AS
CHEMISTRY
7404/2

Paper 2 Organic and Physical Chemistry

Mark scheme

June 2019

Version 1.0 Final

196A74042/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 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 and Observations

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.

- Where an observation is required, the answer must state clearly what is seen, heard or detected by smell. Statements such as 'carbon dioxide is given off' or 'barium sulfate is formed' would not gain marks as observations. Credit would be given for descriptions such as 'effervescence' or 'fizzing' or for 'white precipitate or white ppt'.
- Where relevant, 'no visible change' is an acceptable answer, but the statement 'no observation' would not gain a mark.

3.12 Organic structures

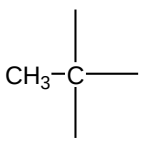
Where students are asked to draw organic structures, unless a specific type is required in the question and stated in the mark scheme, these may be given as displayed, structural or skeletal formulas or a combination of all three as long as the result is unambiguous.

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.



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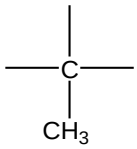

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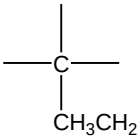

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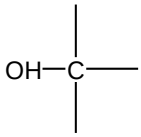

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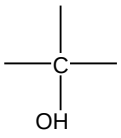

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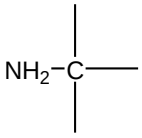

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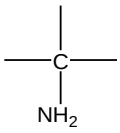

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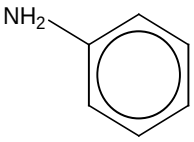

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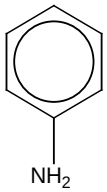

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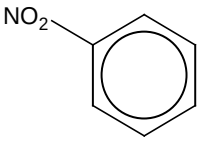

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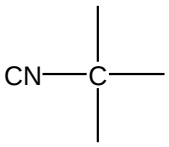

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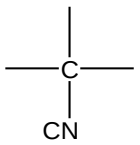

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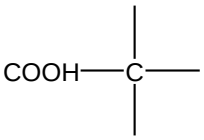

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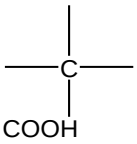

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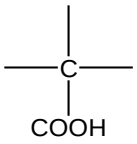

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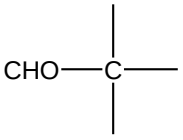

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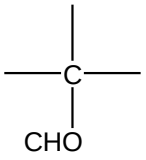

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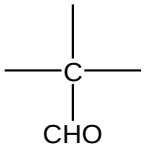

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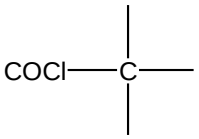

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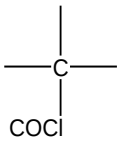


not allowed

- 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
  - 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.

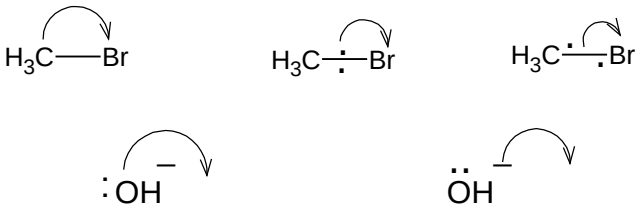
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

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**

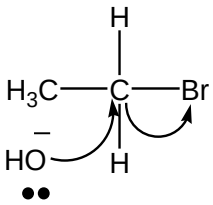
3.14 Organic reaction mechanisms

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

Mechanisms may be drawn using structural, displayed or skeletal formulae. However, if skeletal formulae are used in mechanisms such as elimination reactions (from halogenoalkanes or alcohols) or in electrophilic substitutions, any hydrogen atoms that are essential to a step in the mechanism must be shown.

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.

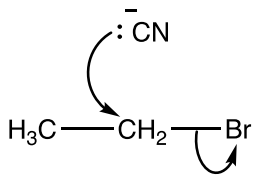
For other extended response answers:

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** Named carbonate / hydrogencarbonate / bicarbonate (or Mg / Na) **M2** No (visible/observed) reaction/change**/**effect **M3** effervescence / bubbles (of gas) / fizzing ***OR*** **M1** universal indicator **M2** neutral / no change / pH7 **M3** orange / red / pH < 7 / acidic	Allow any correct chemical test. If no reagent or incorrect reagent in **M1**, **CE= 0** and no marks for **M2** or **M3** Allow name or formula of suitable reagent in **M1** In **M3** ignore reference to name/formula of correct gas, but penalise reference to name/formula of incorrect gas In **M3** allow reference to limewater going cloudy as an alternative Penalise incorrect formula of correct reagent (or incomplete reagent) in **M1**, but mark on for **M2** and **M3** Where there is no reaction, ignore “nothing (happens)” or “no observation” If use of named alcohol in **M1**, allow no reaction for **M2** and sweet smell for **M3** Allow use of other suitable indicators (e.g. litmus)	1 1 1

