'

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Question	Answer	Marks	Guidance
4(b)			**R** any reference to catalyst changing in mass / surface area / concentration etc **R** changes in particle size/temperature / (kinetic or thermal) energy/speed **R** change in *fraction / proportion / percentage* of particles or collisions with energy greater than or equal to E_a
4(c)	**M1** kinetic energy of particles increases **M2** frequency of collisions between particles increases **M3** higher percentage / proportion / fraction of collisions / particles have energy greater than / equal to activation energy **OR** more **of the** collisions / particles have energy greater than / equal to activation energy	**3**	For 'particles': **A** 'molecules' / 'atoms' / 'ions' Comparisons are needed for all marking points **I** equilibrium shifts '**Particles**' must be seen somewhere in the answer for M1 to be awarded **A** '(kinetic / heat) energy increases' (unqualified as long as '**particles**' is seen elsewhere) **A** 'particles have more energy' / 'particles move faster / quicker' **A** 'particles collide faster / quicker' / 'particles collide at a faster rate' **I** 'particles vibrate quicker' **A** 'more energy between particles' **R** 'particles produce more energy' **A** 'frequency of collisions (between particles) increases' / 'rate of collisions increases' / 'more collisions per unit time' / 'more collisions per second' / 'collisions occur more often' / '(number of) collisions per unit time increase' **A** 'rate of collisions increases' / particles collide more often / more frequently' **I** 'more chance / probability of collisions' **/** 'more collisions' (unqualified) / 'particles collide at a *faster* rate' for M2

Question	Answer	Marks	Guidance
4(c)			**I** collisions with container or wall 'activation energy' / 'E_a' / '(sufficient) energy to react' / 'energy needed to start reaction' must be referred to in M3 if 'collisions' are referred to the phrase 'more of the ..' / reference to 'higher percentage of'.. etc must be seen for M3 **A** 'more **of the** collisions have energy ⩾ Ea' **A** 'more **of the** collisions have (sufficient) energy to react' **A** 'more **of the** collisions have enough Ea / are above Ea' **I** 'number of collisions with energy greater than / equal to E_a increases' (not a proportion) **I** 'majority / most of collisions have energy ⩾ Ea' (not comparative) **OR** if 'particles' are referred, to the phrase 'more of the…' / reference to 'higher percentage of…' etc is not essential for M3 **A** 'more (of the) particles have energy ⩾ Ea' **A** 'more (of the) particles have (sufficient) energy to react' **A** 'more (of the) particles have enough Ea / are above Ea' **A** 'number of particles with energy greater than / equal to Ea increases' **I** 'particles with energy greater than/equal to Ea increases' (phrase 'number of' required') **I** 'majority / most of particles have energy ⩾ Ea' (not comparative) **I** 'fruitful' / 'successful' / 'effective **R** idea of decrease / increase in number of particles for M3 **R** 'Ea required for reaction is decreased / increased' for M3

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Question	Answer	Marks	Guidance
4(d)(i)	**M1** oxidation number of **manganese / Mn** **M2** oxidation number is +7	**2**	for 'oxidation number', **A** 'oxidation state' (allow spelling near misses) e.g. **A** 'oxidisation / oxidising number' **A** 'oxidation number **of manganese** in manganate ion/potassium manganate(VII) / $KMnO_4$' **I** 'valency' for 'oxidation number' **R** 'oxidation number of compound / potassium manganate / manganate / permanganate / $KMnO_4$' for M1 for 'manganese / Mn', **A** 'manganese atom' / Mn atom' / 'manganese(VII)' **R** 'manganese ion' **R** magnesium/ Mg **R** 'manganese molecule' **R** 'charge of manganese' for +7 **A** 7+ (+ sign must be seen) **I** '+ seven' / 'plus 7' / '+VII' **I** comments about electrons (right or wrong) **R** any expression that is an ionic charge e.g. 'Mn^{7+}' for M2 **R** 'charge on ion is +7' / 'charge on atom is +7' but **A** '*oxidation number* of ion is +7' for M2 **A** 1 salvage mark for 'valency of **manganese** is **+7 / 7+**'
4(d)(ii)	**M1** mol O_2 = 0.64 / 32 = **0.02(0)** **M2** mol $KMnO_4$ = 0.02 × 2 = **0.04(0)** **M3** mass $KMnO_4$ = 0.04 × 158 = **6.32** / **6.3**	**3**	mark by step penalise fractions once only **A** ECF M1 × 2 to a minimum of 2 SF (using calculator value or answer space value from M1) but ignore trailing zeros or absence of trailing zeros. **A** rounding or truncating. Ignore rounding errors after 2nd SF **A** ECF M2 × 158 to a minimum of 2 SF (using calculator value or answer space value for M2) but ignore trailing zeros or absence of trailing zeros. **A** rounding or truncating. Ignore rounding errors after 2nd SF.

