AQA

A-LEVEL
Chemistry

7405/2 Organic and Physical Chemistry
Mark scheme

7405
June 2017

Version: 1.0 Final

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

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

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A-Level Chemistry
Mark Scheme Instructions for Examiners

1. General

The mark scheme for each question shows:

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

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

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

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

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

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

2. Emboldening

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

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

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

3. Marking points

3.1 Marking of lists

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

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

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

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

Correct answers	Incorrect answers (i.e. incorrect rather than neutral)	Mark (2)	Comment
1	0	1	
1	1	1	They have not exceeded the maximum number of responses so there is no penalty.
1	2	0	They have exceeded the maximum number of responses so the extra incorrect response cancels the correct one.
2	0	2	
2	1	1	
2	2	0	
3	0	2	The maximum mark is 2
3	1	1	The incorrect response cancels out one of

			the two correct responses that gained credit.
3	2	0	Two incorrect responses cancel out the two marks gained.
3	3	0	

3.2 Marking procedure for calculations

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

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

3.3 Errors carried forward, consequential marking and arithmetic errors

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

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

3.4 Equations

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

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

3.5 Oxidation states

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

3.6 Interpretation of 'it'

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

3.7 Phonetic spelling

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

3.8 Brackets

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

3.9 Ignore / Insufficient / Do <u>not</u> allow

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

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

3.10 Marking crossed out work

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

3.11 Reagents

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

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

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

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

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

3.12 Organic structures

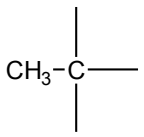
Where students are asked to draw organic structures, unless a specific type is required in the question and stated in the mark scheme, these may be given as displayed, structural or skeletal formulas or a combination of all three as long as the result is unambiguous.

In general

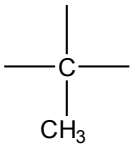
- Displayed formulae must show all of the bonds and all of the atoms in the molecule, but need not show correct bond angles.
- Skeletal formulae must show carbon atoms by an angle or suitable intersection in the skeleton chain. Functional groups must be shown and it is essential that all atoms other than C atoms are shown in these (except H atoms in the functional groups of aldehydes, secondary amines and N-substituted amides which do not need to be shown).

- Structures must not be ambiguous, e.g. 1-bromopropane should be shown as $CH_3CH_2CH_2Br$ and not as the molecular formula C_3H_7Br which could also represent the isomeric 2-bromopropane.
- Bonds should be drawn correctly between the relevant atoms. This principle applies in all cases where the attached functional group contains a carbon atom, e.g nitrile, carboxylic acid, aldehyde and acid chloride. The carbon-carbon bond should be clearly shown. Wrongly bonded atoms will be penalised **on every occasion**. (see the examples below)
- The same principle should also be applied to the structure of alcohols. For example, if students show the alcohol functional group as C ─ HO, they should be penalised **on every occasion**.
- Latitude should be given to the representation of C ─ C bonds in alkyl groups, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.
- Similar latitude should be given to the representation of amines where NH_2─ C will be allowed, although H_2N─ C would be preferred.
- Poor presentation of vertical C ─ CH_3 bonds or vertical C ─ NH_2 bonds should **not** be penalised. For other functional groups, such as ─ OH and ─ CN, the limit of tolerance is the half-way position between the vertical bond and the relevant atoms in the attached group.

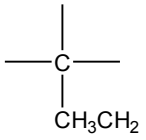
By way of illustration, the following would apply.