Question	Marking guidance	Additional Comments/Guidelines	Mark
01.2	**M1** Tollens' (reagent) OR ammoniacal silver nitrate OR a description of making Tollens' **M2** No (visible/observed) reaction/change or stays colourless **M3** silver mirror or black solid / precipitate **OR** **M1** Fehling's (solution) or Benedict's solution **M2** no (visible/observed) reaction/change or stays blue **M3** red <u>solid / precipitate</u> (credit orange or brown) ***OR*** **M1** acidified potassium dichromate or $K_2Cr_2O_7/H_2SO_4$ ***or*** $K_2Cr_2O_7/H^+$ ***or*** acidified $K_2Cr_2O_7$ **M2** no (visible/observed) reaction/change or stays orange **M3** (orange to) <u>green</u> solution ***or*** goes <u>green</u> ***OR*** **M1** acidified potassium manganate(VII) or $KMnO_4/H_2SO_4$ ***OR*** $KMnO_4/H^+$ ***OR*** acidified $KMnO_4$ **M2** no (visible/observed) reaction/change or stays purple **M3** (purple to) <u>colourless</u> solution **OR** goes <u>colourless</u>	Allow any correct chemical test. If no reagent or incorrect reagent in **M1**, **CE= 0** and no marks for **M2** or **M3** Allow name or formula of suitable reagent in **M1** Penalise incorrect formula of correct reagent in **M1**, but mark on for **M2** and **M3** For Tollens' reagent: for **M1** ignore either $AgNO_3$ or $[Ag(NH_3)_2^+]$ or "the silver mirror test" on their own, or "Tolling's reagent", but mark **M2** and **M3**; for **M3** allow silver precipitate/deposit For Fehling's/Benedict's solution: for **M1** Ignore $Cu^{2+}(aq)$ or $CuSO_4$ or "Fellings" on their own, but mark **M2** and **M3** For acidified potassium dichromate(VI): if "dichromate" or "(potassium) dichromate(IV)" or incorrect formula or no acid, penalise **M1** but mark **M2** and **M3;** for **M3** ignore dichromate described as "yellow" or "red". For acidified potassium manganate(VII): If "manganate" or "(potassium manganate(IV)" or incorrect formula or no acid, penalise **M1** but mark **M2** and **M3**. Credit alkaline / neutral $KMnO_4$ for possible full marks but **M3** gives <u>brown precipitate</u> or solution goes <u>green</u> Where there is no reaction, ignore "nothing (happens)" or "no observation"	1 1 1

Question	Marking guidance	Additional Comments/Guidelines	Mark
02.1	 **M1** arrow from lone pair on C of CN^- to the C of the CH_2 group **M2** arrow from the C–Br bond to the Br	All arrows are double-headed. Penalise one mark from the total for **2.1** 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 CN^- ion **M2** penalise formal charges or incorrect partial charges on C–Br bond SN1: allow SN1 mechanism with **M1** for breakage of C–Br bond and **M2** for attack by CN^- 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 KBr Penalise the mark for attack by CN^- for any extra arrows involving CN or covalent bond in KCN	2

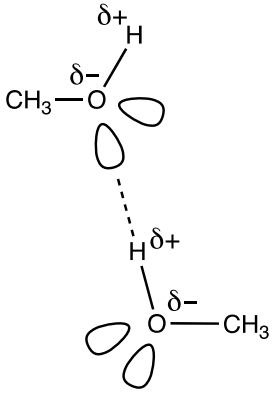
Question	Marking guidance	Additional Comments/Guidelines	Mark
02.2	propan<u>e</u>nitrile	ignore any gaps, hyphens, commas allow propane-1-nitrile	1
02.3	**M1** $\frac{\mathbf{55}(.\mathbf{0})}{\mathbf{108.9+65.1}}$ (x 100) or $\frac{\mathbf{55}(.\mathbf{0})}{\mathbf{174}(.\mathbf{0})}$ (x 100) or $\frac{\mathbf{55}(.\mathbf{0})}{\mathbf{55}(.\mathbf{0})+\mathbf{119}(.\mathbf{0})}$ (x 100) **M2** 31.6(%) (must be 3sf)	31.6 scores 2 marks; 32 scores 1 mark no ECF	1 1

