AQA

AS
Chemistry

7404/2-Paper 2 Organic and Physical Chemistry
Mark scheme

June 2018

Version/Stage: 1.0 Final

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 Assessment Writer.

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 error / 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 (i.e. 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 <u>not</u> 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 (e.g. 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.

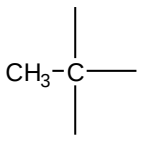
3.12 Organic structures

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.

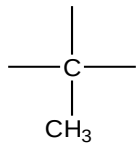
In general

- 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, e.g. 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, e.g 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.

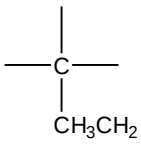
By way of illustration, the following would apply.



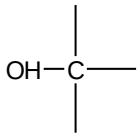
allowed



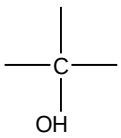
allowed



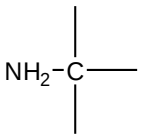
not allowed



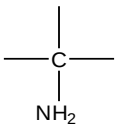
not allowed



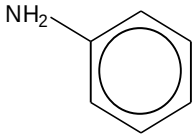
not allowed



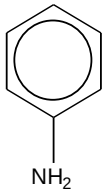
allowed



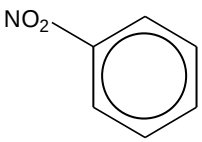
allowed



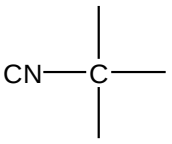
allowed



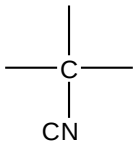
allowed



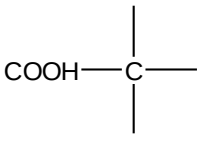
not allowed



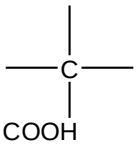
not allowed



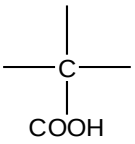
not allowed



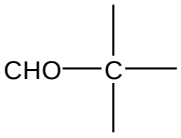
not allowed



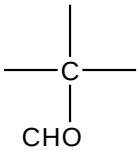
not allowed



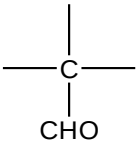
not allowed



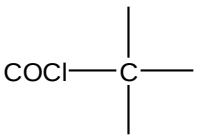
not allowed



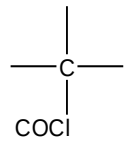
not allowed



not allowed



not allowed



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 <u>may</u> 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.

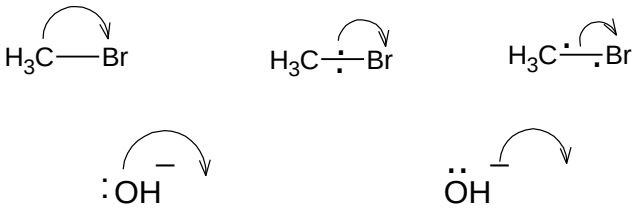
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

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**

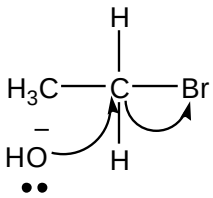
3.14 Organic reaction mechanisms

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 answers.

Question	Marking Guidance	Mark	Comments
1.1	**M1** provides a different route / mechanism / pathway **M2** with lower activation energy	1 1	Ignore reference to (frequency of) collisions, surface area or active sites Penalise reference to increasing energy of particles (CE = 0) Allow E_a / E_{act} or definition of activation energy in **M2**
1.2	**M1** line 2 = steeper than original and finishes at same height **M2** line 3 = less steep than original and finishes at half the height	1 1	If two correct lines are drawn but neither labelled, then allow 1 mark. If two correct lines are drawn and only one is labelled, then allow 2 marks. If only one correct line is drawn and neither are labelled, then 0 marks. If two correct lines are drawn but line 2 is labelled 1 and line 3 is labelled 2, then allow 1 mark Allow some unevenness in drawing of lines in terms of height it levels off at, with up to a quarter of a box of unevenness At the start, lines must separate from the original before the first vertical line. In terms of the origin, lines must start within one half of a square of the origin. For each line ignore the time at which the line becomes horizontal – it is the fact it is more or less steep than the original line that matters (along with the height at which it finishes)

