A-level
CHEMISTRY
7405/2

Paper 2 Organic and Physical Chemistry

Mark scheme

June 2019

Version: 1.0 Final

196A74052/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 not allow

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

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

3.10 Marking crossed out work

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

3.11 Reagents 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.

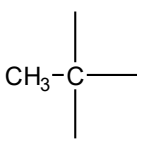
3.12 Organic structures

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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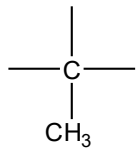

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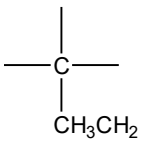

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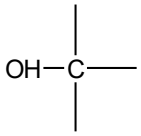

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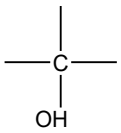

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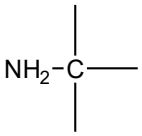

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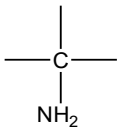

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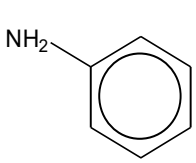

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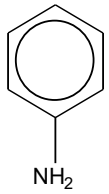

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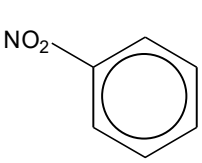

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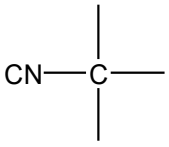

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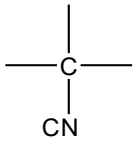

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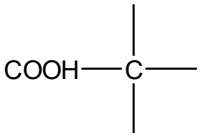

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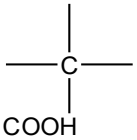

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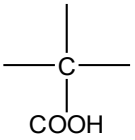

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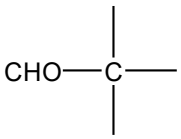

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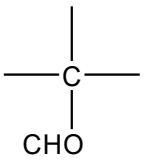

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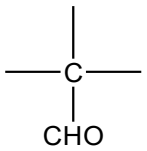

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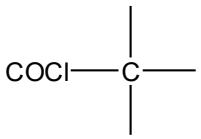

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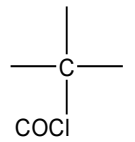

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- Representation of CH_2 by $C–H_2$ will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions may be made in the context of balancing equations)

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.

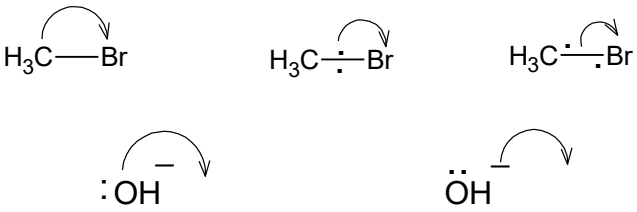
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

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**

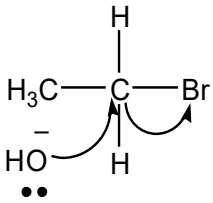
3.14 Organic reaction mechanisms

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.