Question	Marking guidance	Additional Comments/Guidelines	Mark
03.1	**M1** moles cyclohexane = $\frac{192.730-192.100}{84(.0)}$ or $\frac{0.630}{84(.0)}$ (= 0.00750) **M2** heat released = 1216 x 1000 x 0.0075 (= 9120) (J) [or 1216 x 0.0075 = (9.12) (kJ)] **M3** $\Delta T \left(= \frac{q}{mc} = \frac{9120}{50(.0)\text{x } 4.18}\right)$ = 43.6 **M4** final temperature = 19.1 + **M3** = 62.7 or 63 (°C) Alternative **M3/4** **M3** 9120 = 50 x 4.18 x (Final T – 19.1) **M4** Final T = 62.7 or 63 (°C)	Correct answer scores 4 marks 0.0075 scores **M1** with or without working 9120 or 9.12 scores **M1** and **M2** with or without working allow ECF at each stage correct **M3** scores **M1** and **M2** ignore negative sign for q in **M2** and/or ∆T in **M3**, but penalise if used as a temperature fall in **M4** (if alternative method used for **M3/4** and negative value for q is used, allow **M3** for expression with negative q value but do not allow **M4**) (temperatures to at least 2sf) If candidates use a value in kJ rather than J to find ∆T / final T then they lose **M3**, but ECF to **M4** [e.g. 9.12 rather than 9120 giving ∆T = 0.0436 and final temperature = 19.1(436) – this would give 3 marks] If candidates use 0.63 g for m in **M3**, they will get ∆T = 3.46 and final temperature = 22.56 – this would give 3 marks] Cannot score **M2** using moles = 1	1 1 1 1

03.2	thermal energy / heat loss or incomplete combustion or evaporation	or idea of heat being transferred to calorimeter allow idea that it is not under standard conditions allow no lid / poor/no insulation	1

03.3	**M1** 6 x (–394), 6 x (–286) and –3920 **M2** **(**ΔH =) [6 x (–394)] + [6 x (–286)] + 3920 (or (ΔH **=**) [–2364)] + [–1716)] + 3920) (or (ΔH **=**) –4080 + 3920) **M3** = –160 (kJ mol^{-1})	–160 scores 3 marks; +160 scores 2 marks –8000 scores 2 marks; +8000 scores 1 mark –1876 scores 2 marks; +1876 scores 1 mark **M1** is for correct coefficients, i.e. 6 x Δ_cH H_2 & 6 x Δ_cH C & 1 x Δ_cH C_6H_{12} (ignore whether + or –) ECF from **M1** to **M2/3** for incorrect coefficients / arithmetic error / transposition ECF from **M2** to **M3** for use of products – reactants Ignore any cycle	1 1 1

Question	Marking guidance	Additional Comments/Guidelines	Mark
04.1	$C_8H_{18} + 12.5O_2 \rightarrow 8CO_2 + 9H_2O$	Allow multiples Ignore state symbols	1
04.2	$2NO + 2CO \rightarrow N_2 + 2CO_2$ ***or*** $25NO + C_8H_{18} \rightarrow 12.5N_2 + 9H_2O + 8CO_2$	Allow multiples Ignore state symbols Allow $2NO \rightarrow N_2 + O_2$ (or multiples)	1
04.3	**M1** moles $SO_2 = \frac{6\ 490\ 000\ x\ 10^6}{64.1}$ (= $\frac{6.49\ x\ 10^{12}}{64.1}$ = 1.012×10^{11}) **M2** mass CaO = $\left(\frac{1.012\ x\ 10^{11}\ x\ 56.1}{1000}\right)$ = 5.68×10^9 (kg)	**M2** must be in standard form Correct answer in standard form scores 2 marks (allow $5.6 – 5.7 \times 10^9$). Answer to at least 2sf. Correct answer in non-standard form scores 1 mark Answers that are $5.6 – 5.7 \times 10^n$ score 1 mark For other answers, allow ECF from **M1** to **M2** (but answer must be in standard form for **M2** to score) **Alternative** **M1** mass CaO = $\frac{6\ 490\ 000\ x\ 10^6}{64.1}\ x\ 56.1$ = 5.68 million tonnes **M2** 5.68×10^9 (kg) ($7.4.. \times 10^9$ would score 1 mark due to use of $\frac{64.1}{56.1}$)	1 1