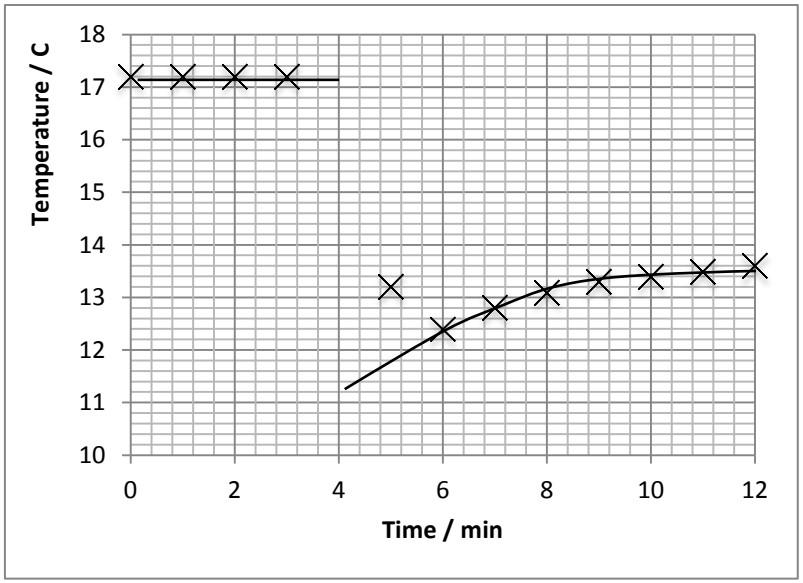
1.3	**M1** more particles/molecules/reactants/H_2O_2/moles in given/same volume/space OR particles/molecules/reactants/H_2O_2/moles closer together **M2** successful collisions are more frequent	1 1	Penalise reference to changing the activation energy (CE = 0) For **M1** do not allow area For **M2** *successful collisions* – allow reference to collisions with sufficient energy or collisions with the activation energy or effective collisions *more frequent* – allow reference to per unit time, per second (but ignore reference to rate of collisions, ignore chance of collisions, ignore likelihood of collisions)

Question	Marking Guidance	Mark	Comments
2.1	use of water would <u>dilute</u> the NaOH OR use of water would change the <u>concentration</u> of NaOH OR to ensure the <u>concentration</u> of the NaOH is not changed OR	1	Ignore reference to weakening the solution, watering down the solution, contaminate Allow it would gives a titre value that is larger it would decrease the pH of the NaOH (any additional qualifying reason given must be correct)
2.2	Rough = 25.2, 1= 23.90, 2 = 23.70, 3 = 24.00	1	Need all four (with rough to 1dp and the other three to 2dp)
2.3	**M1** use of titrations 1 & 3 only **M2** 23.95 (cm^3)	1 1	**M1** is for choosing correct titres **M2** is for calculating the mean to 2dp for their chosen titres 24.0 cm^3 = 1 mark (wrong number of decimal places) 24 cm^3 = 1 mark (only if it is clear that titration 2 is not included) 23.86 cm^3 = 1 mark (used all three titrations) 23.9 cm^3 = 0 marks (used all three titrations and wrong number of decimal places) If error(s) made in 2.2, allow ECF from 2.2, where they choose concordant titres and find the mean (can score **M1** and **M2**)
2.4	($\frac{0.15}{23.95}$ x 100) = 0.63%	1	(0.6263%) Allow any correct value with at least 2 significant figures based on their answer to 2.3. Rounding must be correct.

2.5	**M1** moles NaOH = $\frac{\mathbf{23.95}}{1000}$ x 0.0500 (= 0.001198) **M2** moles acid in flask = $\frac{\boldsymbol{M1}}{3}$ x 10 (= 0.003992) **M3** mass acid (= 0.003992 x 192.0 = 0.766 g) = 766 (mg)	1 1 1	Correct answer to at least 2sf = 3 marks (allow 760-770 mg) Correct value in grams (lose M3) = 2 marks (allow 0.76-0.77 g) Allow ECF at each stage (including those based on value from 2.3) Incorrect answers that are a factor of 10 too small lose M2 (76-77 mg = 2 marks, 0.076-0.077 g = 1 mark) (if use 25 cm^3 for volume of NaOH, then max 2 marks (**M2** and **M3** for 800 mg)