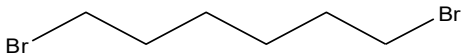
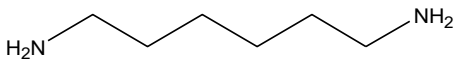
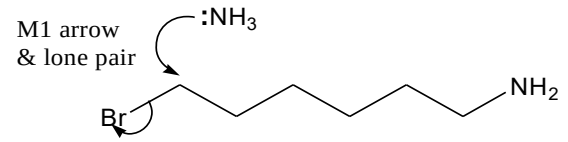
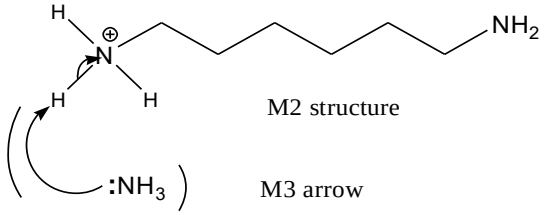
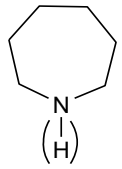
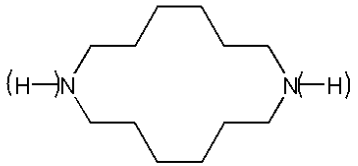
Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other chemically valid points. Students may not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme. The mark 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	Answers	Additional Comments/Guidelines	Mark
01.1	$Br\text{-}(CH_2)_6\text{-}Br + 4NH_3 \rightarrow H_2N\text{-}(CH_2)_6\text{-}NH_2 + 2NH_4Br$ OR  + $4NH_3$ →  + $2NH_4Br$	M1 both organic compounds correct (not molecular formulae) Allow one correct structural formula and the other correct molecular formula of type $XC_6H_{12}X$ M2 balanced	2
01.2	M1 arrow & lone pair   M2 structure M3 arrow NH_3 removal need not be shown but penalise Br^- removal Impurity  (or as structural formula)	Or with structural formulae, $Br(CH_2)_6NH_2$ etc Allow S_N1 Penalise incorrect partial charges in M1 allow 	3 1

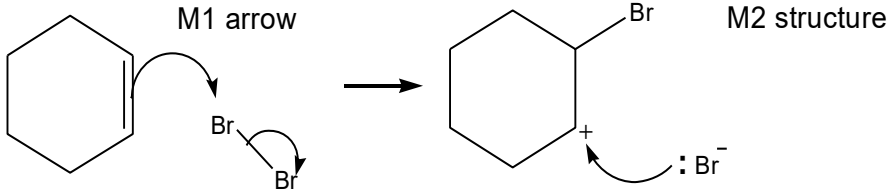
01.3	M1 Stage 1 reagent KCN or NaCN M2 Stage 1 condition aqueous alcohol M3 Stage 2 reagent & condition H_2 and Ni or Pt or Pd	Not HCN this loses M1 and M2 Any mention of acid loses M1 & M2 M2 dependent on correct M1 (allow condition if only CN^- ions) M3 only accessible if a cyanide is used in stage 1 Allow $LiAlH_4$ (in dry ether) – acidic/aqueous = CE, but allow followed by acid. NOT $NaBH_4$ NOT Sn/HCl or Fe/HCl Ignore heat and reflux and pressure Apply list principle to incorrect reagents/conditions	1 1 1

01.4	In 3-aminopentane <u>Lone pair on N</u> more available or <u>Lone pair on N</u> accepts H^+ better because of alkyl electron pushing /inductive effect	Allow converse for ammonia Or greater stability of protonated N Mark independently	 1 1

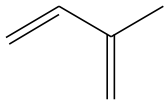
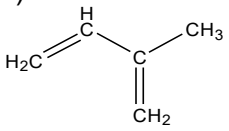
01.5	No carbon (atom is) attached to 4 different groups	Allow central carbon has two alkyl groups Allow symmetrical molecule	1

Question	Answers	Additional Comments/Guidelines	Mark
02.1	Thermometer and bung in flask with bulb level with side arm. Condenser jacket with water in at bottom and out at top.	Must be cross section diagram with no gaps at joints	1 1
02.2	Liquids are immiscible	Allow don't mix, forms two layers (stated or implied) Allow it is insoluble Ignore density or reference to solutions	1
02.3	Liquid goes clear / not cloudy	Ignore colourless	1

