A-level
CHEMISTRY
7405/3

Paper 3

Mark scheme

June 2022

Version: 1.0 Final

226A74053/MS

Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Further copies of this mark scheme are available from aqa.org.uk

AS and A-Level Chemistry
Mark Scheme Instructions for Examiners

1. General

The mark scheme for each question shows:

- the marks available for each part of the question
- the total marks available for the question
- the typical answer or answers which are expected
- extra information to help the examiner make his or her judgement and help to delineate what is acceptable or not worthy of credit or, in discursive answers, to give an overview of the area in which a mark or marks may be awarded.

The extra information in the 'Comments' column is aligned to the appropriate answer in the left-hand part of the mark scheme and should only be applied to that item in the mark scheme.

You should mark according to the contents of the mark scheme. If you are in any doubt about applying the mark scheme to a particular response, consult your Team Leader.

At the beginning of a part of a question a reminder may be given, for example: where consequential marking needs to be considered in a calculation; or the answer may be on the diagram or at a different place on the script.

In general the right-hand side of the mark scheme is there to provide those extra details which might confuse the main part of the mark scheme yet may be helpful in ensuring that marking is straightforward and consistent.

The use of M1, M2, M3 etc in the right-hand column refers to the marking points in the order in which they appear in the mark scheme. So, M1 refers to the first marking point, M2 the second marking point etc.

2. Emboldening

2.1 In a list of acceptable answers where more than one mark is available 'any **two** from' is used, with the number of marks emboldened. Each of the following bullet points is a potential mark.

2.2 A bold **and** is used to indicate that both parts of the answer are required to award the mark.

2.3 Alternative answers acceptable for a mark are indicated by the use of **OR**. Different terms in the mark scheme are shown by a / ; eg allow smooth / free movement.

3. Marking points

3.1 Marking of lists

This applies to questions requiring a set number of responses, but for which students have provided extra responses. The general 'List' principle to be followed in such a situation is that 'right + wrong = wrong'.

Each error / contradiction negates each correct response. So, if the number of errors / contradictions equals or exceeds the number of marks available for the question, no marks can be awarded.

However, responses considered to be neutral (often prefaced by 'Ignore' in the mark scheme) are not penalised.

For example, in a question requiring 2 answers for 2 marks:

Correct answers	Incorrect answers (ie incorrect rather than neutral)	Mark (2)	Comment
1	0	1	
1	1	1	They have not exceeded the maximum number of responses so there is no penalty.
1	2	0	They have exceeded the maximum number of responses so the extra incorrect response cancels the correct one.
2	0	2	
2	1	1	
2	2	0	
3	0	2	The maximum mark is 2
3	1	1	The incorrect response cancels out one of the two correct responses that gained credit.
3	2	0	Two incorrect responses cancel out the two marks gained.
3	3	0	

3.2 Marking procedure for calculations

Full marks should be awarded for a correct numerical answer, without any working shown, unless the question states 'Show your working' or 'justify your answer'. In this case, the mark scheme will clearly indicate what is required to gain full credit.

If an answer to a calculation is incorrect and working is shown, process mark(s) can usually be gained by correct substitution / working and this is shown in the 'Comments' column or by each stage of a longer calculation.

3.3 Errors carried forward, consequential marking and arithmetic errors

Allowances for errors carried forward are most likely to be restricted to calculation questions and should be shown by the abbreviation ECF or consequential in the marking scheme.

An arithmetic error should be penalised for one mark only unless otherwise amplified in the marking scheme. Arithmetic errors may arise from a slip in a calculation or from an incorrect transfer of a numerical value from data given in a question.

3.4 Equations

In questions requiring students to write equations, state symbols are generally ignored unless otherwise stated in the 'Comments' column.

Examiners should also credit correct equations using multiples and fractions unless otherwise stated in the 'Comments' column.

3.5 Oxidation states

In general, the sign for an oxidation state will be assumed to be positive unless specifically shown to be negative.

3.6 Interpretation of 'it'

Answers using the word 'it' should be given credit only if it is clear that the 'it' refers to the correct subject.

3.7 Phonetic spelling

The phonetic spelling of correct scientific terminology should be credited **unless** there is a possible confusion with another technical term or if the question requires correct IUPAC nomenclature.

3.8 Brackets

(…..) are used to indicate information which is not essential for the mark to be awarded but is included to help the examiner identify the sense of the answer required.

3.9 Ignore / Insufficient / Do not allow

Ignore or insufficient is used when the information given is irrelevant to the question or not enough to gain the marking point. Any further correct amplification could gain the marking point.