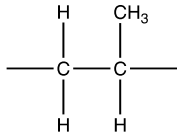
2.6	($\frac{\text{Answer to Q02.5}}{784}$ x 100) = 97.7 or 97.8%	1	Allow any correct value to at least 2 significant figures based on their answer to Q02.5 (values may be over 100% if 2.5 is incorrect)

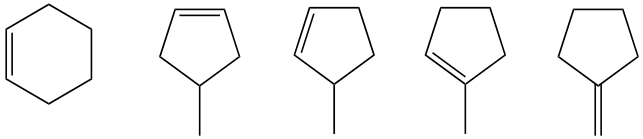
Question	Marking Guidance	Mark	Comments
3.1	**M1** moles (= $\frac{25}{1000}$ x 2.0) = 0.050 **M2** heat released = 0.050 x 56.1 (= 2.805 kJ or 2805 J) **M3** $\Delta T = \frac{q}{mc}$ **M4** $\Delta T = \frac{2805}{50 \times 4.18}$ or $\frac{1000 \times 0.050 \times 56.1}{50 \times 4.18}$ = 13(.4) (°C)	1 1 1 1	Correct answer (to at least 2 sig fig) scores 4 marks 27 or 26.8°C (from moles of two reagents being added together for **M2**, or use of 25 cm^3 in **M4**) scores 3 marks 0.013(.4)°C (from not converting kJ to J) scores 3 marks (loses **M4**) [0.027 or 0.0268°C would score 2 marks (loses **M2** and **M4**) **M1** moles can be shown for either substance or without specifying the substance; if it is shown for both substances, must be correct for both for **M1** Allow ECF from **M1** to **M2** Allow ECF from **M2** to **M4** (providing an attempt to calculate q has been made – no ECF if 56100 or 56.1 is used as q) Correct **M4** scores **M3**. If error made in **M4**, **M3** could score from substituted values in this expression in **M4** **M4** final answer to at least 2 sig fig. Penalise **M4** for negative temperature rise

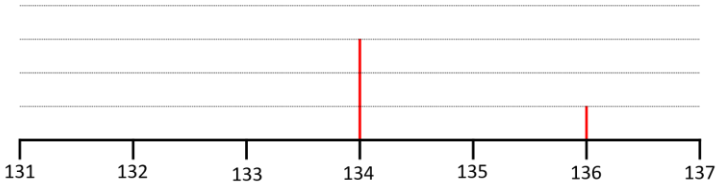
3.2	**M1** draws suitable best fit curve to 4 minutes  **M2** **(**17.2 – value read from graph line at 4 minutes) ± 0.2 (°C)	1 1	**M1** line must be a curve and ignore value at 5 minutes **M1** line should not go to times before 4 minutes **M2** allow use of any curved or straight line that is an attempt to draw a line through the values after 4 minutes (that may include the point at 5 minutes) **M2** allow negative values

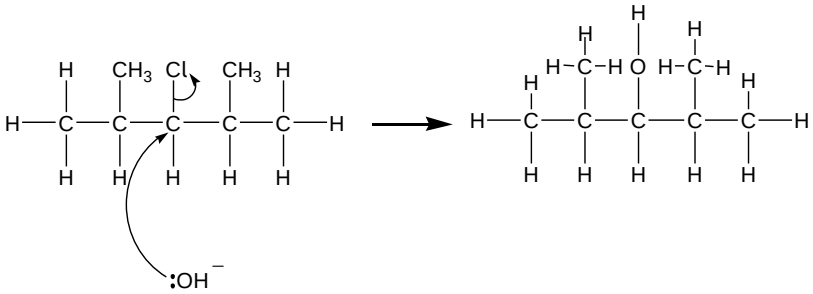
Question	Marking Guidance	Mark	Comments
4.1	**M1** C_nH_{2n+2} **M2** 14.0*n* + 2.0 or 14n + 2	1 1	 or 2(7.0n + 1.0) or 2.0(7n + 1) or 2(7n + 1)
4.2	**M1** nonane has stronger / greater / more <u>van der Waals' forces between molecules</u> **M2** nonane molecules pack closer together / more (surface) contact	1 1	or converse arguments for 2,4-dimethylbutane having lower boiling point question refers to nonane if not expressly stated by candidate intermolecular forces = forces between molecules **M1** ignore abbreviations vdW and/or imf **M2** ignore reference to surface area alone CE=0 reference to breaking (covalent) bonds / breaking chain
4.3	$C_9H_{20} + 14O_2 \rightarrow 9CO_2 + 10H_2O$	1	allow multiples; ignore any state symbols; correct structures rather than formulae are fine
4.4	**M1** nitrogen and oxygen from air react **M2** at high temperature	1 1	**M1** must be at least one reference to air and no reference to nitrogen/oxygen coming from the fuel ignore reference to pressure, heat, hot, incomplete combustion if temperature is stated, must be over 1000°C

