OXFORD

INTERNATIONAL
AQA EXAMINATIONS

INTERNATIONAL A-LEVEL

CHEMISTRY

9620

Unit 4 Organic 2 and Physical 2

Mark scheme

June 2019

Version: 1.0 Final

6X19CHO4/MS

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

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

Further copies of this mark scheme are available from oxfordaqaexams.org.uk

Level of response marking instructions

Level of response mark schemes are broken down into levels, each of which has a descriptor. The descriptor for the level shows the average performance for the level. There are marks in each level.

Before you apply the mark scheme to a student's answer read through the answer and annotate it (as instructed) to show the qualities that are being looked for. You can then apply the mark scheme.

Step 1 Determine a level

Start at the lowest level of the mark scheme and use it as a ladder to see whether the answer meets the descriptor for that level. The descriptor for the level indicates the different 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. With practice and familiarity you will find that for better answers you will be able to quickly skip through the lower levels of the mark scheme.

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 and then use the variability of the response to help decide the mark within the level, ie if the response is predominantly level 3 with a small amount of level 4 material it would be placed in level 3 but be awarded a mark near the top of the level because of the level 4 content.

Step 2 Determine a mark

Once you have assigned a level you need to decide on the mark. The descriptors on how to allocate marks can help with this. The exemplar materials used during standardisation will help. There will be an answer in the standardising materials which will correspond with each level of the mark scheme. This answer will have been awarded a mark by the Lead Examiner. You can compare the student's answer with the example 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 example.

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 valid points. Students do not have to cover all of the points mentioned in the Indicative content to reach the highest level of the mark scheme.

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

A-level Chemistry
Mark Scheme Instructions for Examiners

1. General

The mark scheme for each question shows:

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

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

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

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

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

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

2. Emboldening

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

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

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

3. Marking points

3.1 Marking of lists

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

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

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

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

Correct answers	Incorrect answers (ie incorrect rather than neutral)	Mark (2)	Comment
1	0	1	
1	1	1	They have not exceeded the maximum number of responses so there is no penalty.
1	2	0	They have exceeded the maximum number of responses so the extra incorrect response cancels the correct one.
2	0	2	
2	1	1	
2	2	0	
3	0	2	The maximum mark is 2
3	1	1	The incorrect response cancels out one of the two correct responses that gained credit.
3	2	0	Two incorrect responses cancel out the two marks gained.
3	3	0	

3.2 Marking procedure for calculations

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

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

3.3 Errors carried forward, consequential marking and arithmetic errors

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

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

3.4 Equations

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

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

3.5 Oxidation states

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

3.6 Interpretation of 'it'

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

3.7 Phonetic spelling

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

3.8 Brackets

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

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

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

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

3.10 Marking crossed out work

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

3.11 Reagents

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

The guiding principle is that a reagent is a chemical which can be taken out of a bottle or container. Failure to identify complete reagents **will be penalised**, but follow-on marks (eg 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.

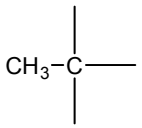
3.12 Organic structures

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, eg nitrile, carboxylic acid, aldehyde and acid chloride. The carbon-carbon bond should be clearly shown. Wrongly bonded atoms will be penalised **on every occasion**. (see the examples below)
- The same principle should also be applied to the structure of alcohols. For example, if students show the alcohol functional group as C ─ HO, they should be penalised **on every occasion**.
- Latitude should be given to the representation of C ─ C bonds in alkyl groups, given that CH_3─ is considered to be interchangeable with H_3C─ even though the latter would be preferred.
- Similar latitude should be given to the representation of amines where NH_2─ C will be allowed, although H_2N─ C would be preferred.
- Poor presentation of vertical C ─ CH_3 bonds or vertical C ─ NH_2 bonds should **not** be penalised. For other functional groups, such as ─ OH and ─ CN, the limit of tolerance is the half-way position between the vertical bond and the relevant atoms in the attached group.

By way of illustration, the following would apply.