02.4	*Via moles* Amount cyclohexanol (= 14.4/100) = 0.144 mol	*Via mass* Amount cyclohexanol (= 14.4/100) = 0.144 mol	*Via volume* Amount cyclohexanol (= 14.4/100) = 0.144 mol	M1
	Mass cyclohexene formed = 4.15 x 0.81 = 3.36 g	Mass cyclohexene formed = 4.15 x 0.81 = 3.36 g	Mass of cyclohexene expected (= 0.144 × 82.0 = 11.808 g) OR M1 × 82	M2
	amount cyclohexene obtained (= 3.36/82.0 = 0.0410 mol) OR M2/82.0	mass of cyclohexene expected (= 0.144 × 82.0 = 11.808 g) OR = M1 × 82.0	volume of cyclohexene expected (= 11.808/0.810 = 14.577cm^3) OR M2/0.810	M3
	%Yield = $\frac{0.0410}{0.144}$ x 100 OR $\frac{M3}{M1}$ x 100	%Yield = $\frac{3.36}{11.808}$ x 100 OR $\frac{M2}{M3}$ x 100	%Yield = $\frac{4.15}{14.577}$ x 100 OR $\frac{4.15}{M3}$ x 100	M4
	= 28.5% (must be 3 sf)	= 28.5% (must be 3 sf)	= 28.5% (must be 3 sf)	M5
	Only award M5 if answer is to 3sf and follows some attempt at % yield calculation in M4			

02.5	 M3 arrow & lone pair on bromide		Lose M1 if Full charges on Br–Br OR Wrong partial charges on Br–Br OR Arrow is to Br^+ ion (formed in a preliminary step) Any C shown in the ring must have the correct number of hydrogens attached to score M2	3

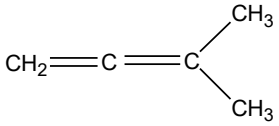
<table>
<tr><th>Question</th><th>Answers</th><th>Additional Comments/Guidelines</th><th>Mark</th></tr>
<tr><td>03.1</td><td>
<table>
<tr><td></td><td>C</td><td>H</td></tr>
<tr><td>%mass</td><td>88.2</td><td>11.8</td></tr>
<tr><td>mol</td><td>$\frac{88.2}{12}$</td><td>$\frac{11.8}{1}$</td></tr>
<tr><td></td><td>=7.35</td><td>=11.8</td></tr>
<tr><td>÷ smaller</td><td>$\frac{7.35}{7.35}$</td><td>$\frac{11.8}{7.35}$</td></tr>
<tr><td></td><td>= 1</td><td>1.61</td></tr>
<tr><td>x5</td><td>=5</td><td>=8</td></tr>
</table>
Empirical formula = molecular formula C_5H_8

M4 (must be branched)
 OR 

</td><td>M1 for amounts 7.35 and 11.8

M2 for process dividing M1 by smaller

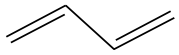
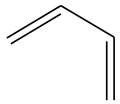
M3 for answer C_5H_8 only

Allow alternatives
 

$HC{\equiv}CCH(CH_3)_2$</td><td>1

1

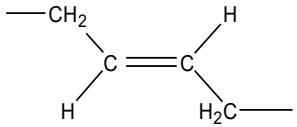
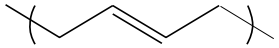
1

1</td></tr>
<tr><td>03.2</td><td>  OR 

<u>Buta-1,3-diene</u></td><td>Must be skeletal

M2 can only be this and is independent of M1</td><td>1

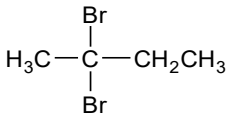
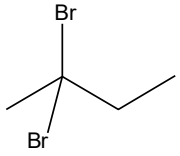
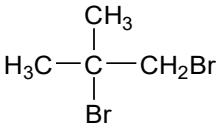
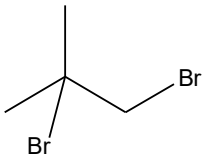
1</td></tr>
</table>

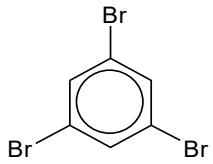
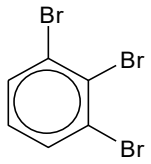
03.3	 Mark independently Restricted rotation about the C=C or double bond	Must show trailing bonds Ignore brackets and *n* Allow skeletal – with brackets  Must be E 'trans' Allow lack of rotation/no rotation/limited rotation about the C=C or double bond Ignore different groups on each carbon of the C=C double bond	1 1