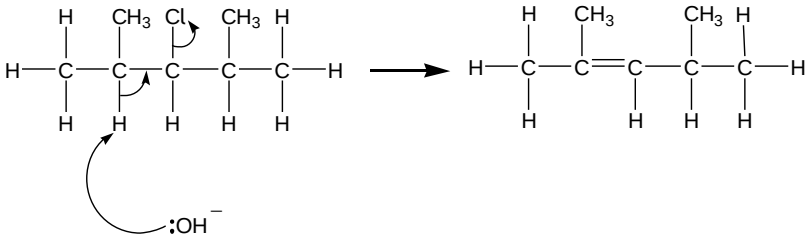
4.5	thermal (cracking)	1	

4.6		1	allow any correct structural representation ignore any n or brackets

Question	Marking Guidance	Mark	Comments
5.1	**M1** C:H = 7.3 : 12.2 seen **M2** **(**converting C:H 7.3 : 12.2 to 3:5) to give empirical formula = C_3H_5 **M3** molecular formula = C_6H_{10} **M4,5** two possible structures of C_6H_{10} (in any structural form) cyclic compounds with 6/5/4/3-membered C ring with one double bond, e.g.  or any dienes with with 6 C atoms, or a molecule with a triple bond **M6** (electrophilic) addition	1 1 1 2 1	Extended response: **M1** is for working of some sort leading to the formulae. If C_3H_5 and C_6H_{10} are both shown but it is not indicated which formula is which; or the formulas are stated the wrong way round, then allow 1 mark for **M2** and **M3** combined; if both correct formulas are given with only one stated correctly to be the empirical/molecular formula, then allow **M2** and **M3**. **M4** and **M5** ignore names given in addition to structures Credit **M4** and **M5** for correct names if no structures drawn Alternative route to C_6H_{10} that could gain credit **M1** 82/12 gives/suggests 6 C atoms **M2** molecular formula = C_6H_{10} **M3** empirical formula = C_3H_5 Alternative route to C_6H_{10} that could gain credit **M1** 82 x 0.878 = 72, (72/12) = 6 C atoms **M2** molecular formula = C_6H_{10} **M3** empirical formula = C_3H_5 Apply list principle to structures in **M4** and **M5** **M6** penalise nucleophilic addition; ignore bromination

Question	Marking Guidance	Mark	Comments
6.1	3-chloro-2,4-dimethylpentane	1	This answer only apart from slips with commas and dashes
6.2	**M1** lines at 134 and 136 **M2** line at 134 to be three times higher than line at 136 	1 1	**M1** is for drawing the correct two lines (if other lines are drawn, penalise **M1** (but ignore any additional very small lines at 135 or 137) **M2** is for the line at 134 being three times as big as the one at 136 (ignore other lines) Accept cross to represent top of lines; if bars drawn – they should be narrow (less than 10% of division) and clear which value they refer to.

6.3	**M1** nucleophilic substitution  **M2** curly arrow from lone pair on O of OH^- to C of C–Cl **M3** curly arrow from C–Cl bond to the Cl **M4** correct structure of alcohol (in any form)	1 1 1 1	Penalise **M3** for formal charge on C and/or Cl of C–Cl or incorrect partial charges on C– Cl; ignore other partial charges on uncharged atoms For SN2: penalise **M2** for any additional arrow(s) on NaOH, or for covalent NaOH; penalise **M3** for any additional arrow(s) to/from the Cl to/from anything else If SN1 mechanism given (loss of Cl first followed by attack by OH^-) then: **M2** curly arrow from C–Cl bond to the Cl **M3** curly arrow from lone pair on O of OH^- to positive C atom of correct carbocation penalise **M2** for any additional arrow(s) to/from the Cl to/from anything else penalise **M3** for any additional arrow(s) on NaOH If curly arrows represent an attempt at an elimination mechanism, cannot score **M2** or **M3** **M4** is independent **M4** ignore presence of non-organic products