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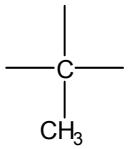

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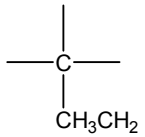

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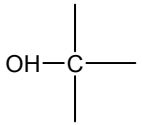

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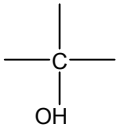

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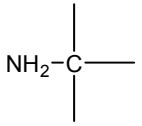

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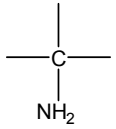

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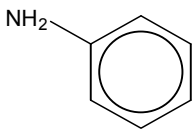

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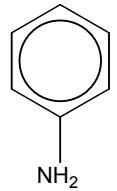

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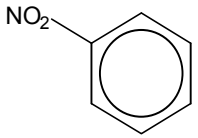

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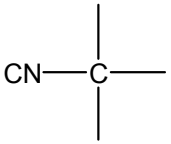

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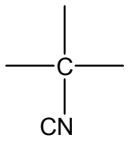

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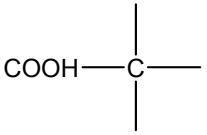

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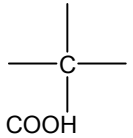

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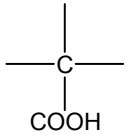

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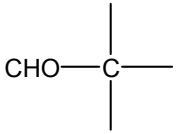

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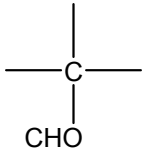

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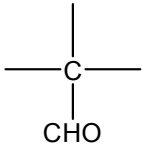

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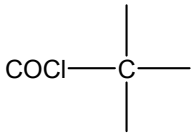

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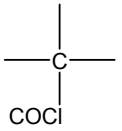

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- Representation of CH_2 by $C–H_2$ will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions may be made in the context of balancing equations)

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
  - 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

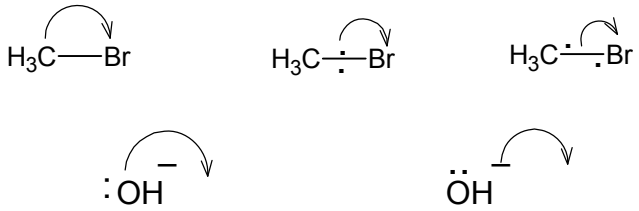
As a general principle, non-IUPAC names or incorrect spelling or incomplete names should **not** gain credit. Some illustrations are given here.

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**

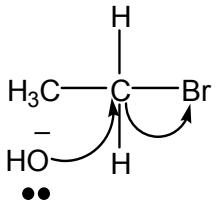
3.14 Organic reaction mechanisms

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



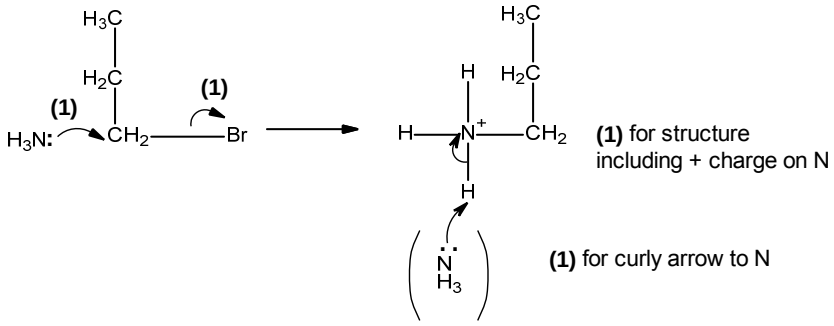
When the curly arrow is showing the formation of a bond to an atom, the arrow can go directly to the relevant atom, alongside the relevant atom or **more than half-way** towards the relevant atom.

In free-radical substitution

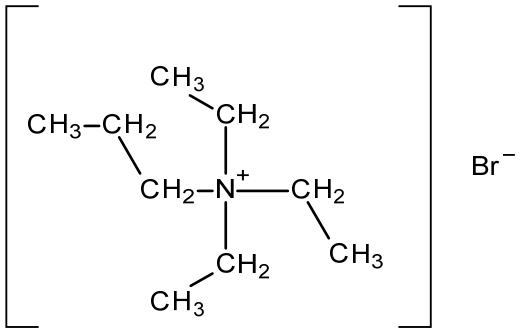
- the absence of a radical dot should be penalised **once only** within a clip.
- the use of half-headed arrows is not required, but the use of double-headed arrows or the incorrect use of half-headed arrows in free-radical mechanisms should be penalised **once only** within a clip

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.