03.4	<u>Carbon Carbon bonds</u> are non polar or (too) strong or not attacked by nucleophiles Or <u>Carbon Carbon bonds</u> cannot be hydrolysed	Allow carbon chains ….. OR Bonds between repeating units …… Ignore C–H bonds	1

Question	Answers	Additional Comments/Guidelines	Mark
04.1	Expt 2 3.2×10^{-4} Expt 3 3.2×10^{-4}	Both needed	1
04.2	**P** order = 1 **Q** order = 2	These answers only, not consequential on 4.1 Allow if 4.1 blank.	1 1
04.3	(Rate = $k[R]^2[S]^2$) k = Rate/$[R]^2[S]^2$ **OR** $1.20 \times 10^{-3}/(1.00 \times 10^{-2})^2(2.45 \times 10^{-2})^2$ k = 19992 = 2.00×10^4 Units $mol^{-3}\ dm^9\ s^{-1}$	M1 for rearrangement M2 for answer (Allow 1.99×10^4) Allow conseq units for their expression in M1	M1 M2 M3

Question	Answers	Additional Comments/Guidelines	Mark
05	Regrettably, this question contained a typographical error which affected some students' ability to answer it. All students were awarded full marks for this question.		

Question	Answers	Additional Comments/Guidelines	Mark
06.1	**Must be a single test-tube reaction** **M1** Reagent: acidified potassium dichromate ***OR*** $K_2Cr_2O_7/H_2SO_4$ ***OR*** $K_2Cr_2O_7/H^+$ ***OR*** acidified $K_2Cr_2O_7$ **M2** ….-1-ol (orange to) <u>green</u> solution ***OR*** goes <u>green</u> **M3** ….-2-ol no (visible/observed) reaction/change or NVR or stays orange **OR** **M1** Reagent**:** acidified potassium manganate(VII) or $KMnO_4/H_2SO_4$ ***OR*** $KMnO_4/H^+$ ***OR*** acidified $KMnO_4$ **M2**….-1-ol (purple to) <u>colourless</u> solution **OR** goes <u>colourless</u> **M3**….-2-ol no (visible/observed) reaction/change or stays purple	If incorrect reagent then no marks For acidified potassium dichromate: if "dichromate" or "(potassium) dichromate(IV)" or incorrect formula or no acid, penalise **M1** but mark on - 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 on Credit alkaline / neutral $KMnO_4$ for possible full marks but **M2** gives <u>brown precipitate</u> or solution goes <u>green</u>	1 1 1
06.2	**A**  **OR** 	**B**  **OR** 	2

06.3	**C**  	**D**  	Allow Kekulé structures Penalise missing aromatic ring each time	2

A 06.4	**F** **G** **E**		1

Question	Answers		Additional Comments/Guidelines	Mark
G 07.1	Cyclopentanone		Allow cyclopentan -1-one but no other numbers Ignore spaces, commas and hyphens	1
07.2	This question is marked using Levels of Response. Refer to the Mark Scheme Instructions for Examiners for guidance.		**Indicative Chemistry content** **Stage 1**: boiling points 1a) **Y** has a higher bp 1b) **Y** has H-bonds between molecules and **X** has dip-dip imf 1c) More energy required to overcome H-bonds Mention of covalent bond breaking loses 1c **Stage 2**: ^{13}C NMR 2a) Both have 3 peaks/absorptions in their ^{13}C NMR 2b) **X** has peaks at 20-50 **OR** 190-220ppm 2c) **Y** has peaks at 50-90 **OR** 90-150ppm (Ignore peaks at 5-40ppm - present in both) **Stage 3**: ir 3a) **X** has a peak (for C=O) at 1680-1750 cm^{-1} 3b) **Y** has peak (for O–H) at 3230-3550 cm^{-1} **OR** peak (for C=C) at 1620-1680 cm^{-1} 3c) They would have different fingerprint regions (below 1500 cm^{-1})	**6**
	Level 3 5-6 marks	**All stages are covered and each stage is generally correct and virtually complete.** Answer is well structured with no repetition or irrelevant points. Accurate and clear expression of ideas with no errors in use of technical terms.		
	Level 2 3-4 marks	**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**. Answer shows some attempt at structure Ideas are expressed with reasonable clarity with, perhaps, some repetition or some irrelevant points. Some minor errors in use of technical terms		
	Level 1 1-2 marks	**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.** Answer includes isolated statements and these are presented in a logical order. Answer may contain valid points which are not clearly linked. Errors in the use of technical terms.		
	0 mark	Insufficient correct chemistry to gain a mark.		