Do **not** allow means that this is a wrong answer which, even if the correct answer is given, will still mean that the mark is not awarded.

3.10 Marking crossed out work

Crossed out work that **has not been** replaced should be marked as if it were not crossed out, if possible. Where crossed out work **has been** replaced, the replacement work and not the crossed out work should be marked.

3.11 Reagents

The command word 'Identify', allows the student to choose to use **either** the name or the formula of a reagent in their answer. In some circumstances, the list principle may apply when both the name and the formula are used. Specific details will be given in mark schemes.

The guiding principle is that a reagent is a chemical which can be taken out of a bottle or container. Failure to identify complete reagents **will be penalised**, but follow-on marks (eg for a subsequent equation or observation) can be scored from an incorrect attempt (possibly an incomplete reagent) at the correct reagent. Specific details will be given in mark schemes.

For example, **no credit** would be given for:

- the cyanide ion or CN^- when the reagent should be potassium cyanide or KCN;

- the hydroxide ion or OH^- when the reagent should be sodium hydroxide or NaOH;
- the $Ag(NH_3)_2^+$ ion when the reagent should be Tollens' reagent (or ammoniacal silver nitrate). In this example, no credit is given for the ion, but credit could be given for a correct observation following on from the use of the ion. Specific details will be given in mark schemes.

In the event that a student provides, for example, **both** KCN and cyanide ion, it would be usual to ignore the reference to the cyanide ion (because this is not contradictory) and credit the KCN. Specific details will be given in mark schemes.

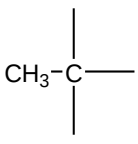
3.12 Organic structures

Where students are asked to draw organic structures, unless a specific type is required in the question and stated in the mark scheme, these may be given as displayed, structural or skeletal formulas or a combination of all three as long as the result is unambiguous.

In general

- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Skeletal formulae must show carbon atoms by an angle or suitable intersection in the skeleton chain. Functional groups must be shown and it is essential that all atoms other than C atoms are shown in these (except H atoms in the functional groups of aldehydes, secondary amines and N-substituted amides which do not need to be shown).
- Structures must not be ambiguous, eg 1-bromopropane should be shown as $CH_3CH_2CH_2Br$ and not as the molecular formula C_3H_7Br which could also represent the isomeric 2-bromopropane.
- Bonds should be drawn correctly between the relevant atoms. This principle applies in all cases where the attached functional group contains a carbon atom, eg nitrile, carboxylic acid, aldehyde and acid chloride. The carbon-carbon bond should be clearly shown. Wrongly bonded atoms will be penalised **on every occasion**. (see the examples below)
- The same principle should also be applied to the structure of alcohols. For example, if students show the alcohol functional group as C ─ HO, they should be penalised **on every occasion**.
- Latitude should be given to the representation of C ─ C bonds in alkyl groups, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.
- Similar latitude should be given to the representation of amines where NH_2─ C will be allowed, although H_2N─ C would be preferred.
- Poor presentation of vertical C ─ CH_3 bonds or vertical C ─ NH_2 bonds should **not** be penalised. For other functional groups, such as ─ OH and ─ CN, the limit of tolerance is the half-way position between the vertical bond and the relevant atoms in the attached group.

By way of illustration, the following would apply.



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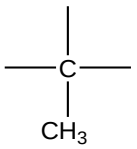

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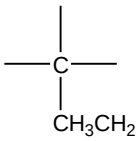

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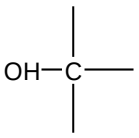

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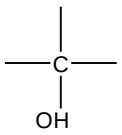

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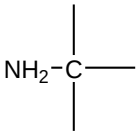

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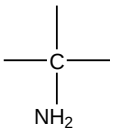

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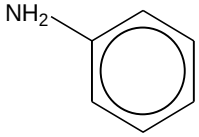

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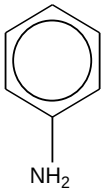

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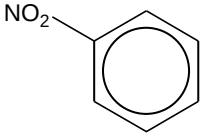

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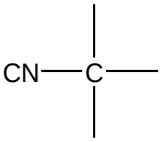

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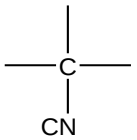

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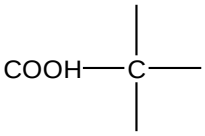

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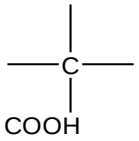

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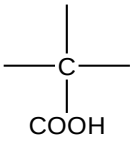