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Question	Answer	Marks	Guidance
5(a)(i)	electrolyte	1	**A** phonetic near miss e.g. 'electrolite' / 'electrolyt' **I** 'molten' / 'solution' / 'aqueous'
5(a)(ii)	**M1** inert **M2** good conductor of electricity	2	**A** 'not reactive' / 'unreactive' / 'does not react' / 'does not react with the electrolyte' / 'does not react with the solution' / 'does not react with the products (of electrolysis)' / 'does not take part in the reaction' **I** 'not very reactive'/ 'low reactivity' / 'quite unreactive' / 'does not break down' **I** 'does not corrode' **A** '(good) conductor of electricity' For 'electricity', **A** 'electric current' or 'electrical energy'
5(a)(ii)			**I** 'conductor (alone) / 'conductive' / 'increases conductivity' / 'conducts heat' / 'carries electric charge' / 'carries / conducts current' (must be 'electrical current') **I** any reasons given for conductivity e.g. electrons or ions **I** 'high melting point' / 'high boiling point' **I** 'metal' **R** 'conductor when molten or aqueous' **I** comments on strength / comments on cost / comments on hardness for M1 and M2
5(a)(iii)	$2Br^- \rightarrow Br_2 + 2e^-$ **M1** any negative Br species **losing** electron(s) **M2** correct ionic half equation	2	**A** $2Br^- - 2e^- \rightarrow Br_2$ for both marks **A** e and 'e⁻s' and 'es' for e^- e.g. 2es E.g. **A** $Br^{2-} - 2e \rightarrow 2Br$ / $Br_2^- \rightarrow Br_2 + e^-$ scores M1 **A** 1 salvage mark if equation completely correct but both 'Br' appear as BR / both 'Br' appear as br e.g. $2BR^- \rightarrow BR_2 + 2e^-$ **or** $2br^- \rightarrow br_2 + 2e^-$

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Question	Answer	Marks	Guidance
5(a)(iv)	**M1** hydrogen ions are **positive** **M2** • hydrogen ions are attracted to **negative** cathode **OR** • hydrogen ions gain electrons at the cathode **OR** • hydrogen is less reactive than lithium	**2**	for 'hydrogen ion', **A** 'H^+ / 'proton' **M1** **A** 'hydrogen is a cation' **A** H^+ seen anywhere for M1 **I** 'hydrogen is positive' (no ions) **I** 'lithium ions / Li^+ are positive / are cations' for M1 **A** H^+ seen as a reactant in an equation 'attempt' e.g. $H^+ \rightarrow H + e$ **I** incorrect formulas for hydrogen ions for M1 e.g. H^{2+} or H_2^+ **M2** **A** '(hydrogen ions are) attracted to **negative** cathode / **negative** electrode / electrode of opposite charge' **A** 'cations are attracted to the **negative** cathode' **I** lithium ions are attracted to negative cathode / negative electrode / electrode of opposite charge' for M2 **A** 'hydrogen ions travel / go / move to the negative cathode / negative electrode / electrode of opposite charge' **A** 1 salvage mark total for 'hydrogen is positive' AND 'hydrogen is attracted to the **negative** cathode' i.e. no 'ions' **OR** **A** '(hydrogen ions) gain electrons at the cathode / get reduced at the cathode' for M2 **A** correct ionic half-equation for both M1 and M2 $2H^+ + 2e \rightarrow H_2$ **A** ionic half–equation showing electron gain with incorrect formulas for hydrogen ions for M2 only e.g. $H^{2+} + 2e \rightarrow H$ **I** 'hydrogen ions gain electrons/get reduced' (no cathode) **OR**