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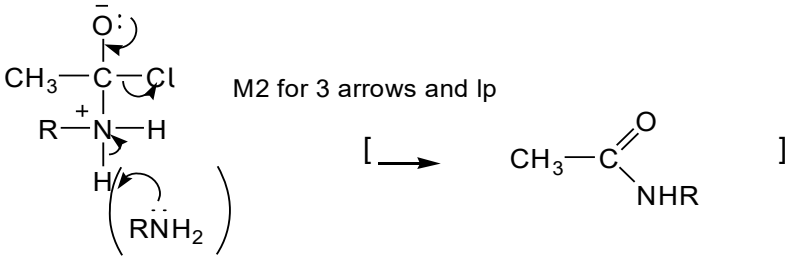
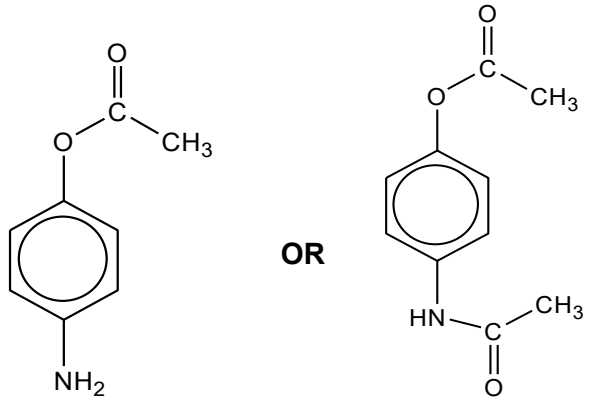
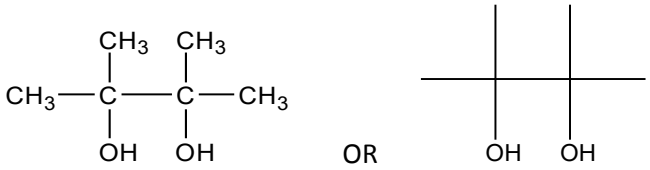
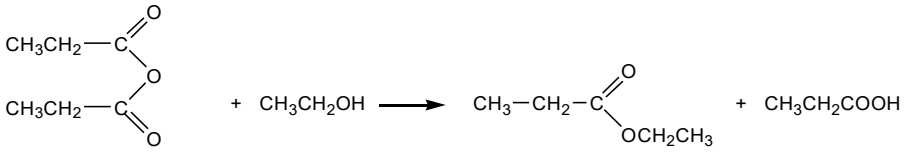
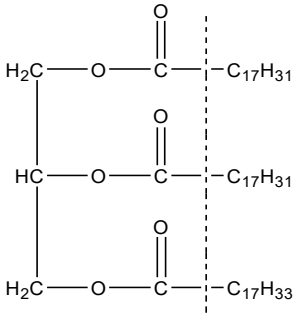
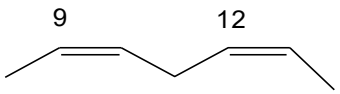
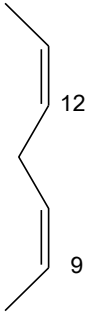
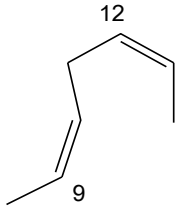
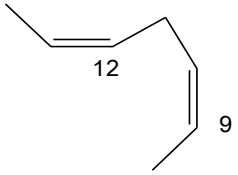
Question	Answers	Additional Comments/Guidelines	Mark
G 08.1	Electrophilic substitution both words needed	Allow minor spelling errors e.g. electrophillic or subsitution Ignore nitration	1
08.2	+ $3H_2$ …… + $2H_2O$	Allow 6[H]	1
08.3	 M1 for structure M2 for 3 arrows and lp	M1 for structure of ion including 2 charges (+ on N must be correct in both cases if drawn twice) M2 for 3 arrows and lp on O - may be scored in two steps Ignore use of RNH_2 to remove H^+ in M2, but penalise use of Cl^-	2
08.4	Corrosive **OR** forms strong acid/HCl (fumes) **OR** vulnerable to hydrolysis **OR** dangerous (to use)	Allow anhydride is less corrosive **OR** does not form strong acid fumes **OR** less vulnerable to hydrolysis **OR** ethanoyl chloride is more expensive Allow reacts violently / extremely exothermic / extremely vigorous Ignore toxic / harmful / hazardous	1