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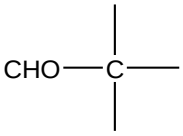

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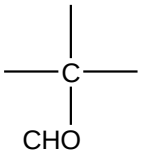

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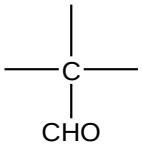

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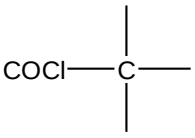

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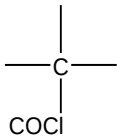


not allowed

- Representation of CH_2 by $C–H_2$ will be penalised.
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions may be made in the context of balancing equations)

CH_3COH	for	ethanal
CH_3CH_2HO	for	ethanol
$OHCH_2CH_3$	for	ethanol
C_2H_6O	for	ethanol
CH_2CH_2	for	ethene
$CH_2.CH_2$	for	ethene
$CH_2:CH_2$	for	ethene

- Each of the following **should gain credit** as alternatives to correct representations of the structures.

$CH_2 = CH_2$	for	ethene, $H_2C=CH_2$
$CH_3CHOHCH_3$	for	propan-2-ol, $CH_3CH(OH)CH_3$

- In most cases, the use of 'sticks' to represent C ─ H bonds in a structure should **not** be penalised. The exceptions to this when "sticks" will be penalised include
  - structures in mechanisms where the C ─ H bond is essential (e.g. elimination reactions in halogenoalkanes and alcohols)
  - when a displayed formula is required
  - when a skeletal structure is required or has been drawn by the candidate

3.13 Organic names

As a general principle, non-IUPAC names or incorrect spelling or incomplete names should **not** gain credit. Some illustrations are given here.

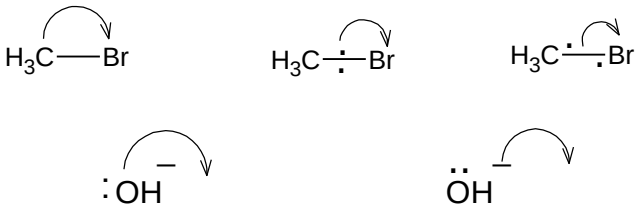
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

but-2-ol	should be **butan-2-ol**
2-hydroxybutane	should be **butan-2-ol**
butane-2-ol	should be **butan-2-ol**
2-butanol	should be **butan-2-ol**
ethan-1,2-diol	should be **ethane-1,2-diol**
2-methpropan-2-ol	should be **2-methylpropan-2-ol**
2-methylbutan-3-ol	should be **3-methylbutan-2-ol**
3-methylpentan	should be **3-methylpentane**
3-mythylpentane	should be **3-methylpentane**
3-methypentane	should be **3-methylpentane**
propanitrile	should be **propanenitrile**
aminethane	should be **ethylamine** (although aminoethane can gain credit)
2-methyl-3-bromobutane	should be **2-bromo-3-methylbutane**
3-bromo-2-methylbutane	should be **2-bromo-3-methylbutane**
3-methyl-2-bromobutane	should be **2-bromo-3-methylbutane**
2-methylbut-3-ene	should be **3-methylbut-1-ene**
difluorodichloromethane	should be **dichlorodifluoromethane**

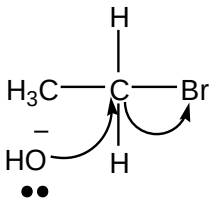
3.14 Organic reaction mechanisms

Curly arrows should originate either from a lone pair of electrons or from a bond.

The following representations should not gain credit **and will be penalised each time** within a clip.



For example, the following would score zero marks



When the curly arrow is showing the formation of a bond to an atom, the arrow can go directly to the relevant atom, alongside the relevant atom or **more than half-way** towards the relevant atom.

In free-radical substitution:

- the absence of a radical dot should be penalised **once only** within a clip.
- the use of half-headed arrows is not required, but the use of double-headed arrows or the incorrect use of half-headed arrows in free-radical mechanisms should be penalised **once only** within a clip.

The correct use of skeletal formulae in mechanisms is acceptable, but where a C-H bond breaks, both the bond and the H must be drawn to gain credit.

3.15 Extended responses

For questions marked using a 'Levels of Response' mark scheme:

Level of response mark schemes are broken down into three levels, each of which has a descriptor. Each descriptor contains two statements. The first statement is the Chemistry content statement and the second statement is the communication statement.

Determining a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the Chemistry content descriptor for that level. The descriptor for the level indicates the qualities that might be seen in the student's answer for that level. If it meets the lowest level, then go to the next one and decide if it meets this level, and so on, until you have a match between the level descriptor and the answer.