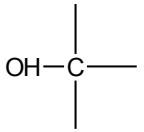
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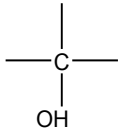
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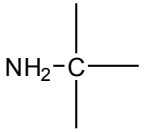
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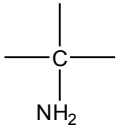
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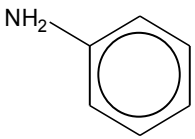
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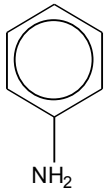
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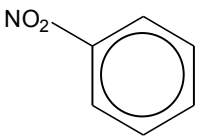
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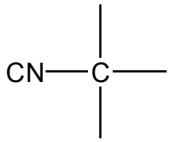
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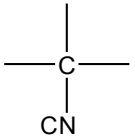
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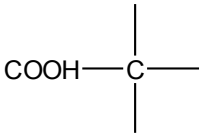
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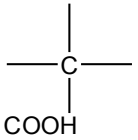
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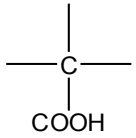
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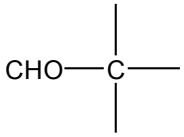
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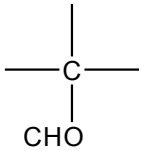
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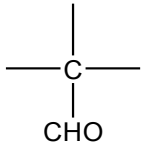
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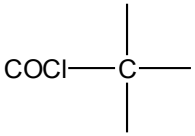
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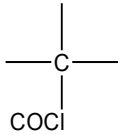
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- Representation of CH_2 by $C–H_2$ will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions <u>may</u> be made in the context of balancing equations)

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

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

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

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

3.13 Organic names

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

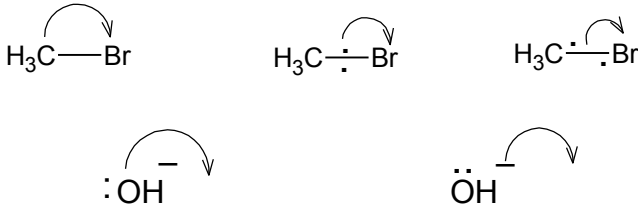
but-2-ol	should be **butan-2-ol**
2-hydroxybutane	should be **butan-2-ol**
butane-2-ol	should be **butan-2-ol**
2-butanol	should be **butan-2-ol**
ethan-1,2-diol	should be **ethane-1,2-diol**
2-methpropan-2-ol	should be **2-methylpropan-2-ol**
2-methylbutan-3-ol	should be **3-methylbutan-2-ol**
3-methylpentan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

2-methyl-3-bromobutane	should be **2-bromo-3-methylbutane**
3-bromo-2-methylbutane	should be **2-bromo-3-methylbutane**
3-methyl-2-bromobutane	should be **2-bromo-3-methylbutane**
2-methylbut-3-ene	should be **3-methylbut-1-ene**
difluorodichloromethane	should be **dichlorodifluoromethane**

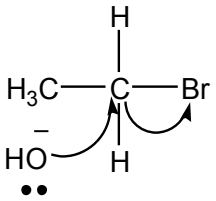
3.14 Organic reaction mechanisms

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

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



For example, the following would score zero marks



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

In free-radical substitution

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

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

3.15 Extended responses

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

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

Determining a level

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

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

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

• If the answer completely matches the communication descriptor, award the higher mark within the level.

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

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

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

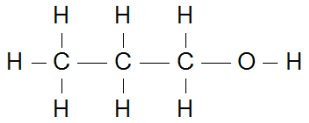
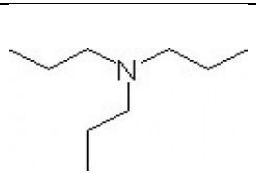
Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other chemically valid points. Students may not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme. The mark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

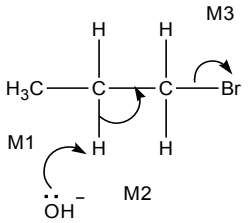
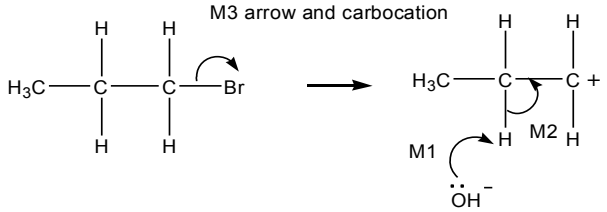
An answer which contains nothing of relevance to the question must be awarded no marks.