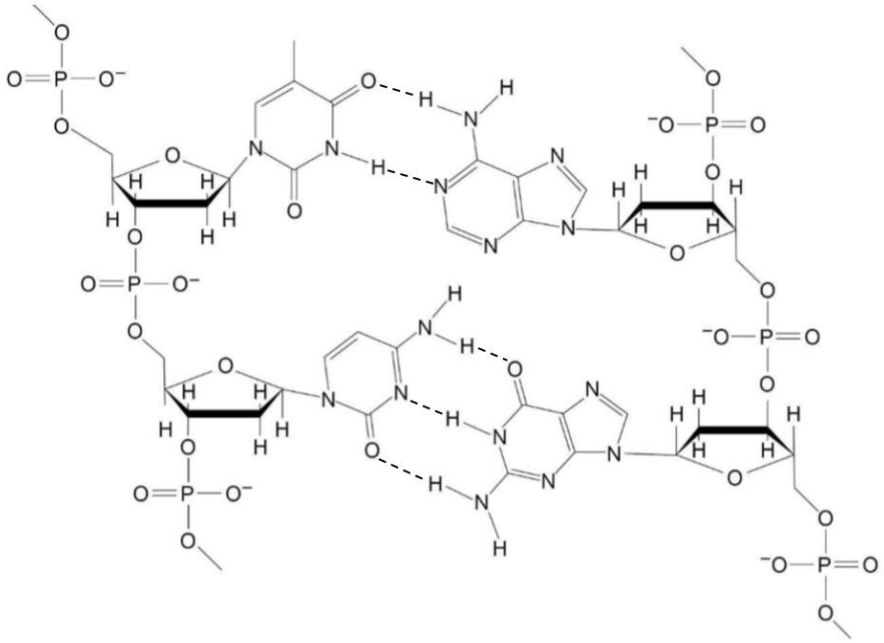
08.5	 **OR**		1
08.6	+ CH_3COONH_4 ..... + $2H_2O$	Allow CH_3COO^- / $CH_3CO_2^-$ and NH_4^+ Allow NH_4CH_3COO	1
08.7	*Via moles* M1 M_r paracetamol = 151(.0) M2 Amount paracetamol = 250×10^3 / 151.0 = 1655.6 mol **OR** (250×10^3) / M1 (= amount hydroquinone used) M3 Mass hydroquinone = 1655.6 × 110.0 = 182119 g = 182 kg **OR** correct answer to M2 × 110.0 / 1000	*OR via mass* M1 M_r paracetamol = 151(.0) So 110 g hydroquinone forms 151 g paracetamol M2 Mass hydroquinone needed 250 × 110 / 151.0 **OR** 250 × 110 / M1 = 182 kg Min 2sf If Mr values used wrong way round can score M2	M1 M2 M3