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Question	Answer	Marks	Guidance
5(a)(iv)			**A** 'Lithium / Li is more reactive / higher in the reactivity series than hydrogen / H ORA **I** 'hydrogen ions / H^+ get reduced / gain electrons / get discharged more easily (than lithium ions / Li^+ / metal ions) / in preference to lithium ions / Li^+ / metal ions' ORA **I** lithium *ions* are more reactive than hydrogen *ions* / higher in the reactivity series than hydrogen *ions* **I** 'hydrogen forms and not lithium' (unqualified)
5(a)(v)	ions	**1**	**A** 'cations **and** anions' / 'positive **and** negative ions' **I** named ions e.g. lithium ions / bromide ions / hydrogen ions / hydroxide ions / Li^+ / Br^- / H^+ / OH^- **I '**cations' (alone) / 'anions' (alone) / 'positive ions' (alone) / 'negative ions' (alone) **I '**delocalised' / 'sea' / 'mobile' / 'free' e.g. 'delocalised ions' scores **I** 'charged particles' / 'charge carriers' **R '**electrons'
5(a)(vi)	**M1** at anode: bromine **M2** at cathode: lithium	**2**	Names take precedence, **I** incorrect formulas **R** incorrect name **I** states **A** Br_2 **A** attempt at ionic half–equation with Br_2 as only product (other than e^-) **I** Br / Br^- **A** Li **A** attempt at ionic half-equation with Li as only product. **I** Li^+ **A** 1 mark ECF if lithium at anode and bromine at cathode

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Question	Answer	Marks	Guidance
5(b)	aluminium oxide	**1**	Name take precedence, **I** incorrect formulas **R** incorrect name **A** aluminium oxide / alumina / Al_2O_3 **I** correct oxidation state of aluminium **R** incorrect oxidation state in name
5(c)	Any two from • solvent • lowers the operating temperature • increases conductivity	**2**	for 'electrolyte', **A '**aluminium oxide' / 'bauxite' / 'alumina' / 'Al_2O_3' / 'solution' **A '**lowers the melting point (of the electrolyte)' / 'lowers temperature (of the electrolyte)' **A** 'save energy' / 'saves electricity' / 'saves heat' / 'lowers energy / electricity cost' **I '**reduces cost' (unqualified) **I** any quoted temperatures **R '**lowers melting point of *aluminium*' **R** 'lowers *boiling* point of aluminium / aluminium oxide' **A '**helps / improves conductivity' **I '**to make conductivity good' / 'increases heat conductivity' / 'it's a good conductor' **R** 'improves conductivity of *aluminium*' / 'makes the mixture conduct' **I** explanations **I** 'cryolite is a catalyst / increases rate'

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Question	Answer	Marks	Guidance
6(a)(i)	(an oxide that) reacts with acids **and** with bases to produce a salt and water	**1**	**A** amphoteric substance referred to as 'it' / 'oxide' / 'compound' / 'substance' / 'salt' / 'molecule' / 'species' **I** 'element' / 'metal' **R** 'atom' / 'ion' **A '**(oxide that) reacts with acids **and / or** with bases' **A '**(oxide that) neutralise acids **and / or** bases' **A '**(oxide that) acts as an acid **and / or** a base' / 'is an acid **and** / **or** a base' **A '**(oxide that) has acidic **and** / **or** basic properties for 'acid(s)', **A '**acidic oxide' / 'proton donor' / 'H^+ donor' / H^+ for 'base(s)', **A** alkali / 'basic oxide' / 'basic hydroxide' / 'proton acceptor' / 'H^+ acceptor' / OH^- **I** non-metal oxides / metal oxides for 'reacts with/neutralises etc' **I '**dissolves' i.e. 'dissolves in acids and bases' does not score. **I** correct equations that show oxides reacting as both acids **and** bases **I** 'produce a salt and water' but **R** incorrect products e.g. 'salt and hydrogen'
6(a)(ii)	$Ca(AlO_2)_2$	**1**	**A** $Ca(AlO_2)_2$ on RHS of **ionic** equation 'attempt' using the ions given in the question with calcium aluminate as the only product e.g. $2Ca^{2+} + AlO_2^- \rightarrow Ca(AlO_2)_2$ **R** formulas with charges e.g. $Ca^{2+}(AlO_2^-)_2$ **R** symbols in wrong order e.g. $(AlO_2)_2Ca$ **R** any numbers in front e.g. $2Ca(AlO_2)_2$ unless used in balancing an ionic equation