When assigning a level you should look at the overall quality of the answer and not look to pick holes in small and specific parts of the answer where the student has not performed quite as well as the rest. If the answer covers different aspects of different levels of the mark scheme you should use a best fit approach for defining the level.

Once the level has been decided, the mark within the level is determined by the communication statement:

- If the answer completely matches the communication descriptor, award the higher mark within the level.
- If the answer does not completely match the communication descriptor, award the lower mark within the level.

The exemplar materials used during standardisation will help you to determine the appropriate level. There will be an exemplar in the standardising materials which will correspond with each level of the mark scheme and for each mark within each level. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the exemplar to determine if it is the same standard, better or worse than the example. You can then use this to allocate a mark for the answer based on the Lead Examiner's mark on the exemplar.

You may well need to read back through the answer as you apply the mark scheme to clarify points and assure yourself that the level and the mark are appropriate.

Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other chemically valid points. Students may not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme. The mark scheme will state how much chemical content is required for the highest level.

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

For other extended response answers:

Where a mark scheme includes linkage words (such as 'therefore', 'so', 'because' etc), these are optional. However, a student's marks for the question may be limited if they do not demonstrate the ability to construct and develop a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. In particular answers in the form of bullet pointed lists may not be awarded full marks if there is no indication of logical flow between each point or if points are in an illogical order.

The mark schemes for some questions state that the maximum mark available for an extended response answer is limited if the answer is not coherent, relevant, substantiated and logically structured. During the standardisation process, the Lead Examiner will provide marked exemplar material to demonstrate answers which have not met these criteria. You should use these exemplars as a comparison when marking student answer.

Question	Answers	Additional Comments/Guidelines	Mark
01.1	The enthalpy change / Δ*H* when one mole of a (solid) ionic compound dissociates (fully) into gaseous ions	**Ignore** standard states / conditions **Allow** heat change at constant pressure when… **Ignore** heat change (alone) / energy change **M2 Allow** suitable equation with state symbols for ions **Not** one mole of gaseous ions	1 1 (2 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
01.2	$NH_4NO_3(s) \xrightarrow{(26)} NH_4^+(aq) + NO_3^-(aq)$ (LE) $NH_4^+(g) + NO_3^-(g)$ (–307) (–314) LE = 26 + 307 + 314 = (+)647	**Allow** + water or +aq M1 = cycle (3 'corners' with formulae and state symbols and suitable arrows) **Allow** equivalent Born-Haber style energy cycle **Not** ecf to M2 and M3 from incorrect cycle M2 = working e.g. 26 = LE – 307 – 314 M3 = answer (+)647 gets 3/3 if M1 given or 2/3 if not –647 = 2/3 if M1 given or 1/3 if not +595 / –595 = 2/3 if M1 given or 1/3 if not –621/+621 = 1/3 if M1 given **Not** ecf for M3 from incorrect expression in M2	 1 1 1 (3 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
01.3	($q = mc\Delta T$ =) 25.0 × 4.18 × (20.2–12.2) **OR** 25.0 × 4.18 × 8 (= 836 (J) or 0.836 (kJ))	**Not** if m = 29 **Ignore** sign of q	1
	4.00 g NH_4NO_3 = 4.00/80 **OR** 0.0500 mol		1
	$\Delta H^{\ominus}_{soln}$ = 836/0.05 = 16720 = (+)16.7(2) (kJ mol^{-1})	**Allow** ecf from M1 and/or from M2 –16.7(2) = 2/3 +19.4 = 2/3 (using m = 29 in M1) –19.4 = 1/3 +2.68 = 2/3 –2.68 = 1/3 +587 or +588 = 2/3 –587 or –588 = 1/3 **Allow** 2 sig figs or more	1 (3 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
01.4	(2 × 0.1/8) × 100 = 2.5%	**Allow** ecf from ΔT in 01.3	1 (AO2)

Question	Answers	Additional Comments/Guidelines	Mark
01.5	use a larger mass/amount of NH_4NO_3 / solid	Marking points are independent **Allow** smaller volume of water / less water **Allow** use more NH_4NO_3 **Not** larger volume of water **Ignore** higher concentration (of NH_4NO_3) **Ignore** any references to changing apparatus e.g. insulation	1
	so temperature change/decrease is greater **OR** final temperature is lower	**Allow** temperature increase is greater **Not** final temperature is higher	1 (2 x AO3)