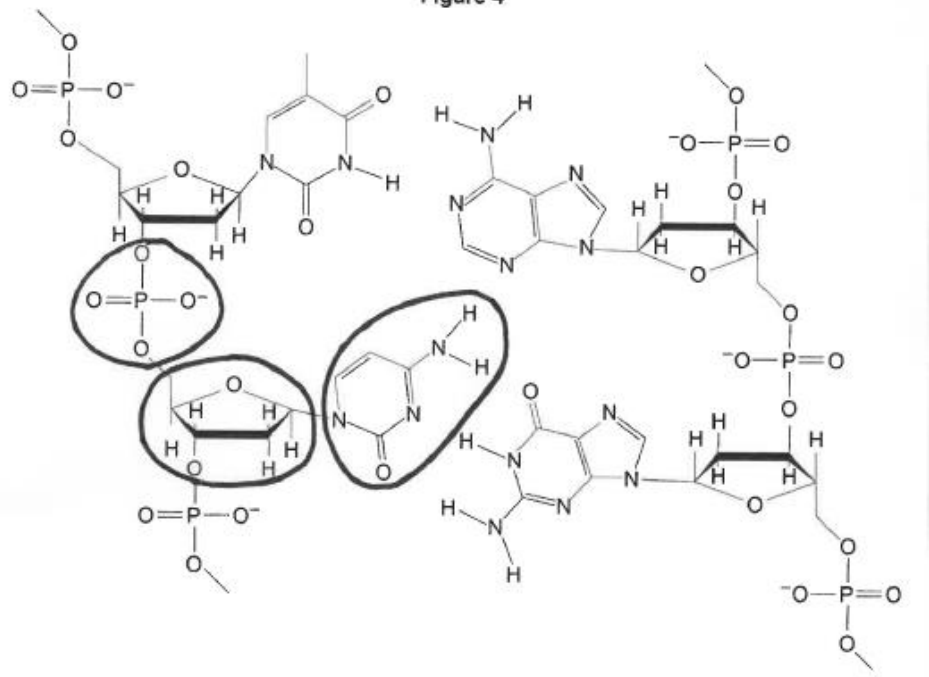
Question	Answers	Additional Comments/Guidelines	Mark
09.1	Conc HCl	Allow concentrations of 5M or higher Allow conc sulfuric or conc strong alkalis	1
09.2	Using ninhydrin or ultraviolet light	Allow I_2 (vapour)	1
G 09.3	7 or seven		1
09.4	Some of the amino acids did not separate/dissolve with the first/either solvent **OR** Some amino acids have the same Rf value or have the same affinity with the first/either solvent	Not amino acids have different Rf values in different solvents	1

Question	Answers	Additional Comments/Guidelines	Mark
10.1	$(COOH)_2 = C_2H_2O_4 = 90$ 118 - 90 = 28 OR C_2H_4 $C_4H_6O_4$	 Must be molecular formula Structural formula can score M1 & M2	M1 M2 M3
10.2	Amount NaOH = $(21.60 \times 10^{-3}) \times 0.109$ $= 2.3544 \times 10^{-3}$ mol Amount H_2A in 25cm^3 = 1.177×10^{-3} mol Amount H_2A in 250 cm^3 = 1.177×10^{-2} mol Mass = 1.39 g (Must be 3sf)	 M1 for answer (to 3sfs min) M2 = 0.5 × M1 M3 = M2 × 10 M4 = answer to (M3 × 118) and must be 3sf	 M1 M2 M3 M4
G 10.3	4 or four		1
10.4			1
10.5	The precise (relative molecular) masses are <u>different</u> or wtte	Allow M_r are different to 2 or more or several dp Ignore different molecular formula Ignore accuracy Penalise fragments	1