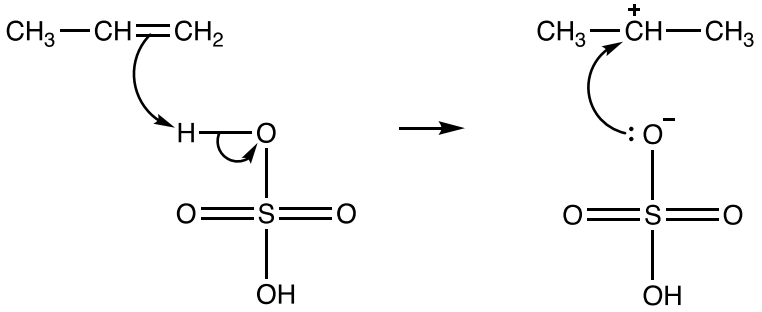
Question	Marking guidance	Additional Comments/Guidelines	Mark
05.1	 **M1** on at least one O atom two lone pairs and on at least one OH δ+ on H and δ– on O **M2** dotted line shown between lone pair on one molecule and the correct H on another **M3** O····H–O in straight line	Accept pair of dots or crosses for lone pair in place of orbital shape (orbital shape may or may not include two electrons) Ignore any partial charges on C–H or C–O bonds For straight line in **M3**, allow a deviation of up to 15° If a different molecule containing hydrogen bonding due to O–H bond drawn (e.g. ethanol, water) or an incorrect attempt at the structure of methanol, then maximum of 2 marks (i.e. only penalise if would score all three marks otherwise)	1 1 1
05.2	Idea that lone pairs have greater repulsion than bonding pairs	There must be a comparison between the repulsion of a lone pair and bonding pair Allow covalent bond = bonding pair	1

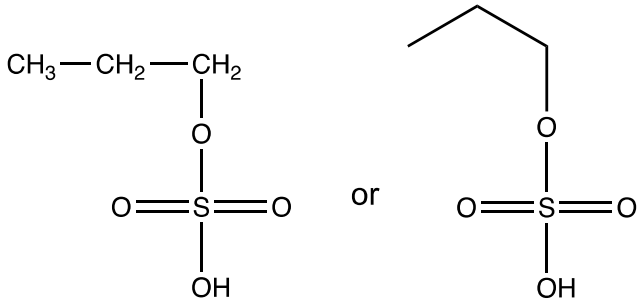
<table>
<tr><td rowspan="5">05.3</td><td colspan="2">This question is marked using levels of response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.</td><td>6</td><td rowspan="5">Stage 1
Describes the effect of catalyst use
1a use of a catalyst has no impact on equilibrium yield
1b use of a catalyst gives faster rate
1c use of catalyst lowers costs

Stage 2
Describes the effect of pressure
2a higher pressure gives a higher equilibrium yield
2b higher pressure gives a faster rate
2c the higher the pressure, the greater the cost

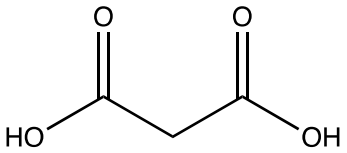
Stage 3
Describes the effect of temperature
3a lower temperature gives a higher equilibrium yield
3b higher temperature gives a faster rate
3c the higher the temperature, the greater the cost

Note that converse statements are fine (e.g. 1a higher temperature gives a lower equilibrium yield)</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	Additional Comments/Guidelines	Mark
06.1	**M1** <u>electrophilic addition</u>  **M2** must show an arrow from the double bond towards the H atom of the H_2SO_4 molecule **M3** must show the breaking of the H-O bond in H_2SO_4 **M4** is for the structure of the correct carbocation **M5** must show an arrow from the lone pair of electrons on the negatively charged oxygen of HSO_4^- towards the positively charged atom of <u>their</u> carbocation drawn	All arrows are double-headed. Penalise one mark from the total for **M2-5** if half headed arrows are used. Do not penalise the "correct" use of "sticks" Penalise only once in any part of the mechanism for a line and two dots to show a bond For **M2/3**, the full structure of H_2SO_4 does not need to be shown, but the key features for the mechanism should be shown and the formula must be correct. Penalise only once in **M2/3** an incorrect but genuine attempt at the structure of sulfuric acid **M2** ignore partial negative charges on the double bond **M3** penalise incorrect partial charges on the H–O bond and penalise formal charges Penalise **M4** if there is a bond drawn to the positive charge **Max 3 of 4 marks (M2-5)** for wrong organic reactant or wrong carbocation (ignore structure of product) If attack is shown from C=C to H^+ rather than H_2SO_4, then allow **M2** but not **M3** For **M5**, credit attack on a partially positively charged carbocation structure, but penalise **M4** for the structure of the carbocation. For **M5**, the full structure of HSO_4^- is not essential, but attack must come from a lone pair on an individual oxygen on HSO_4^-, but the – sign could by anywhere on the ion (e.g. $:OSO_3H^-$)	1 1 1 1 1