Question	Answers	Additional Comments/Guidelines	Mark
01.6	heat gain (from the surroundings) / incomplete dissolving	**Allow** incomplete reaction **Allow** thermal energy gain **Not** heat loss **Ignore** energy gain **Ignore** references to mistakes in method	1 (AO3)

Question	Answers	Additional Comments/Guidelines	Mark
01.7	ΔS = (113 + 146) – 151 = +108 (J K^{-1} mol^{-1})		1
	$\Delta G = \Delta H - T\Delta S$ **OR** 26 – (298 × 108 × 10^{-3})	**Allow** ecf 26 – (298 x M1 x 10^{-3}) **Allow** ecf 26 – (298 x M1) **Allow M2** for 26000 – (298 x 108) **Allow M2** for 26 – (298 x 108)	1
	ΔG = –6.184 / –6.18 / –6.2	–32158 = **M1** and **M2** –32.2 = **M1** and **M2** –6184 = **M1** and **M2** (+)58.2 = **M2** and **M3** (ecf if -108 for M1)	1
	negative value for ΔG indicates reaction is feasible/spontaneous	**Allow** positive value for ΔG indicates reaction is NOT feasible/spontaneous **Allow** <0 or >0 as appropriate **M4** is standalone	1 (3 x AO2, 1 x AO3)

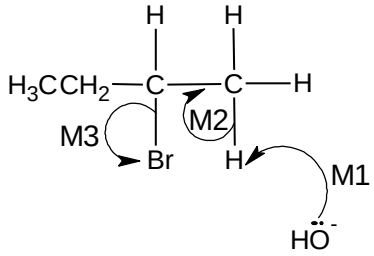
Question	Answers	Additional Comments/Guidelines	Mark
01.8	Converting ΔH into J **OR** ΔS into kJ		1
	($T = \Delta H/\Delta S$ = 123/144 × 10^{-3} **OR** 123000/144) = 854(.1666666) (K)	0.854 (K) = 1/2 0.00117 (K) = 1/2 (calculation upside down) 2SF minimum	1 (2 x AO2)

Question	Answers		Additional Comments/Guidelines	Mark
02	This question is marked using levels of response. Refer to the Mark Scheme Instructions for examiners for guidance on how to mark it.		**Indicative Chemistry content** **Stage 1 Formula** (1a) divides % masses by A_r for each element (N = 0.221; H = 6.18; Al = 0.221; S = 0.441; O =4.41) (1b) divides throughout by smallest and confirms <u>formula</u> as $NH_{28}AlS_2O_{20}$ Correct formula ticks 1a and 1b irrespective of method (1c) x = 12 **Stage 2 Ion ID** (2a) addition of $NaOH/OH^-$ and warming gives gas that turns (damp) red litmus blue (= ammonia) showing NH_4^+ (water bath = warm) (2b) white ppt with acidified $BaCl_2/Ba^{2+}$ = SO_4^{2-} (2c) addition of $NaOH/OH^-$ until in excess gives white ppt that redissolves = Al^{3+} **OR** addition of carbonate giving white ppt and effervescence/fizzing/bubbles/gas formed **Stage 3 Equations** (Ignore state symbols) (3a) $NH_4^+ + OH^- \rightarrow NH_3 + H_2O$ (3b) $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$ (3c) $Al(H_2O)_6^{3+} + 3\ OH^- \rightarrow Al(H_2O)_3(OH)_3 + 3\ H_2O$ **Allow** $Al^{3+} + 3\ OH^- \rightarrow Al(OH)_3$ (3d) $Al(H_2O)_3(OH)_3 + OH^- \rightarrow Al(H_2O)_2(OH)_4^- + H_2O$ **Allow** $Al(OH)_3 + OH^- \rightarrow Al(OH)_4^-$ etc. **OR** $2Al(H_2O)_6^{3+} + 3CO_3^{2-} \rightarrow 2Al(H_2O)_3(OH)_3 + 3CO_2 + 3H_2O$ Equation with CO_3^{2-} 'ticks' 3c AND 3d	6 (2 x AO2, 4 x AO3)
	Level 3 5-6 marks	All stages are covered and the explanation of each stage is correct and virtually complete Answer communicates the whole explanation, including equations, coherently and shows a logical progression through all three stages		
	Level 2 3-4 marks	All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies **OR** two stages covered and the explanations are generally correct and virtually complete Answer is coherent and shows some progression through all three stages. Some steps in each stage may be incomplete		
	Level 1 1-2 marks	Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies **OR** only one stage is covered but the explanation is generally correct and virtually complete Answer shows some progression between two stages		
	Level 0 0 marks	Insufficient correct Chemistry to warrant a mark		