For other extended response answers:

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

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

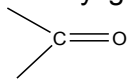
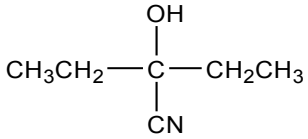
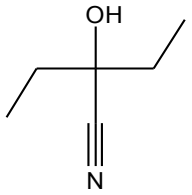
Question	Answers	Mark	Additional Comments/Guidance
01.1		1	Must be displayed
01.2	Nucleophilic substitution Excess NH_3	1 1	 Ignore aqueous, alcoholic, conc, dil, temp, heat, pressure
01.3	Amount of $CH_3CH_2CH_2Br$ 25.2/122.9 (=0.205) (mol) Amount of $CH_3CH_2CH_2NH_2$ M1 x 0.75 (= 0.154) (mol) Mass $CH_3CH_2CH_2NH_2$ M2 x 59.0 = 9.07g Must be 3sf	M1 M2 M3	If either Mr incorrect or used incorrectly then only award 1 mark for 75% yield calculation (ignore rounding to 123 for $CH_3CH_2CH_2Br$) OR Max mass amine = M1 x 59.0 (= 12.1) (g) Actual mass = M2 x 0.75 = 9.07g Must be 3sf Allow 9.09 but if 9.08 check for AE 18.9 scores 1 for 75%
01.4	 tertiary amine or 3° amine (only award if a tertiary amine shown)	1 1	Must be skeletal Ignore lone pair

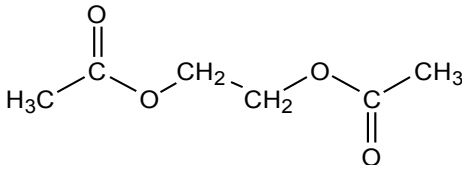
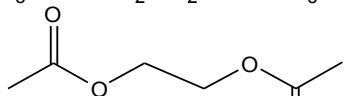
Question	Answers	Mark	Additional Comments/Guidance
01.5	NaOH/ ethanol or KOH / ethanol (both required)	1	**Not** aqueous Ignore heat, temp, conc., dil, Accept alcoholic for ethanol
01.6	(Basic) Elimination  M1 arrow from <u>lone pair on O</u> of hydroxide to correct H (or to space mid way between hydroxide O and H) M2 arrow from C-H bond to C-C bond following attack by OH^{-} on the correct H M3 arrow from C-Br bond to Br If nucleophilic substitution shown then allow M3 only in mechanism If wrong haloalkane used then Max 2 for mechanism	1 3	Also credit E1 mechanism  M3 curly arrow for loss of Br^{-} & structure of carbocation M1 arrow from <u>lone pair on O</u> of hydroxide to H (or to space mid way between hydroxide O and H) (same as E2) M2 arrow from C-H bond to C-C bond (same as E2)
Total		**13**	

Question	Answers	Mark	Additional Comments/Guidance
02.1	Straight line through (0.00, 0.50) which cuts time axis at between 5 and 12.5 secs OR conc 0.3 at time between 2s and 5s	1	If 'tangent' does not touch 0.5 mol dm^{-3} then CE=0 for 2.1 and 2.2. no tangent scores 0 in 2.1 and 2.2.
02.2	Mark is for correct calculation of their gradient : e.g. 0.50/11 = 0.045 or 4.5×10^{-2} (mol dm^{-3} s^{-1})	1	If 'tangent' does not touch 0.5 mol dm^{-3} then CE=0 for 2.1 and 2.2 Ignore negative sign (Expect a value between 0.04 and 0.1
02.3	[A] increases by $\sqrt{1.7}$ new[A] = 1.30 × 0.50 = 0.65 (mol dm^{-3}) 2 sfs min new$[A]^2$ = 1.7 × $(0.50)^2$ = 0.425 New [A] = 0.65 (mol dm^{-3}) 2 sfs min	2	Award 2 for 0.65 Award 1 mark for an AE using a correct method If candidate use their rate then CE=0 0.85 scores 1 if √ shown
Total		**4**	

Question	Answers	Mark	Additional Comments/Guidance
03.1	k = (rate/[C][D]) =) $\frac{3.1\times10^{-3}}{(0.48)\times(0.23)}$	1	Mark is for insertion of numbers into correctly rearranged rate equation
	= 2.8×10^{-2} min 2sfs	1	
	$mol^{-1}\ dm^3\ s^{-1}$	1	Mark units separately in any order.