06.2	 or	Any correct structural formula, including OSO_3H bonded through O to correct C	1

06.3	**M1** idea that **E** is formed from/via more stable carbocation **M2** idea that 2^y carbocation is more stable than 1^y carbocation	**M1-2** Allow carbonium ion in place of carbocation **M2** Allow descriptions in terms of number of alkyl groups attached to positive C atom Ignore reference to inductive effect Penalise **M1** if answer suggests that the products are carbocations (but could score **M2**) In order to access **M1** and/or **M2** there must be some reference to carbocations (carbonium ions) by name or structure or description	1 1

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.1		Must be a skeletal formula Need to show the H atoms of OH groups	1

07.2	**M1** weigh out sample in bottle / boat / container **M2** transfer to (conical) flask / beaker (or suitable container) and wash all sample in or re-weigh bottle / boat / container or re weigh bottle / boat / container **M3** <u>dissolve</u> sample in (deionised / distilled) water (if volume of water is specified, must be less than 250 cm^3) **M4** add into volumetric flask with washings **M5** make up to mark / 250 cm^3 in volumetric flask **M6** shake / invert (this should be to give a homogenous solution rather than to dissolve; must be after made up to mark; ignore any earlier shaking)	**This is an extended response question and there is a requirement for shaking right at the <u>end</u>. (M6 requires idea of mixing at the end.)** Maximum of 4 marks for candidates who add any substance other than water. Penalise **M1** for weighing out wrong substance or using the acid as a liquid or solution (for **M1**, acid must be a solid that is being weighed). For **M1**, ignore any reference to a specific mass. For dissolving, ignore any reference to warming. Allow graduated flask for volumetric flask **Candidates may dissolve sample directly in volumetric flask. Mark scheme for this method:** **M1** weigh out sample in bottle / boat / container **M2** add into volumetric flask **M3** wash all sample in or re-weigh bottle / boat / container or re-weigh bottle / boat / container or re-weigh bottle / boat / container **M4** <u>dissolve</u> sample in (deionised / distilled) water (if volume of water is specified, must be less than 250 cm^3) **M5** make up to mark / 250 cm^3 in volumetric flask **M6** shake / invert (this should be to give a homogenous solution rather than to dissolve; must be after made up to mark; ignore any earlier shaking)	1 1 1 1 1 1

Question	Marking guidance	Additional Comments/Guidelines	Mark
07.3	**M1** moles of acid = $0.00500\ x\ \frac{250}{1000}$ (= 0.00125) **M2** mass of acid (= 0.00125 x 104(.0) = 0.130 g) = 130 (mg)	130 scores 2 marks Final answer must be at least 2sf Allow ECF from **M1** to **M2** 0.13(0) scores 1 mark 2080 (mg) scores 1 mark	1 1

Question	Marking guidance	Additional Comments/Guidelines	Mark
08.1	**M1** moles of propan-1-ol = $\frac{6.0 \times 0.80}{60.0}$ (= 0.080) **M2** moles of $K_2Cr_2O_7$ = $\frac{M1}{3}$ (= 0.0267) **M3** volume of $K_2Cr_2O_7$ = $\frac{M2}{0.40} \times 1000$ = 67 (cm^3) (allow 66.666…. to 68)	67 cm^3 scores 3 marks allow ECF for **M2** and **M3** final answer to at least 2 sf 200 (cm^3) scores 2 marks; 66.6 (cm^3) is outside range and scores 2 marks; 66.6 (cm^3) (i.e. 66.6 dot scores 3 marks)	1 1 1
08.2	**M1** an attempt to draw apparatus that is clearly for (fractional) distillation **M2** suitable drawing of distillation apparatus with condenser attached to side of distillation head • condenser must have outer tube for water that is sealed at the ends but have two openings for water in/out (that are open) • condenser must have downwards slope • condenser must be open at each end • as this is a cross-section, there should be a continuous flow through the diagram from the flask to the end of the open condenser (there should be no lines drawn across implying a seal of any sort) • there must be no gaps at joints between apparatus where vapour could escape • there must be some opening to the system at the collection end **M3** condenser labelled including labels for water in and water out (water must come in at lower end)	On this occasion, the apparatus does not need a thermometer or a collection container Ignore any fractionating column IN **M1** and **M2** between the flask and condenser. For **M3**, if water in and out clearly stated, ignore direction of any arrows drawn. Allow 'condensing tube' or 'condensing column' or similar for name of condenser. If a reflux diagram is drawn (any diagram with a condenser attached vertically into the flask is a reflux set up, even with a downwards tube from the top of the condenser): • cannot score **M1** or **M2** • could score **M3** for condenser labelled including labels for water in and water out (water must come in at the lower end)	1 1 1