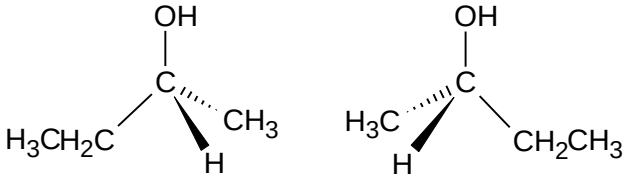
Question	Answers	Additional Comments/Guidelines	Mark
03.1	(for alkenes) elimination (for alcohols) nucleophilic substitution	**Allow** base elimination **Not** nucleophilic elimination	1 1 (2 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
03.2	(Different molecules/compounds with the) same (molecular and) structural formula Different spatial arrangement of atoms	 **Allow** different spatial arrangement of bonds/groups	1 1 (2 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
03.3	**A** = but-1-ene two groups/atoms/Hs the same on one of the C=C carbons	**Not** butene **Allow** two groups/atoms/Hs the same on first C **Not** two groups the same on one <u>side</u> of C=C **Ignore** references to no chiral carbon **Ignore '**priority' i.e. 2 groups with the same priority… gets M2 for '2 groups the same…'	1 1 (1 x AO1, 1 x AO3)

Question	Answers	Additional Comments/Guidelines	Mark
03.4		If wrong halogenoalkane used then max 2/3 **M1** lone pair on O, negative charge (anywhere) and curly arrow from lone pair to H on carbon 1 **Not** if (covalent) NaOH / additional arrows to or from NaOH / additional arrows to or from Na^+ **M2** curly arrow from C(1)–H to C(1)–C(2) **M2** is standalone from **M1** **Allow** ecf if H on carbon 3 attacked in **M1** for curly arrow from C(3)-H to C(2)–C(3) **Not** as ecf if H on carbon 2 attacked in **M1** for curly arrow from C(2)-H **M3** Curly arrow from C–Br to Br (mark is independent) **Not** if any additional arrows / incorrect polarity or formal charges on C–Br **Allow** ecf for mechanism to form but-2-ene from 03.3 **Allow** E1 mechanism M1 curly arrow from C–Br bond to the Br M2 curly arrow from lone pair on O of OH^- to a correct H on the correct C adjacent to C+ on the carbocation M3 curly arrow from a correct C–H bond to a correct C–C bond penalise M1 for any additional arrow(s) to/from the Br to/from anything else penalise M2 for any additional arrow(s) on NaOH	1 1 1 (3 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
03.5	*Z*-but-2-ene **AND** *E*-but-2-ene lack of/restricted/no (free) rotation around C=C/double bond	**allow** 'cis'/'trans' and **B** and **C** either way round **Allow** *E*/*Z* but-2-ene, cis/trans but-2-ene **Allow** C=C/double bond cannot rotate	1 1 (1 x AO1, 1 x AO3)

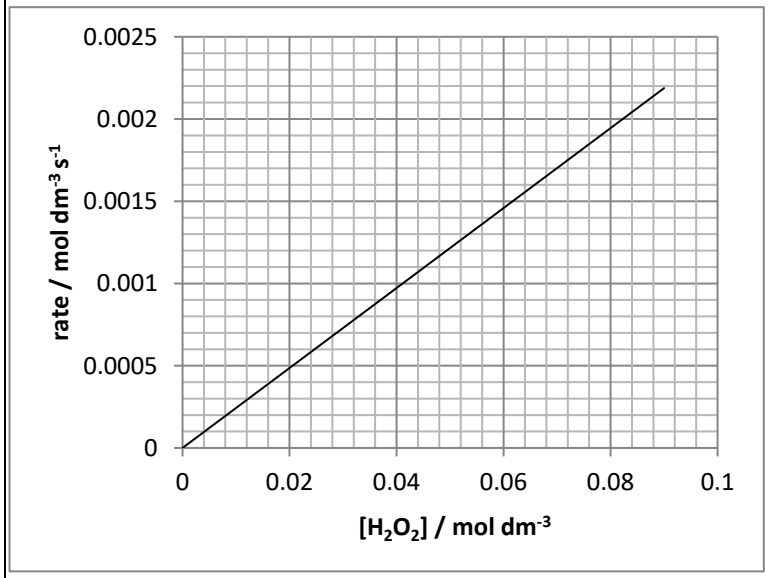
Question	Answers	Additional Comments/Guidelines	Mark
03.6		**M1** any correct 2D or 3D structure of butan-2-ol **Allow** C_2H_5 **M2** must show at least one wedge bond and one dash bond in each structure from the chiral C and any bonds **in the plane cannot** be at 180º to each other second structure could be drawn as mirror image of first **or** with same orientation of bonds and two groups swapped round **Allow** ECF for second structure from incorrect first structure, providing molecule is chiral	1 1 (1 x AO2, 1 x AO3)

