AS
CHEMISTRY
7404/2

Paper 2 Organic and Physical Chemistry

Mark scheme

June 2023

Version: 1.0 Final

236A7404/2/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

Copyright information

AQA retains the copyright on all its publications. However, registered schools/colleges for AQA are permitted to copy material from this booklet for their own internal use, with the following important exception: AQA cannot give permission to schools/colleges to photocopy any material that is acknowledged to a third party even for internal use within the centre.

Copyright © 2023 AQA and its licensors. All rights reserved.

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 (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 <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.

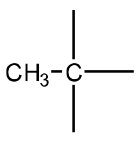
3.12 Organic structures

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.

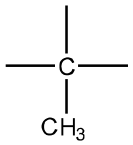
In general

- 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, 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.

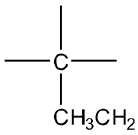
By way of illustration, the following would apply.



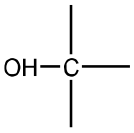
allowed



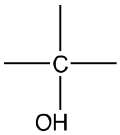
allowed



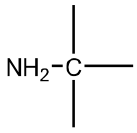
not allowed



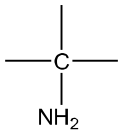
not allowed



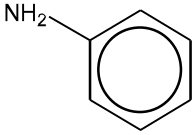
not allowed



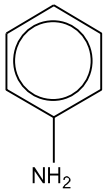
allowed



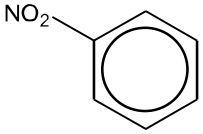
allowed



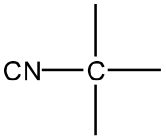
allowed



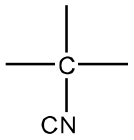
allowed



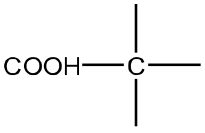
not allowed



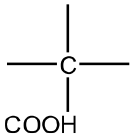
not allowed



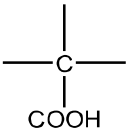
not allowed



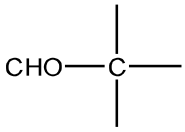
not allowed



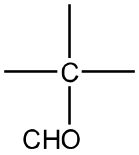
not allowed



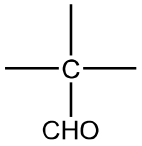
not allowed



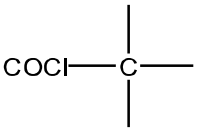
not allowed



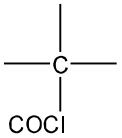
not allowed



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.

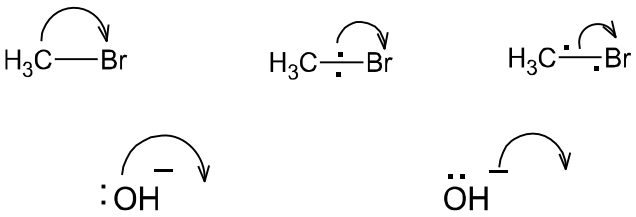
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

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**

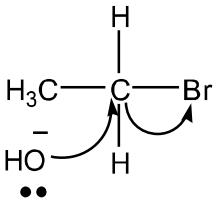
3.14 Organic reaction mechanisms

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.