6.4	**M1** elimination **M2** base  **M3** curly arrow from lone pair on O of OH^- to H on one of the C atoms adjacent to the C–Cl **M4** curly arrow from a correct C-H bond adjacent to the C–Cl to a correct C-C bond. Only award if an arrow is shown attacking the H atom of a correct adjacent C-H bond in **M3** **M5** curly arrow from C–Cl bond to the Cl (mark is independent **M6** correct structure of alkene (in any form)	1 1 1 1 1 1	**M1** allow base elimination (but nothing else) **M2** allow proton acceptor Penalise **M5** for formal charge on C and/or Cl of C–Cl or incorrect partial charges on C–Cl; ignore other partial charges on uncharged atoms For E2: penalise **M3** for any additional arrow(s) on KOH, or for covalent KOH; penalise **M5** for any additional arrow(s) to/from the Cl to/from anything else If E1 mechanism given (loss of Cl first followed by attack by OH^-) then: **M3** curly arrow from C–Cl bond to the Cl **M4** curly arrow from lone pair of OH^- to a correct H on the correct C adjacent to C^+ on the carbocation **M5** curly arrow from a correct C-H bond to a correct C-C bond penalise **M3** for any additional arrow(s) to/from the Cl to/from anything else penalise **M4** for any additional arrow(s) on KOH If curly arrows represent an attempt at a substitution mechanism, cannot score **M3** or **M4** **M6** is independent **M6** ignore presence of non-organic products

6.5	**C** as C=C 1620-1680 cm^{-1} OR no O-H 3230-3550 cm^{-1}	1	need the correct compound and an explanation full wavenumber range or value(s) within the range on this occasion candidates do not need to refer to the O-H bond being O-H alcohol as opposed to O-H acid – just reference to O-H with wavenumbers is required

6.6	C–Br is weaker than C–Cl or C–Br has lower bond enthalpy than C–Cl or C–Br breaks more easily C–Cl	1	Must compare the C–Br and C–Cl bonds specifically Ignore references to bond length, size of atoms, shielding, electronegativity and polarity Penalise idea that bromine is more reactive than chlorine

<table>
<tr><td>7.1</td><td colspan="3">This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.</td></tr>
<tr><td></td><td colspan="2">How to choose the level</td><td>Requirements for communication for higher mark</td><td>Stages</td></tr>
<tr><td>Level 3
5-6 marks</td><td>All three stages are covered and explanation of each stage is generally correct and virtually complete – leads to all four compounds being distinguished</td><td></td><td>• Answer communicates whole process coherently with logical progression
• Chemical tests (appear to) start with all compounds rather than selected compounds
• Chemical tests reagents and observations are complete and correct
• Chemical tests leave two compounds to be distinguished by spectroscopy
• Enough detail is given about the spectroscopy to distinguish these two compounds</td><td rowspan="4">Stage 1
Carries out a test-tube reaction to identify a compound (or to split the compounds into two groups).
1a reagent
1b observation with correct deduction

Stage 2
Carries out a second test-tube reaction to identify a second compound.
2a reagent
2b observation with correct deduction

Stage 3
Uses spectroscopy to distinguish two compounds.
3a suitable technique
3b data that will distinguish compounds

See next page for indicative content</td></tr>
<tr><td>Level 2
3-4 marks</td><td>All three stages are covered but the explanations of each stage may be incomplete or may contain inaccuracies</td><td>Two stages covered and explanations are generally correct and virtually complete</td><td>• Answer is mainly coherent
• Chemical tests reagents and observations are complete and correct
• Enough detail is given about the spectroscopy to distinguish these two compounds (if spectroscopy included)</td></tr>
<tr><td>Level 1
1-2 marks</td><td>Two stages covered but the explanations of each stage may be incomplete or may contain inaccuracies</td><td>One stage covered and explanation is generally correct and virtually complete</td><td>• Chemical tests reagents and observations are complete and correct (if awarded level 1 for one chemical test stage)
• Enough detail is given about the spectroscopy to distinguish these two compounds (if spectroscopy included)</td></tr>
<tr><td>0 marks</td><td colspan="2">Nothing valid to warrant a mark</td><td></td></tr>
</table>