03.2	ln k = ln 2.8×10^{-2} (= - 3.58)	M1	M1 = ln (their k) If incorrect then award M2 and M3 only	Alternative value ln k = ln 3.2×10^{-3} = - 5.74
	E_a = RT(ln A - ln k) OR $-E_a$ = RT(ln k – ln A)	M2	if ln 16.9 used max 3 If temp used 25 max 2 Incorrect rearrangement then M1 only	
	E_a = 8.31 × 298 (16.9 + 3.58) (= 50716 J mol^{-1})	M3		E_a = 8.31 × 298 (16.9 + 5.74) (= 56076 J mol^{-1})
	E_a = 51 kJ mol^{-1}	M4	– 50.7 or -51 scores max 2	E_a = 56 kJ mol^{-1}
Total		**7**		

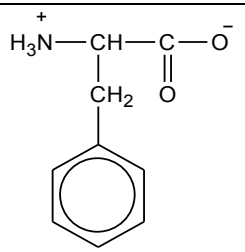
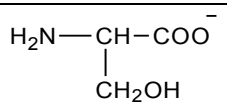
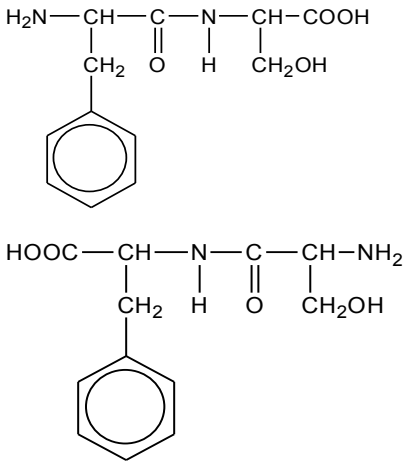
Question	Answers	Mark	Additional Comments/Guidance
04.1	2-hydroxyhexanenitrile	1	
04.2	(Plane) polarised light Enantiomers would <u>rotate</u> light in opposite directions	1 1	 not different alone
04.3	<u>planar</u> carbonyl group or <u>planar</u>  Attack from either side With <u>equal</u> probability OR produces <u>equal</u> amounts (of the two isomers/enantiomers)	1 1 1	Not planar molecule, not planar bond, not planar C=O
04.4	 Does not contain a chiral centre **OR** does not contain C attached to 4 different groups **OR** contains two identical/ethyl groups **OR** symmetrical (product)	1 1	Allow C_2H_5 or skeletal  M2 dependent on correct M1 (No structure = 0) If pentan-3-one drawn then allow symmetrical ketone for M2
Total		**8**	

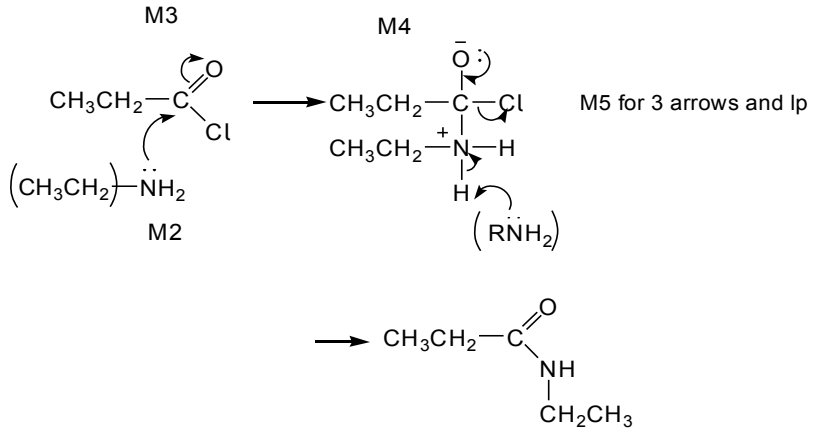
Question	Answers	Mark	Additional Comments/Guidance
05.1		1	Allow $CH_3COOCH_2CH_2OOCCH_3$ OR $CH_3COOCH_2CH_2OCOCH_3$  OR
05.2	Mol $HOCH_2CH_2OH$ = 6.00×10^{-2} OR 0.06(00) Mol $C_6H_{10}O_4$ = 1.45×10^{-1} OR 0.145 Mol H_2O = 2.90×10^{-1} OR 0.29(0)	1 1 1	