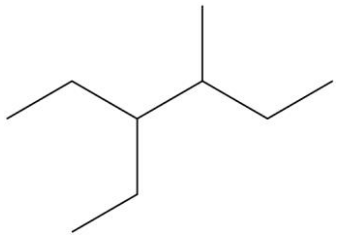
Question	Marking guidance	Additional Comments/Guidelines	Mark
01.1	**M1** Tollens' reagent or ammoniacal silver nitrate **M2** silver mirror **M3** no reaction / no (visible) change / colourless OR **M1** Fehling's solution **M2** orange/brick/red solid/precipitate **M3** no reaction / no (visible) change	Alternative **M1** sodium **M2** no reaction / no (visible) change **M3** fizzing / bubbles / effervescence Do not allow acidified potassium dichromate(VI) If no reagent or incorrect reagent in **M1**, then no marks can score in **M2/3** Allow name or formula of suitable reagent for **M1.** Penalise incorrect formula of correct reagent in **M1** (even if correct name also given) but mark on for **M2/3** For Tollens': ignore $AgNO_3$ or $[Ag(NH_3)_2]^+$ or silver mirror test or "Tollings' reagent" on their own, but mark on for **M2/3.** Allow silver/black precipitate/solid/deposit for **M2.** For Fehling's (or Benedict's): ignore $Cu^{2+}(aq)$ or $CuSO_4$ or "Fellings" on their own, but mark on for **M2/3** Ignore "nothing (happens)" / "no observation"	3 (3 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
01.2	**M1** bromine (water) / Br_2 / Br_2(aq) **M2** orange/yellow / no reaction / no (visible) change **M3** colourless / decolourised	Alternative **M1** acidified potassium manganate(VII) / $KMnO_4/H^+$ **M2** no reaction / no (visible) change / purple **M3** colourless / decolourised If no reagent or incorrect reagent in **M1**, then no marks can score in **M2/3** Allow name or formula of suitable reagent for **M1.** Penalise incorrect formula of correct reagent in **M1** (even if correct name also given) but mark on for **M2/3.** Allow brown-red or brown for **M2.** (Ignore red) Ignore clear for **M3**	3 (3 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
01.3	**M1** H = 1.0078 **M2** C = 12.0096 **M3** M_r= (6 × M1) + (6 × M2) = 78.1044	**M2** Allow ECF from **M1** **M3** Allow ECF from **M1** and **M2** Penalise not giving answers to 4dp once only (on the first occasion it would score otherwise) (providing answers are given to at least 2dp)	3 (3 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
02.1	(mixture of) compounds/substances with similar boiling points	Allow similar number of carbon atoms / chain length / M_r / size Ignore same boiling point / number of C atoms / chain length / M_r / size Ignore reference to similar melting points Ignore reference to similar chemical properties	1 (AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
02.2	zeolites / aluminosilicates	Ignore aluminium oxide	1 (AO1)

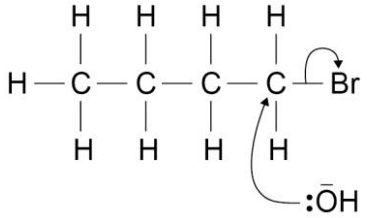
Question	Marking guidance	Additional Comments/Guidelines	Mark
02.3	 1	Must be skeletal formula Ignore working, including other forms of structure of this compound.	1 (AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
02.4	**M1** C_9H_{20} **M2** $C_9H_{20} + 14\,O_2 \rightarrow 9\,CO_2 + 10\,H_2O$	For **M2** allow ECF from their molecular formula, providing it is an attempt at the molecular formula of a hydrocarbon Penalise **M1** only for not using molecular formula Allow multiples and fractions	2 (2 x AO1)

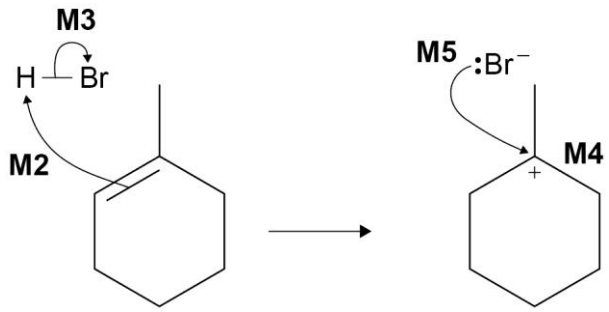
Question	Marking guidance	Additional Comments/Guidelines	Mark
02.5	(C=O) bonds vibrate (at IR frequency) / (IR/it makes) bonds vibrate **or** net change in dipole moment of molecule during (asymmetric) vibration **or** (C=O) bonds are polar	Do not allow that CO_2 is a polar molecule / has a dipole	1 (AO1)

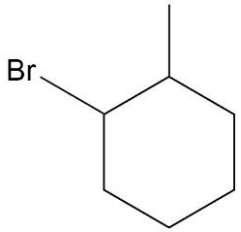
Question	Marking guidance	Additional Comments/Guidelines	Mark
02.6	**M1** acid rain / respiratory problems **M2** catalytic converters	**M1** Allow direct consequences of acid rain; allow smog; allow production of ground level ozone **M2** allow description of process that occurs in catalytic converter but must include reference to a (named) catalyst	2 (2 x AO1)