Possible test tube reactions

Tollens' reagent [or Fehling's / Benedict's]

Identifies butanal – silver mirror (or black ppt) [or orange/brick/red ppt with Fehling's]

(No reaction with other compounds)

Acidified potassium dichromate

Reacts with butanal and butan-2-ol – goes green

(No reaction with other compounds)

Sodium *(not on specification but may be mentioned)*

Reacts with butan-2-ol and 2-methylpropan-2-ol – fizzes

(No reaction with other compounds)

Examples of incomplete/incorrect reagents include "Tolling's solution", no acid with potassium dichromate, wrong oxidation state for Cr in potassium dichromate if stated.

Examples of incomplete/incorrect observations include silver precipitate with Tollens', green ppt with acidified potassium dichromate

Possible spectroscopic methods for a pair

IR (infra-red) spectroscopy

If different functional groups: need to identify wavenumber and bond of key functional group signal (e.g. (alcohol) O-H 3230-3550 or C=O 1680-1750 (cm^{-1})).

If same functional group, need idea of using fingerprint region to look for match to known compounds / comparing region to samples in a database

Mass spectrometry

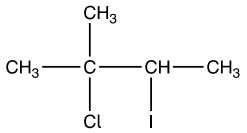
If different, can use different M_r values with values of M_r given

butanone 72(.0), 2-methylpropan-2-ol = 74(.0), butan-2-ol = 74(.0), butanal = 72(.0)

If compounds have same M_r, then would have to use idea that fragmentation patterns would be different *(not on specification but may be mentioned)*

Question	Marking Guidance	Mark	Comments
8.1	**M1** no effect (on yield) **M2** increases rate / speed of both / forward and reverse reactions <u>equally / by the same amount</u>	1 1	CE = 0 if yield changes If no reference to effect on yield, could still score **M2** Ignore reference to no change in position of equilibrium, and reference to lowering activation energies **M2** allow changes rate of both / forward and reverse reactions <u>equally / by the same amount</u>
8.2	$(K_c =) \frac{[CH_3OH]}{[CO][H_2]^2}$	1	Must be square brackets Ignore state symbols Ignore units
8.3	**M1** divides moles by volume (0.250 or $\frac{250}{1000}$) **M2** $K_c = \frac{\frac{0.0610}{0.250}}{\left[\frac{0.340}{0.250}\right]\left[\frac{0.190}{0.250}\right]^2} \left(= \frac{0.244}{1.36 \times 0.76^2}\right)$ **M3** 0.311	1 1 1	Correct answer scores 3; **M3** to at least 2sf (0.3106159 …); ignore units Allow ECF from **M1** to **M2** if an attempt to calculate concentration has been made by dividing by some factor of 250 cm^3 Allow ECF from **M2** to **M3** for use of an expression containing each reagent in a correctly substituted K_c expression If volume not used, then allow **M3** only for 4.97 (4.96985 … to at least 2sf)

8.4	**M1** $\frac{1}{Answer\ to\ 8.3}$ = 3.22 **M2** $mol^2\ dm^{-6}$	1 1	**M1** to at least 2sf (0.31 gives 3.2(258)) **M1** = 1.21 if alternative answer to 8.3 used If an error was made in 8.3, but the candidate produced an answer in 8.4 that did fit the inverted calculation from 8.3, then candidate could score **M1** (if volumes are not used, then candidate would get 0.20(12.)

Question	Marking Guidance	Mark	Comments
9	**B**	1	490 cm^3
10	**D**	1	CBr_4
11	**C**	1	
12	**C**	1	The higher the temperature, the higher the equilibrium yield of ethanol
13	**B**	1	butan-2-ol
14	**B**	1	each fraction is a mixture of hydrocarbons
15	**C**	1	6
16	**D**	1	D
17	**B**	1	36.4%
18	**C**	1	PH_3
19	**C**	1	Its brittleness is reduced by plasticisers
20	**A**	1	+112

Question	Marking Guidance	Mark	Comments
21	**C**	1	6.8×10^{25}
22	**C**	1	1.20 g of dichloromethane (density = 1.33 g cm^{-3})
23	**D**	1	$CH_3CFCl_2 \rightarrow CH_3CFCl\bullet + Cl\bullet$