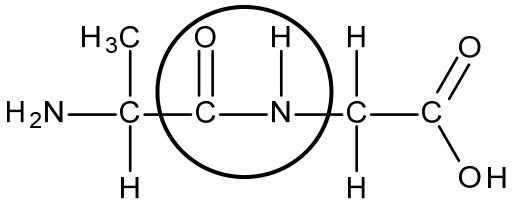
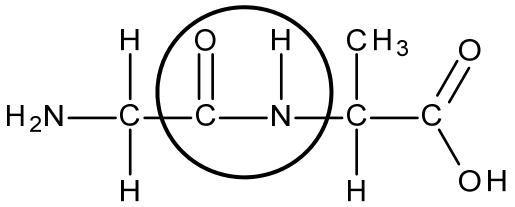
Question	Marking guidance	Mark	Comments
01.1	$CH_3CH_2CH_2NH_2 + H^+ \rightarrow CH_3CH_2CH_2NH_3^+$	1	Ignore spectator ions if included Do not accept $CH_3CH_2CH_2NH_2 + HCl \rightarrow CH_3CH_2CH_2NH_3Cl$ Do not accept $C_3H_7NH_2$ etc or $CH_3CH_2CH_2NH_2 + HCl \rightarrow CH_3CH_2CH_2NH_3^+ Cl^-$
01.2	Propyl group is (more) electron donating (than H) Increases lone pair density on N / lone pair on N more available	1 1	Allow the alkyl group has a positive inductive effect / the positive inductive effect of more alkyl groups NOT just inductive effect

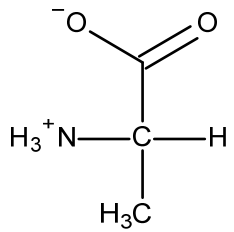
01.3	Nucleophilic substitution  1 for each correct curly arrow; 1 for intermediate	1 4	M1: Mechanism Name M2: Curly arrow from lone pair on N of ammonia to C–Br (do not allow if ammonia is negatively charged) M3: Curly arrow showing breaking of C–Br bond (ignore partial charges, but penalise incorrect partial charges) M4: intermediate ion (penalise use of incorrect halogenoalkane) M5: loss of H^+ (ignore use of ammonia, penalise use of halide ion) Allow M3 before M2 and then M2 for attack on a correct carbocation Penalise use of incorrect partial charges in M3

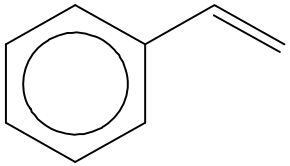
01.4	Propylamine reacts with more 1-bromopropane (to form secondary amines / tertiary amines / quaternary ammonium salts)	1	Allow further reaction/substitution occurs Allow secondary/tertiary amines/quarternary ammonium salts produced

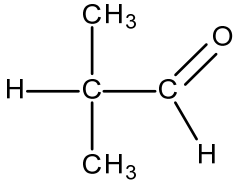
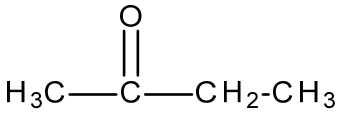
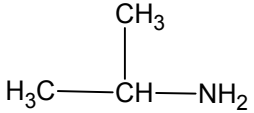
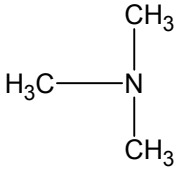
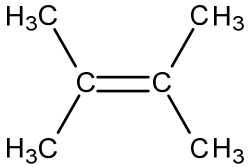
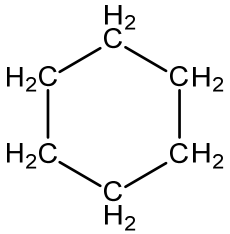
01.5	 Type of compound: Quaternary ammonium salt Use: (cationic) surfactant/detergent/fabric softener	1 1 1	M1: do not penalise absence of Br^- Allow also + charge on outside of square brackets Allow skeletal Allow $-C_2H_5$

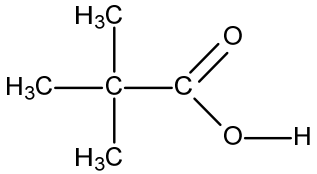
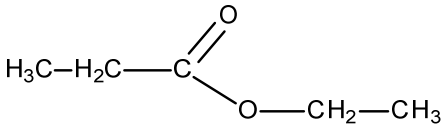
Total		**12**	

Question	Marking guidance	Mark	Comments
2.1	2-aminopropanoic acid	1	
2.2	Does not have a chiral carbon atom / there is no asymmetric carbon atom	1	Allow there are no carbon atoms which are bonded to four different groups
2.3		1	
		1	
	One peptide bond outlined correctly	1	Circled group only needs to be on one dipeptide