05.3	$(K_c =)\ \dfrac{[\text{ester}]\times[H_2O]^2}{[CH_3COOH]^2\times[HOCH_2CH_2OH]}$ The volume cancels out (Penalise a contradictory justification from expression if the volumes do not cancel out) OR there are <u>equal no of moles on each side of the equation</u> OR there are <u>equal no of molecules on each side of the equation</u>	1 1	Allow words for acid and alcohol

05.4	(Mol $CH_3COOH/V)^2$ = $\dfrac{(8.02\times10^{-1}/V)(1.15/V)^2}{6.45\times(2.64\times10^{-1}/V)}$ Mol CH_3COOH = $\sqrt{\dfrac{(8.02\times10^{-1})\times(1.15)^2}{6.45\times(2.64\times10^{-1})}}$ = $\sqrt{0.623}$ Mol CH_3COOH = 0.789 (<u>must be 3 sfs</u>) Allow 0.788 – 0.790	M1 M2 M3	0.789 scores 3 Allow without V : $(nCH_3COOH)^2$ = $\dfrac{(8.02\times10^{-1})(1.15)^2}{6.45\times(2.64\times10^{-1})}$ If $(nCH_3COOH)^2$ =0.623 then award M1 and M2 If Kc is correct in 05.3 but incorrect rearrangement, then CE=0 except if upside down rearrangement then M3 only awarded for 1.27 If Kc is incorrect in 05.3 then only M1 can be awarded for correct rearrangement.

Total		**9**	

Question	Answers	Mark	Additional Comments/Guidance
06.1		1	Allow $-CO_2^-$ Allow $^+H_3N-$ and NH_3^+-
06.2		1	
06.3		1 1	If same wrong amino acid twice – max 1

Question	Answers	Mark	Additional Comments/Guidance
06.4	(nucleophilic) addition-elimination  N-ethylpropanamide	M1 M2 – M5 M6	Not electrophilic addition-elimination. M2 for arrow from lp on N to C (or to space half way between N and C) Ignore $\delta+$ and $\delta-$ unless wrong M3 for arrow from C=O bond to O Not score M3 as an independent first step, but can allow M2 for attack on C+ produced If Cl lost at this stage, Max 1 for mechanism for M2 M4 for structure of ion including 2 charges (+ on N must be correct in both cases if drawn twice) M5 for 3 arrows and lp on O - may be scored in two steps Ignore use of RNH_2 to remove H^+ in M5, but penalise use of Cl^-
Total		**10**	

Question	Answers	Mark	Additional Comments/Guidance

<table>
<tr><td rowspan="5">07.1</td><td colspan="2">This question is marked using Levels of Response. Refer to the Mark Scheme Instructions for Examiners for guidance.</td><td rowspan="5">Indicative Chemistry content

Stage 1: An initial test to separate into two groups (2 groups of 2 OR 1 group of 3 and 1 group of 1)

Stage 2: An second test to distinguish within a group or to separate into two further groups

Stage 3: A third test leads to a set of results/observations which distinguishes between all 4 compounds

Tests must include reagent and observation which identifies compound(s)

-COOH
a) $NaHCO_3$ / Na_2CO_3 (or correct alternative)
b) effervescence /gas turns limewater milky
c) K and /or M but not L and/or N
-OH and -CHO
d) acidified $K_2Cr_2O_7$
e) solution turns green
f) K and/or L and/or N but not M
-CHO
g) Fehlings OR Tollens
h) red ppt OR silver mirror
i) N only but not K and/or L and/or M
-Br
j) Silver nitrate
k) cream ppt
l) L and/or N but not K and/or M

Isolated tests on individual compounds - max LEVEL 2
Isolated tests not linked to any compound – max LEVEL 1
Penalise observation if deduction wrong, but allow observation if deduction incomplete</td></tr>
<tr><td>Level 3

5-6 marks</td><td>All stages are covered and each stage is generally correct and virtually complete.