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Question	Answer	Marks	Guidance
6(a)(iii)	$6HCl + Al_2O_3 \rightarrow 2AlCl_3 + 3H_2O$ **M1** $AlCl_3$ as product **M2** correct equation	**2**	
6(a)(iv)	$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ **M1** correct ionic equation **M2** state symbols	**2**	Ionic equation must be balanced **R** ionic charges on $AgCl$ i.e. Ag^+Cl^- **R** spectator ions / electrons as reactants or products **R** full non-ionic equation or semi-ionic equation for M1 **A** M2 for state symbols on any +ve silver ion **and** any –ve chloride ion **and** any silver chloride formula (as the only product) e.g. $Ag^{2+}(aq) + Cl^{2-}(aq) \rightarrow Ag_2Cl(s)$ **R** AQ / Aq / aQ for aq
6(b)(i)	chromium / Cr	**1**	**R** incorrect name / incorrect formulas **A** 'chromium atoms'/ 'chromium ions' / 'chromium(VI) ions' **A** Cr written as ion e.g. Cr^{6+} **I** 'transition metal / element' **I** 'chrome' but **A** as ECF from **2(a)(iii)** **R** 'chromate' / 'dichromate' but **A** 'chromium in chromate'
6(b)(ii)	$(NH_4)_2Cr_2O_7 \rightarrow N_2 + Cr_2O_3 + \mathbf{4}H_2O$ M1 all species M2 correct equation	**2**	**R** additional species e.g. O_2 for M1

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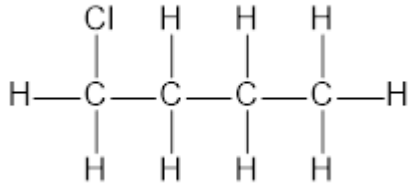
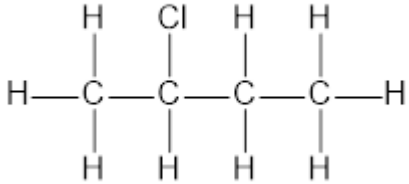
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Question	Answer	Marks	Guidance
6(c)(i)	no reactants or products can enter or leave	1	**A** 'no reactants can enter / leave' or 'no products can enter / leave' (alone) for 'no reactants' / 'no products' **A** 'nothing' / 'no particles' / 'no gases' / 'no molecules' / 'no atoms' / 'no matter' / 'no elements' / 'no mass' etc for 'enter' / 'leave' **A** 'gained' / 'added' / 'join' / 'lost' / 'removed' / 'escape' **A** 'only heat / energy can be exchanged / transferred / enter / leave' **I** phrases which reword the question e.g. 'fully enclosed reaction system' / 'closed environment' / 'sealed system' / 'contained system' **I** comments with reference to 'air not entering / leaving' **I** equilibrium statements e.g. 'concentrations don't change' **I** 'no electrons can leave' / 'no external interactions' **R** 'no heat / energy can enter / leave'
6(c)(ii)	**M1** decreases **M2** decreases **M3** no change	3	**A** synonyms **I** vertical arrows **I** equilibrium shifts
6(c)(iii)	Contact (process)	1	**I** oxidation

Question	Answer	Marks	Guidance
7(a)(i)	C_nH_{2n+2}	1	**A** letters other than n **I** $H_{2n+2}C_n$ **I** 'alkanes' **R** C_nH2_{n+2} / C_nH_{2n}+2 if the subscript is obviously too large

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Question	Answer	Marks	Guidance
7(a)(ii)	ultraviolet light	1	**A** 'sunlight' / 'UV light' / 'UV radiation' / 'UV' **I** 'heat'/ examples of temperatures/ 'pressure' **I** just 'light' **I** just 'sun' **R** 'catalyst'/ 'lowers E_a'
7(a)(iii)	structural isomers	1	**I** 'isomers' (alone)
7(a)(iv)	**M1** displayed formula of 1-chlorobutane  **M2** displayed formula of 2-chlorobutane 	2	**A** CL **I** HCl **I** names **R** displayed formulas of branched chain isomers 1–chloro (2–)methyl propane and 2–chloro (2–)methyl propane for M1 and M2 (not made from butane) **I** structural or semi–displayed formulas **A** ECF for M2 if correct structural formulas of both isomers are given with no other answers e.g. $CH_3CH_2CH_2CH_2Cl$ **and** CH_3CHC / CH_2CH_3
7(b)(i)	$C_4H_6O_3$	1	**A** elements in any order **I** structural formulas in attempted working e.g. $COOHCHCHCH_2OH \rightarrow C_4H_6O_3$