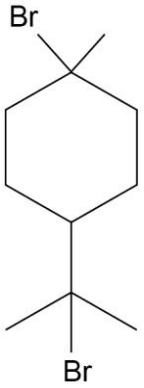
Question	Marking guidance	Additional Comments/Guidelines	Mark
02.7	no net emissions of carbon dioxide/CO_2 to the atmosphere	Allow explanation showing that same amount of CO_2 taken in and released to the atmosphere Answer needs to refer to carbon dioxide (not just carbon)	1 (AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
03.1	 **M1** arrow from lone pair on O of OH^- to the correct C **M2** arrow from the C–Br bond to the Br	All arrows are double-headed. Penalise one mark from the total if half headed arrows are used Do not penalise the "correct" use of "sticks" Penalise only once in mechanism for a line and two dots to show a bond Allow the minus sign to be anywhere on the OH^- ion **M2** penalise formal charges or incorrect partial charges on C–Br bond Allow SN1 mechanism with **M1** for breakage of C–Br bond **M2** for attack by OH^- on correct carbocation **Max 1 of 2 marks** for wrong organic reactant Ignore wrong organic product (if shown) **Extra arrows or incorrect covalent bonds:** Penalise the mark for breaking of C–Br bond for any extra arrows involving Br or covalent bond in NaBr in **M2** Penalise the mark for attack for any extra arrows involving OH^- or covalent bond in NaOH in **M1** **M2** could potentially score if an elimination mechanism is shown	2 (2 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
03.2	**M1** Iodide ions are produced more rapidly than bromide ions or gradient (of iodide ions graph) is steeper **M2** C–I is weaker than C–Br **or** C–I has lower bond enthalpy than C–Br **or** C–I breaks more easily than C–Br	**M2** Must compare the C–I and C–Br bonds specifically Ignore references to bond length, size of atoms, shielding, electronegativity and polarity Penalise idea that iodine is more reactive than bromine	2 (2 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.1	**M1** electrophilic addition  **M2** must show an arrow from the double bond towards the H atom of the HBr molecule **M3** must show the breaking of the H-Br bond **M4** is for the structure of the correct carbocation (the added H does not need to be shown) **M5** must show an arrow from the lone pair of electrons on the negatively charged Br towards the positively charged atom of <u>their</u> carbocation drawn	All arrows are double-headed. Penalise one mark from the total if half headed arrows are used Do not penalise the "correct" use of "sticks" Penalise only once in mechanism for a line and two dots to show a bond Mechanism can involve skeletal or structural formulae. If skeletal, do not penalise presence of hydrogen atoms (and bonds) **Max 3 of 4 marks** (**M2-5**) for wrong organic reactant or wrong carbocation (ignore structure of product) Ignore partial negative charges on the double bond in **M2** Penalise incorrect partial charges on the H–Br bond or formal charges in **M3** Penalise **M4** if there is a bond drawn to the positive charge For **M5**, credit attack on a partially positively charged carbocation structure, but penalise **M4** for the structure of the carbocation.	5 (1 x AO1, 4 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.2	 **M1** **M2** idea that 1-bromo-1-methylcyclohexane is formed from/via or has more stable carbocation **M3** idea that major product from tertiary carbocation rather than secondary carbocation **M4** idea of stability from greater (positive) inductive effect (from more alkyl/C groups) or more electron-releasing alkyl/C groups	**M1** Penalise inclusion of —H bonds (allow carbonium ion in place of carbocation) **M2** and **M3** must refer to stability of carbocations (ignore reference to stability of products) **M3** allow descriptions in terms of number of alkyl groups attached to positive C atom **M4** must be a comparison	4 (3 x AO2, 1 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.3		Any correct form of the structure	1 (AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
05.1	Correct answer scores 3 **M1** temperature rise = 59.2 °C and mass = 250 g **M2** q = 250 × 4.18 × 59.2 (= 61864 (J)) **M3** heat change per mole $\left(= \frac{-61.684}{0.030}\right)$ = –2062 kJ mol^{-1}	Allow ECF at each stage **M1/2** Allow 78.1–18.9 in place of 59.2 **M3** allow correct value to at least 2sf, (–2100, –2060, –2062, –2062.1, –2062.13, etc) –11572 for using 273+59.2 scores **M2** and **M3** Use of 4.81 in place of 4.18 gives –2372 and would score **M1** and **M3**	3 (3 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
05.2	**M1** idea that value measured is not accurate due to due to heat loss / incomplete combustion **M2** idea that the result from the experiment must be less exothermic than the true value and so cannot be propan-1-ol / both ethanol & propan-1-ol / the others	**M1** allow evaporation of alcohol **M2** allow alternative language for less exothermic: e.g. smaller enthalpy of combustion / less negative	2 (2 x AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
05.3	Correct answer (286) with working scores 3 **M1** ΔH (or –3388) = ΣB(reactants) – ΣB(products) **or** ΔH (or –3388) = ΣBonds broken - ΣBonds formed **or** ΔH (or –3388) = 4 B(C–C) + 11 B(C–H) + B(C–O) + B(O–H) + 7½ B(O=O) – 10 B(C=O) – 12 B(O–H) **M2** –3388 = 4 B(C–C) + 11(412) + 360 + 463 + 7½(496) – 10(805) – 12(463) **or** –3388 = 4 B(C–C) + 9075 – 13606 **or** –3388 = 4 B(C–C) – 4531 **or** 4 B(C–C) = 1143 **M2** also scores **M1** **M3** B(C–C) = $\frac{M2}{4}$ = (+)286 (kJ mol^{-1}) (allow ECF from **M2** to **M3**)	If no other marks scored, allow 1 mark for 13606 for bonds formed or 9075 for bonds broken (apart from C-C) 229 scores 2 marks (for assuming there are 5 not 4 C–C bonds) –1979.75 scores 2 marks (rearrangement error) **M3** ignore units; allow 285.75, 285.8, 286 (not 290)	3 (3 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
05.4	Correct answer scores 2 **M1** amount of butan-1-ol in 1 dm^3 = $\frac{810}{74(.0)}$ (=10.95 mol) **M2** energy from 1 dm^3 = **M1** × 2676 = 29300 ($kJ\ dm^{-3}$)	Allow correct answers to at least 2sf (29291.351..) Ignore sign of final answer Overall calculation is: $\frac{2676 \times 810}{74(.0)}$ 29.3 scores 1 mark Allow ECF from **M1** to **M2** if **M1** is an attempt using 74(.0) Alternative **M1** energy per gram of fuel = $\frac{2676}{74(.0)}$ (= 36.1 kJg^{-1}) **M2** energy per dm^3 = **M1** × 810 = 29300 ($kJ\ dm^{-3}$)	2 (2 x AO2)