Question	Answers	Additional Comments/Guidelines	Mark
03.7	Silver iodide then silver bromide then silver chloride bond strength C–I < C–Br < C–Cl	**Allow** yellow then cream then white **Allow** iodide/AgI then bromide/AgBr then chloride/AgCl **Allow** iodo(butane) then bromo(butane) then chloro(butane) **Ignore** iodine then bromine then chlorine **Ignore** incorrect formulae **Allow** carbon-halogen bond strength decreases down the group / from Cl to I	1 1 (2 x AO3)

Question	Answers	Additional Comments/Guidelines	Mark
04.1	**M1** High**er**/**est** concentration of / more H_2O_2 / particles / molecules / reactants **M2** More frequent successful collisions	**Alternative approach** **M1** Low**er**/**est** concentration of / fewer particles / molecules / reactants as time goes on **M2** Less frequent successful collisions (look for both ideas even if separated) **Ignore** 'chance' / 'probability'	1 1 (2 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
04.2	**M1** Suitable tangent drawn **M2** **–**0.00120 to –0.00155 (mol dm^{-3} s^{-1})	**M1** Tangent must be drawn with ruler and touch line at 0.05 mol dm^{-3} (± 1 square) and not cross the curve (if white seen between lines it crosses) **M2** **Ignore** units **Allow** ecf from unsuitable tangent i.e if M1 not awarded **Ignore** sign of gradient	1 1 (2 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
04.3	**M1** $[H_2O_2]_{initial}$ = 0.083 mol dm^{-3} **M2** $[H_2O_2]_t$ = 0.0664 (mol dm^{-3})	**Allow** 0.082 – 0.084 **Allow** 0.0656 – 0.0672 (scores 2/2) 2SF minimum **Allow** ecf from **M1** (M2 = M1 x 0.8)	1 1 (2 x AO3)

Question	Answers	Additional Comments/Guidelines	Mark
04.4	**M1** Points plotted **M2** best fit straight line drawn  	**M1** allow each point (± $\frac{1}{2}$ square) **M2** line should be drawn with a ruler and cover the five points given going within 1 square of each point, no doubles no kinks. The line does not need to be extended to the origin **Allow** reasonable best fit line if points plotted incorrectly	1 1 (1 x AO2, 1 x AO3)

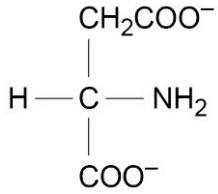
Question	Answers	Additional Comments/Guidelines	Mark
04.5	**M1** 1st (order) **M2** straight line graph through the origin	 **Ignore** rate is (directly) proportional to $[H_2O_2]$ **Allow** constant gradient line through the origin **Allow** use of data from line to show e.g. x2 conc = x2 rate **Allow** if M1 missing **Not** if M1 wrong	1 1 (2 x AO3)