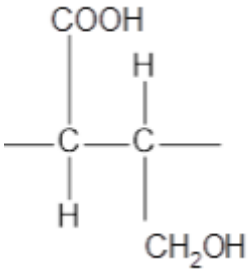
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Question	Answer	Marks	Guidance
7(b)(ii)	**M1** turns colourless **M2** bubbles / fizzing/ effervescence	**2**	**A** ‘(turns) colourless’ / ‘decolourises’ **I** ‘clear’ **I** original colour of aqueous bromine **R** incorrect observations e.g. ‘precipitate’ / ‘fizzing’ **I** ‘colourless gas’ / ‘carbon dioxide’ or other named gas / gas tests **R** ‘solid / sodium carbonate dissolves / disappears’ **R** incorrect observations e.g. ‘precipitate’ / coloured gas / colour changes / ‘turns milky’

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Question	Answer	Marks	Guidance
7(b)(iii)	**M1** chain of only four carbon atoms joined by single bonds **M2** 2 repeat units with correctly placed COOH, CH_2OH groups and H atoms **M3** correct structure **AND** continuation bonds	**3**	**I** side chains **I** monomer molecule seen as part of working out **A** carbons written in chain as '–CH–' for M1 **I** valency of C for M1 i.e. **A** 4 C in a row connected with single bonds **A** butane displayed formula or structure for M1 **R** presence of 'blocks' in the chain = 0 marks for question **M2** valency of carbons in chain must be correct for M2 2 repeat units of:  **A** –COOH and $–CH_2OH$ or semi / fully displayed (any unambiguous structure) **A** $–CO_2H$ for –COOH **R** –C=OOH / $–CHO_2$ for –COOH **R** $–COHH_2$ / $–CH_2HO$ / $–CH_3O$ for $–CH_2OH$ **A** any possible arrangement of groups (idio / iso / syntactic etc) **I** connectivity errors for M2 **I** brackets and / or 'n' / other numbers / other products for M2

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Question	Answer	Marks	Guidance
7(b)(iii)			**R** incorrect connectivity e.g. –HOOC / –HOH_2C for M3 but make allowance if bond from C backbone connects between C and O of COOH or between C and H_2 of CH_2OH **R** other products for M3 the continuation bonds will normally be drawn horizontally but can be vertical
7(b)(iv)	**M1** dicarboxylic acids **M2** diols	**2**	**A** answers in either order **A** 'dialkanoic acids' / 'dioic acids' / 'diacarboxylic acids' / 'diacyl chlorides' **I** 'carboxylic acid' **I** named examples of dicarboxylic acids **R** 'dicarboxylic acid group' **A** 'dialcohols' **I** 'alcohols' **I** named examples of diols **R** 'diol group' but allow ECF if M1 and M2 both given as 'group' **A** 1 salvage mark for 'carboxylic acid' **and** 'alcohol' / 'carboxylic acid group **and** alcohol group' **A** 1 salvage mark for 'hydroxycarboxylic acid' if no other mark scored.

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Question	Answer	Marks	Guidance
7(c)	**M1** **C** 88.9 / 12 **H** 11.1 / 1 **OR** 7.41 : 11.1 **M2** **C** 7.41 / 7.41 **H** 11.1 / 7.41 **OR** 1 : 1.5 **OR** 2:3 **M3** C_2H_3	**3**	**A** 3 marks for C_2H_3 **A** correct fractions with incorrect evaluation or vice versa **M1** **A** rounding or truncation to minimum of 1DP i.e. 7.4 / 7.41 / 7.40 AND 11.1 gets M1 **I** figures after 2DP **M2** M2 subsumes M1. **A** 2 marks if 1:1.5 or 2:3 or $CH_{1.5}$ is seen **A** correct fractions with incorrect evaluation or vice versa **A** rounding or truncation to minimum of 1DP for **H** i.e. 1 AND 1.4 / 1.49 / 1.498 / 1.5 **I** figures after 2DP **I** transcription errors in the fractions if 1:1.5 is seen **M2 A** 1 mark ECF for evidence (either expression or evaluation) that an incorrect set of calculated M1 values (to a minimum of 1DP) are divided by the lowest M1 value. No M3 available **M3** C_2H_3 / H_3C_2 are the only correct answers (no ECF from M2) **A** symbols in either order **A** any size of symbols / subscripts **R** numbers in front of the formula **I** attempts at structural / displayed formulas for M3

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