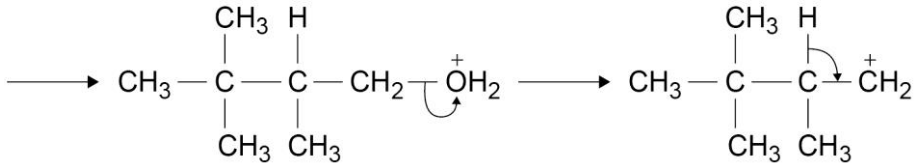
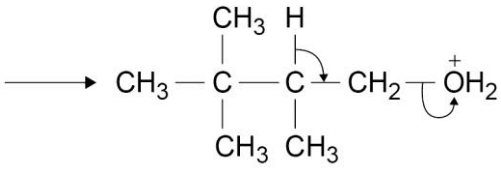
Question	Marking guidance	Additional Comments/Guidelines	Mark
06.1	Cl is more electronegative (than C) **or** C and Cl have different electronegativities	Allow idea that electrons (in bond) are not shared equally	1 (AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.2	idea that dipole moments (or dipoles) cancel out (due to symmetry)	Allow polar bonds / polarities cancelling out	1 (AO3)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.3	**M1** van der Waals' forces between molecules in CCl_4 stronger than (combined van der Waals' and) dipole-dipole forces between molecules in CH_2Cl_2 **M2** as CCl_4 has (many) more electrons than CH_2Cl_2	**M1** must refer to the forces being between molecules at some point NOT **M1** for any reference to bond breaking NOT **M1** for any reference to incorrect intermolecular forces Allow London forces or temporary (induced) dipole-dipole forces for van der Waals' forces For **M2**, allow CCl_4 has higher mass or higher M_r or bigger than CH_2Cl_2	2 (2 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
06.4	**M1** attraction between O lone pair **M2** and δ+ H of OH on another molecule	no marks if answer indicates that the hydrogen bond is the O–H bond within a molecule Marks could be awarded from a suitable diagram	2 (2 x AO1)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.1	**M1** idea of ensuring condenser fills with water **M2** idea that condenser is cool(er) **or** ensuring (more) vapour condenses		2 (2 x AO3)