Answer is communicated coherently and shows a logical progression from Stage 1 to Stages 2 and 3 to distinguish all the compounds with results for all remaining compounds stated.

Describing subsequent organic test on product (unnecessary) - limits to lower mark in level</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.

Answer is communicated mainly coherently and shows a logical progression from Stage 1 to Stages 2 and 3.

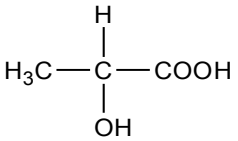
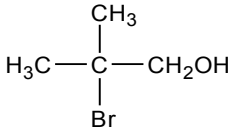
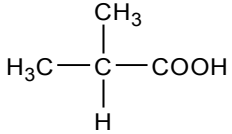
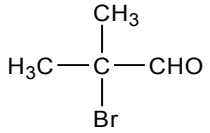
Describing subsequent organic test on product (unnecessary) - limits to lower mark in level</td></tr>
<tr><td>Level 1

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.

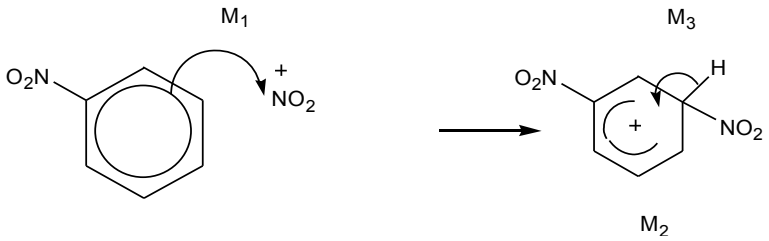
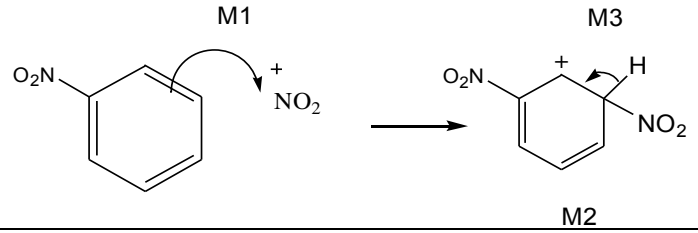
Answer includes isolated statements but these are not presented in a logical order.</td></tr>
<tr><td>0 mark</td><td>Insufficient correct chemistry to gain a mark.</td></tr>
</table>

Alternative tests

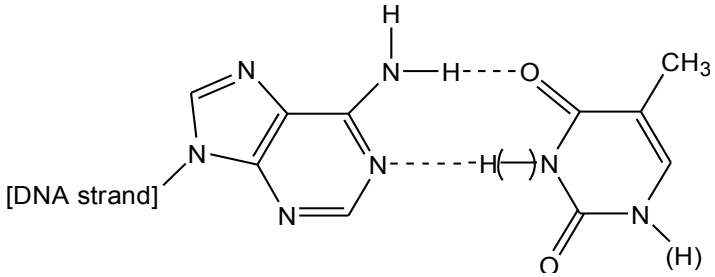
-COOH	**-COOH**	**-OH only**
a) named alcohol & H_2SO_4 b) sweet smell (of ester) c) K and /or M but not L and/or N	a) named indicator b) correct colour c) K and /or M but not L and/or N	m) named carboxylic acid & H_2SO_4 n) sweet smell (of ester) o) K and/or L but not M and /or N

					
Test	**Tests for**	**K**	**L**	**M**	**N**
a) $NaHCO_3$ / Mg / Indicator	K M	✓	×	✓	×
d) $K_2Cr_2O_7$ / H^+	K L N	✓	✓	×	✓
g) Fehlings / Tollens	N	×	×	×	✓
j) $AgNO_3$ see Note *	L N	×	✓	×	✓
a) named alcohol & H_2SO_4	K M	✓	×	✓	×
m) named carboxylic acid & H_2SO_4	K L	✓	✓	×	×

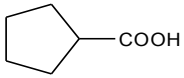
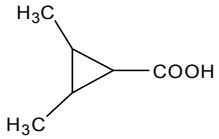
Note * allow NaOH then HNO_3, $AgNO_3$ as one test; but treat NaOH, $AgNO_3$ without acid as incomplete,so can mark on.