Question	Answers	Additional Comments/Guidelines	Mark
05.1	**M1** $C_{14}H_{30} \rightarrow C_6H_{12} + C_8H_{18}$ or $C_{14}H_{30} \rightarrow 2\ C_3H_6 + C_8H_{18}$	**M1** Allow any correct structural representation of tetradecane, octane, and a cycloalkane with formula C_6H_{12} OR C_3H_6	1
	M2 **(**catalyst is in) different phase/state (to reactants)	**M2** Assume that 'it' refers to the catalyst **Allow** ……. to reactants and products **Not** …… to products	1 (1 x AO1, 1 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
05.2	**M1** autocatalyst: product of the reaction catalyses the reaction	**Not** 'reactant'	1
	M2 slow: negative ions repel / ions of same charge repel		1
	M3 high E_a	**Allow** catalyst reduces E_a as an alternative for **M3**	1
	M4 attraction between oppositely charged ions / negative reactant ion(s) and positive catalyst / Mn^{2+} / Mn^{3+}	**Not** catalyst reduces E_a as an alternative for **M4**	1
	M5 $4\ Mn^{2+} + MnO_4^- + 8\ H^+ \rightarrow 5\ Mn^{3+} + 4\ H_2O$	**Ignore** state symbols	1
	M6 $2\ Mn^{3+} + C_2O_4^{2-} \rightarrow 2\ Mn^{2+} + 2\ CO_2$		1 (6 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
05.3	**M1** idea of change from Co^{2+} to Co^{3+} and back to Co^{2+}		1
	M2 $E^{\ominus}$ $S_2O_8^{2-}$ / SO_4^{2-} > $E^{\ominus}$ Co^{3+} / Co^{2+} and so $S_2O_8^{2-}$ ions oxidise Co^{2+} **or** Co^{2+} ions reduce $S_2O_8^{2-}$	**M2 alternatives** electrode potential for $S_2O_8^{2-}$ greater than Co^{3+} so $S_2O_8^{2-}$ ions oxidise Co^{2+} **or** Co^{2+} ions reduce $S_2O_8^{2-}$ **OR** 2.01 (V) > 1.82 (V) so $S_2O_8^{2-}$ ions oxidise Co^{2+} **or** Co^{2+} ions reduce $S_2O_8^{2-}$ **OR** $2\ Co^{2+} + S_2O_8^{2-} \rightarrow 2\ Co^{3+} + 2\ SO_4^{2-}$ E_{cell} = (+)0.19 (V)	1
	M3 $E^{\ominus}$ Co^{3+} /Co^{2+} > $E^{\ominus}$ I_2 /I^- and so Co^{3+} ions oxidise I^- **or** I^- ions reduce Co^{3+}	**M3 alternatives** electrode potential for Co^{3+} greater than I_2 so Co^{3+} ions oxidise I^- **or** I^- ions reduce Co^{3+} **OR** 1.82 (V) > 0.54 (V) so Co^{3+} ions oxidise I^- **or** I^- ions reduce Co^{3+} **OR** $2\ Co^{3+} + 2\ I^- \rightarrow 2\ Co^{2+} + I_2$ E_{cell} = (+)1.28 (V) for **M2** and **M3 Allow** 1 mark (out of 2 marks) (if neither M2 or M3 already given) for combined: Co^{2+} ions reduce $S_2O_8^{2-}$ <u>AND</u> Co^{3+} oxidises I^-, **OR** $2\ Co^{2+} + S_2O_8^{2-} \rightarrow 2\ Co^{3+} + 2\ SO_4^{2-}$ **<u>AND</u>** $2\ Co^{3+} + 2\ I^- \rightarrow 2\ Co^{2+} + I_2$ **Not** if with negative E_{cell} value **Allow** if incorrect positive E_{cell} values	1 (3 x AO3)

6	C (AO2)	1	O
7	C (AO3)	1	HOOCCOOH
8	C (AO1)	1	poly(propene)
9	D (AO1)	1	There is an increase in the most probable energy of the molecules.
10	C (AO1)	1	Fluorine in F_2O is –1
11	C (AO1)	1	the surface area of the platinum electrode
12	A (AO1)	1	Electrons travel in the external circuit from zinc to lead.
13	A (AO3)	1	CH_3COO^-
14	B (AO2)	1	1.40
15	B (AO3)	1	KOH and CH_3COOH
16	A (AO2)	1	$Al(g) \rightarrow Al^+(g) + e^-$
17	D (AO3)	1	The second ionisation energy of rubidium is lower than the second ionisation energy of lithium.
18	D (AO1)	1	To prevent the precipitation of other silver compounds
19	D (AO3)	1	$FeCl_3(aq)$ and concentrated HCl(aq)
20	B (AO1)	1	ligand substitution
21	C (AO2)	1	1.0

22	C (AO2)	1	Free-radical substitution
23	B (AO2)	1	$CH_3CH_2NH_2$
24	A (AO1)	1	They are easily oxidised to carboxylic acids by acidified $K_2Cr_2O_7$ solution.
25	B (AO1)	1	methyl propanoate
26	B (AO1)	1	$CH_3CONHCH_2CH_3$
27	A (AO2)	1	$H_2NCH_2CH_2NH_2$
28	C (AO3)	1	Poly(propene)
29	D (AO2)	1	
30	B (AO3)	1	hydrolysis
31	B (AO2)	1	CH_3COOCH_3 and NaOH(aq)
32	B (AO1)	1	hydrogen bonds
33	D (AO1)	1	It reacts with hydrochloric acid.
34	C (AO1)	1	CH_3CH_2OH
35	B (AO3)	1	$CH_3CH(NH_2)CH_2COOH$