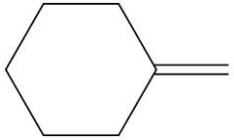
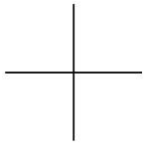
Question	Marking guidance	Additional Comments/Guidelines	Mark
07.2	**M1** elimination  OR  **M2** correct protonated intermediate with OH_2^+ **M3** loss of H_2O: correct arrow from middle of C–O bond to the O **M4** loss of H^+: correct arrow from middle of correct C–H bond to correct C–C bond	**M1** ignore dehydration; ignore reference to acid-catalysed **M2** + charge anywhere on OH_2 group **M3** and **M4** can be two separate steps or all in one step – if two steps shown then the correct carbocation is part of **M4** Ignore structure of product For **M3/4**, penalise extra arrows on the original structure (or elsewhere) that contradict "correct" ones	4 (1 x AO1, 3 x AO2)

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.3	Correct answer scores 5 **M1** mass of alcohol = 12 × 0.818 (= 9.816 g) **M2** amount of alcohol = $\frac{\mathbf{M1}}{116(.0)}$ (= 0.0846 mol) **M3** M_r of alkene = 98(.0) **M4** mass of alkene expected = **M2** × **M3** (= 8.29 g) **M5** % yield = $\frac{6.12}{\mathbf{M4}}$ × 100 = 73.8% (at least 2sf)	Alternative **M4** mol of alkene formed = $\frac{6.12}{\mathbf{M3}}$ (= 0.0624 mol) **M5** % yield = $\frac{\mathbf{M4}}{\mathbf{M2}}$ × 100 = 73.8% (at least 2sf) Allow ECF at each stage **M5** should be an attempt at (their) mass (or moles) of alkene achieved divided by their mass (or moles) of alkene expected x 100	5 (1 x AO1, 4 x AO2)

<table>
<tr><th>Question</th><th colspan="2">Marking Guidance</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr><td rowspan="5">08</td><td colspan="2">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><td rowspan="5">Stage 1 – Single distribution curve
1a suitable axis labels:
vertical: number/proportion/fraction of molecules/particles;
horizontal: (kinetic) energy
1b suitable shape (including on LHS must start reasonably close to 0,0 and RHS must not meet x-axis or rise upwards (on each curve drawn))

Stage 2 - Distribution curve at higher temperature
2a peak moves to the right and down
2b area under the curve (roughly) the same
2c lines cross once only

Stage 3 - Why a gas reacts faster at higher temperature
3a molecules have more energy
3b more molecules have the activation energy
3c higher proportion of collisions are successful / increases frequency of successful collisions</td><td rowspan="5">6
(6 x AO1)</td></tr>
<tr><td>Level 3
(5-6 marks)</td><td>All stages are covered and each stage is generally correct and virtually complete.
(6 v 5) Answer is well structured, with no repetition or irrelevant points, and covers all aspects of the question. Accurate and clear expression of ideas with no errors in use of technical terms.</td></tr>
<tr><td>Level 2
(3-4 marks)</td><td>All stages are covered but stage(s) may be incomplete or may contain inaccuracies OR
two stages are covered and are generally correct and virtually complete.
(4 v 3) Answer has some structure and covers most aspects of the question. Ideas are expressed with reasonable clarity with, perhaps, some repetition or some irrelevant points. If any, only minor errors in use of technical terms.</td></tr>
<tr><td>Level 1
(1-2 marks)</td><td>Two stages are covered but stage(s) may be incomplete or may contain inaccuracies OR
only one stage is covered but is generally correct and virtually complete.
(2 v 1) Answer includes statements which are presented in a logical order and / or linked.</td></tr>
<tr><td>0 marks</td><td>Insufficient correct chemistry to gain a mark.</td></tr>
</table>

Question	Marking Guidance	Mark	Comments
9	D	1 (AO3)	methylpropene
10	C	1 (AO1)	$\bullet CH_3 + Cl_2 \rightarrow CH_3Cl + \bullet Cl$
11	C	1 (AO1)	$CCl_3CH_2CCl_3 + 2Cl_2 \rightarrow CCl_3CCl_2CCl_3 + 2HCl$
12	A	1 (AO1)	Ozone absorbs ultraviolet radiation
13	B	1 (AO2)	
14	B	1 (AO2)	but-2-en-1-ol
15	B	1 (AO3)	polymerisation of tetrafluoroethene
16	D	1 (AO3)	An increase in temperature decreases the value of K_c
17	D	1 (AO3)	10
18	A	1 (AO2)	*E*-3-fluorohex-3-ene
19	C	1 (AO2)	line **C**
20	A	1 (AO1)	

21	D	1 (AO1)	methylpropanoic acid
22	B	1 (AO1)	CH_3COCH_3
23	A	1 (AO1)	31.5%