Question	Answers	Mark	Additional Comments/Guidance
08.1	$HNO_3 + 2H_2SO_4 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$	1	Allow $H_2SO_4 + HNO_3 \rightarrow NO_2^+ + HSO_4^- + H_2O$ Allow a combination of equations which produce NO_2^+ Penalise equations which produce SO_4^{2-}
08.2	Electrophilic substitution.  OR Kekule  	1 3	Ignore nitration M1 Arrow from inside hexagon to N or + on N (Allow NO_2^+) M2 Structure of intermediate • horseshoe centred on C1 and must not extend beyond C2 and C6, but can be smaller • + in intermediate not too close to C1 (allow on or "below" a line from C2 to C6) M3 Arrow from bond into hexagon (Unless Kekule) • Allow M3 arrow independent of M2 structure • + on H in intermediate loses M2 not M3
08.3	D	1	
08.4	(Balance between) solubility in moving phase and retention by stationary phase	1	OR (relative) affinity for stationary/solid and mobile/liquid/solvent (phase)

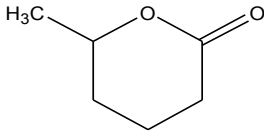
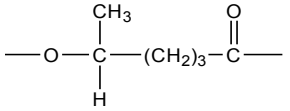
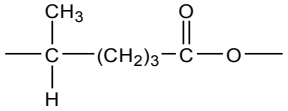
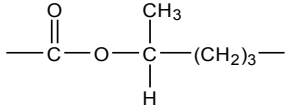
08.5	Solvent depth must be below start line	1	Ignore safety
08.6	1,2- is more polar **OR** 1,4- is less polar **OR** 1,2 is polar, 1,4- is non-polar 1,4- (or Less/non polar is) less attracted to (polar) plate / stationary phase / solid **OR** (Less/non polar is) more attracted to / more soluble in (non-polar) solvent / mobile phase / hexane	1 1	M2 dependent on correct M1 If M1 is blank then read explanation for possible M1 and M2 Allow converse argument for 1,2
08.7	No CE = 0 Yes - mark on but there is **NO MARK FOR YES** Solvent (more) polar or ethyl ethanoate is polar Polar isomer more attracted to / more soluble in / stronger affinity to the solvent (than before)	 1 1	Mark independently following yes Penalise bonded to mobile phase in M2
Total		**12**	

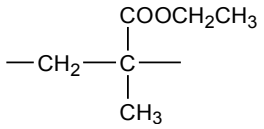
Question	Answers	Mark	Additional Comments/Guidance
09.1	X – base Y – phosphate (group)	1 1	Ignore organic Any mention of sugar in either loses that mark
09.2	If not Thymine CE=0  Correct structure scores 2, penalise by 1 each error in • structure of thymine • orientation of thymine • hydrogen bonding	2	Ignore lp on N and O Don't penalise non-linear H bonds on RHS of thymine – allow with or without H or – [DNA strand]
Total		**4**	