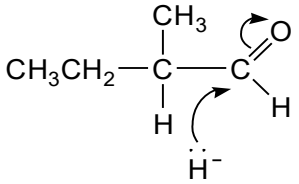
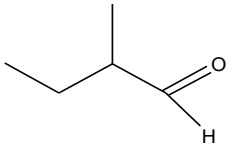
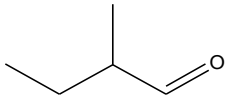
Question	Answers	Additional Comments/Guidelines	Mark
11.1	 Ethyl propanoate only	M1 Structure of ester (allow $C_2H_5CO_2C_2H_5$) M2 propanoic acid formula (allow $C_2H_5CO_2H$) and correctly balanced equation M3 Ethyl propanoate only	1 1 1
11.2	 M1 for all except $C_{17}H_{3x}$ (i.e. all to the left of the dotted line) M2 for two $C_{17}H_{31}$ and one $C_{17}H_{33}$ in any order top to bottom	Allow $–O_2C–$, –OOC–, –OCO– Not $–CO_2–$, –COO–	1 1

11.3	 M1 for skeleton M2 for both Z correct Independent marks Other representations include   	C9 – C14 shown with double bonds in the correct place Ignore structure beyond carbon 14 If hydrogens shown or not skeletal can only score M2	1 1
11.4	$C_{19}H_{34}O_2 + 26½O_2 \longrightarrow 19CO_2 + 17H_2O$	Allow 53/2 or all doubled	1
11.5	Absorption in spectrum at 2350 cm^{-1} does not correspond to data booklet value of 1680 – 1750 cm^{-1} or for C=O bonds in organic compounds)	Allow would expect a peak at 1680 – 1750 cm^{-1}	1
11.6	C=O <u>Bonds</u> in CO_2 absorb infrared radiation (of 2350 cm^{-1}) IR radiation emitted by the earth does not escape (from the atmosphere) OR This energy is transferred to other molecules in the atmosphere by collisions (so all atmosphere is warmed)	 Ignore IR reflected	1 1

Question	Answers	Additional Comments/Guidelines	Mark
12.1		M1 scored for the 2 H 'bonds' between A and T M2 scores for the 3 H 'bonds' between C and G Lose 1 for each extra 'bond' H bonds must be linear Penalise the use of full bonds instead of dashed lines once only Ignore lone pairs and partial charges even if wrong	1 1

12.2	Figure 4 	M1 scored for correct selection of cytosine and associated sugar M2 scored for selection of <u>correct</u> (upper) phosphate M1 & M2 can be scored with one 'ring' Allow ring either side of the top O of either phosphate If wrong base circled, can score M2 for correct phosphate conseq to their base, i.e. top left, Thymine it's the upper phosphate top right, Adenine it's the lower phosphate bottom right, Guanine it's the lower phosphate	1 1

12.3	(Complementary means the two strands must have base sequences) that match (all) <u>A to T and C to G</u>	Ignore reference to (hydrogen) bonding	1

Question	Answers	Additional Comments/Guidelines	Mark
13.1	M1 for structure of 2-methylbutanal M2 for **2** curly arrows and lp on hydride, i.e.  Explanation: M3 H^- ion / nucleophile is attracted to δ+ C M4 electron rich C=C M5 H^- ion / nucleophile is repelled by C=C OR C=C only attacked by/reacts with electrophiles	Allow C_2H_5 for CH_3CH_2  OR  Penalise M2 for wrong partial charges on C=O Ignore product	1 1 1 1 1
13.2	Tollens' (reagent) OR ammoniacal silver nitrate OR description of making Tollens' Silver mirror/ppt OR black solid / precipitate / deposit	Fehling's/ Benedict's (solutions) red solid / precipitate (allow orange or brown)	NOT dichromate 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 on For Fehling's/Benedict's solution: for **M1** Ignore $Cu^{2+}(aq)$ or $CuSO_4$ or "Fellings" on their own, but mark on	1 1