Question	Marking guidance	Additional Comments/Guidelines	Mark
09.1	$CF_2ClCF_2Cl \rightarrow \bullet CF_2CF_2Cl + \bullet Cl$ or $C_2F_4Cl_2 \rightarrow \bullet C_2F_4Cl + \bullet Cl$	Any correct structure or molecular formula for reactant and/or product The dots can be shown anywhere around each radical	1
09.2	**M1** $Cl\bullet + O_3 \longrightarrow ClO\bullet + O_2$ **M2** $ClO\bullet + O_3 \longrightarrow Cl\bullet + 2O_2$	**M1** and **M2** could be in either order Credit the dot anywhere on the radical Penalise absence of dot once only Individual multiples acceptable but both need to be equivalent multiples for both marks to be awarded Ignore state symbols (Accept alternative pair of equations for **M2** (both needed for **M2**) $O_3 \longrightarrow O + O_2$ $ClO\bullet + O \longrightarrow Cl\bullet + O_2$)	1 1

Question	Marking guidance	Additional Comments/Guidelines	Mark
09.3	Volume as a gas: **M1** moles butane = $\frac{38.8}{58.0}$ (= 0.669) **M2** $V = \frac{nRT}{P}$ **M3** $V = \frac{0.669\ x\ 8.31\ x\ 272}{101000}$ **M4** **(** = 0.0150 m^3) = 15000 (cm^3) (14971) Volume as a liquid: **M5** $V = \frac{38.8}{0.60}$ = 65 or 64.7 or 64.666… (cm^3) Expansion factor **M6** $(\frac{M4}{M5})$ = $(\frac{15000}{64.7})$ = 232 (allow 230 – 232)	Answers to **M4**, **M5** and **M6** should be 2sf or more **M1-M4** 15000 (cm^3) (14971) scores **M1**-**M4** **M1** may score from a value or expression within **M3** **M2** could score from an attempt at **M3** that shows attempts at values for n, R, T and P in suitable places **M4** ignore additional answers following this in other units (if incorrect it will be penalised in **M6**) Allow ECF in **M3** and **M4** based on incorrect moles of butane from **M1**; allow ECF in **M4** based on incorrect units in **M3** Allow ECF in **M3** and **M4** based on inverted expression for volume $V = \frac{P}{nRT}$; for other incorrect expressions, allow a maximum of one mark for **M3** or **M4** for correct unit conversion for P to Pa in **M3** or volume to cm^3 in **M4** **M5** ignore additional answers following this in other units (if incorrect it will be penalised in **M6**) 64.6 (cm^3) is outside range and does not score **M5** 64.6 (cm^3) (i.e. 66.6 dot scores **M5**) **M6** allow ECF based on values for **M4** and **M5**	1 1 1 1 1 1

Question	Marking Guidance	Mark	Comments
10	**C**	1	0.017
11	**D**	1	The mean energy of the molecules is greater than the most probable energy of the molecules
12	**A**	1	1.5
13	**D**	1	$CH_2{=}CHCH_2CHO$
14	**C**	1	4
15	**D**	1	$CH_3Cl + Cl\bullet \rightarrow \bullet CH_2Cl + HCl$
16	**C**	1	$CH_3CH_2CH_2Br$
17	**A**	1	It displays *E*-*Z* isomerism
18	**D**	1	3-methylbutan-2-ol
19	**B**	1	CH_3OH
20	**D**	1	pentan-2-ol
21	**D**	1	CH_3CH_2COOH
22	**A**	1	2-methylbut-1-ene
23	**B**	1	4-hydroxybutanone
24	**A**	1	2.28×10^{-18} J