Question	Answers	Mark	Additional Comments/Guidance
10.1	Z-2-methylpent-2-en (-1-) oic acid	1	Ignore missing hyphens or extra commas, spaces, hyphens
10.2	$C_6H_{10}O_2 + 7½\ O_2 \rightarrow 6CO_2 + 5H_2O$	M1	Allow multiple
	Volume of CO_2 formed = 180 cm^3	M2	If incorrect volume:155 gives 125mg / 335 gives 270mg could score M1,M3,M4 – max 3 If incorrect volume from AE then penalise M2 and mark on (Final answer is 0.806 x their volume)
	Mol carbon dioxide = pV/RT = $\frac{105000 \times (180 \times 10^{-6})}{8.31 \times 298}$ = 7.632×10^{-3}	M3	If unit error in p, V or T lose M3 and M5 If incorrect rearrangement lose M3 and M5 If both errors seen then no further marks
	Mol **P**, $C_6H_{10}O_2$ used = $7.632 \times 10^{-3} / 6 = 1.272 \times 10^{-3}$	M4	M3 divided by 6 If wrong no further marks
	Mass **P** used = $1.272 \times 10^{-3} \times 114(.0)$ g = 145 mg	M5	Mark for answer (allow ans to 2 sf) **Check chemical equation before awarding final mark**

10.3	 **OR**  Fig 4: IR <u>OH (acid)</u> peak (2500-3000cm^{-1}) present Fig 5: ^{13}C NMR 4 peaks so 4 (non-equivalent) environments Or Peak at 160-185 (show C=O) in (esters or) acids Or Peak at 40-50 (show R-CO-<u>C</u>H) presence of carbonyl **Both M2 & M3 can be awarded on the spectra**	M1 M2 M3	Mark independently Apply the list principle Ignore C=O signal at 1750 cm^{-1} Allow correct Fig 4 answers in Fig 5 and converse

10.4	**R** has 4 C next to C=O **S** has 2 C next to C=O in range δ = 20-50 **R** has two peaks and **S** only one peak in this range Or **R** has more peaks (allowed if no numbers given) **OR** **S** has a -C(H_2)-C(H_3) **R** does not **S** has one peak in range δ = 5-40 **R** does not *I* lowest peak for **S** is lower than lowest for **R** (Both have) three peaks	M1 M2 M1 M2 M3	M1 for structural point M2 for resulting peak in spectra

10.5	**R** Both singlets **S** has triplet and a quartet OR **R** CH_3/peak at 2.1-2.6 is a singlet **S** CH_3/peak at 0.7-1.2 is a triplet OR **R** CH_2/peak at 2.1-2.6 is a singlet **S** CH_2/peak at 2.1-2.6 is a quartet (Both have) two peaks	M1 M2 M1 M2 M1 M2 M3	
10.6	  OR   OR condensation	1 1 1	Must have trailing bonds Ignore brackets and *n* Ignore esterification

10.7	 Strong / non-polar C-C bonds (in the chain) cannot be attacked by nucleophiles/acids/cannot be hydrolysed. OR <u>Only</u> polar ester group Can be attacked by nucleophiles/acids/can be hydrolysed	M1 M2 M3 M2 M3	Must have trailing bonds Ignore brackets and *n* M3 dependent on correct *or close M2* Allow 1 mark for in (polar) ester link in side chain/not in main chain therefore polymer chain not broken

Total		**21**	

Question	Answers	Mark	Additional Comments/Guidance
11.1	(Strength depends on availability of) lone pair on N (atom)	M1	
	E N (next to ring): (lp) delocalised into ring	M2	
	(lp) less available (to donate to or to accept a H^+)	M3	
	F or **G**: N (next to alkyl): (positive) inductive effect/electrons pushed to N	M4	
	(lp) more available (to donate to or to accept a H^+)	M5	
	order of increasing base strength **E<G<F**	M6	Or **F** is most basic **and E** is least basic
11.2	Intermediate compounds		
	Product of step 1 $C_6H_5CH_2Cl$	1	Allow $C_6H_5CH_2Br$
	Product of step 2 $C_6H_5CH_2CN$	1	**In steps 2 and 3, only allow marks for reagents/conditions if intermediate compounds are correct or close.**
	Reagents/conditions		
	Step 1		
	Cl_2 & UV	1	Allow Br_2 & UV
	Step 2		
	KCN alcoholic & aq (both reqd)	1	Ignore temperature
	Step 3		Allow $LiAlH_4$ in (dry) ether – (with acid CE, followed by acid allow)
	H_2 / Ni or Pt or Pd	1	Not $NaBH_4$ and not Sn/HCl or Fe/HCl
Total		**11**	