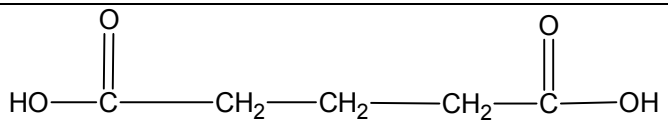
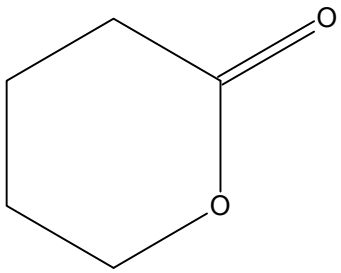
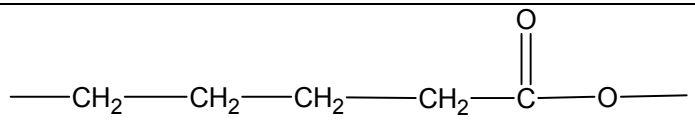
2.4	 Explanation: Strong electrostatic attraction between opposite charged ions	1 1	 Allow strong ionic bonds needs lots of energy to break
2.5	Ninhydrin / uv light (Larger molecules) much less soluble in the solvent / has a strong affinity to stationery phase/TLC plate	1 1	 Allow Very weak affinity to the mobile phase
2.6	Any TWO from: Unhydrolyzed peptide **or** Partially hydrolysed peptide **or** tripeptide **or** dipeptide **or** two species with the same solubility/affinity for stationary/mobile phase	2	Allow sparingly soluble impurities Do not allow two of the amino acids are the same
2.7	Tyrosine and methionine	1	Automarked (two ticks – one mark)
2.8	Does not analyse order the amino acids are joined	1	
Total		**13**	

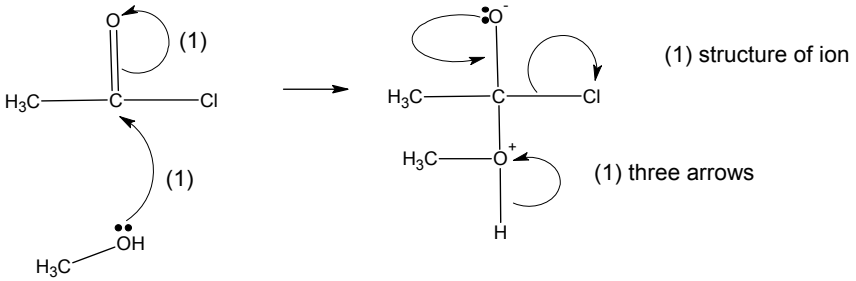
Question	Marking guidance	Mark	Comments
3.1	Addition (polymerisation)	1	Additional
3.2		1	Must be skeletal
3.3	C–C bonds are non polar / strong So cannot be hydrolysed/attacked by acids / attacked by alkalis / attacked by nucleophiles	1 1	
3.4	Need to be sorted / (high) transport costs	1	
3.5	Toxic gases are formed / Carbon monoxide formed which is toxic CO_2 is produced which is a greenhouse gas/contributes to global warming	1	Allow – particulates cause global dimming/respiratory disease NOT JUST CO_2 produced
Total		**6**	

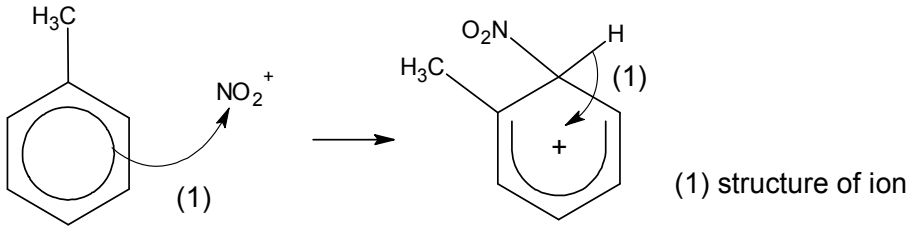
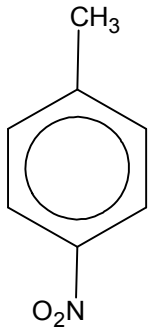
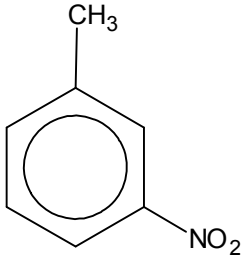
Question	Marking guidance	Mark	Comments
4.1	 **P**  **Q**	2	Allow skeletal/displayed structural formulae
4.2	 **R**  **S**	2	Allow skeletal/displayed structural formulae
4.3	 **T**  **U**	2	Allow skeletal/displayed structural formulae

4.4	 **V**  **W**	2	Allow skeletal/displayed structural formulae

Total		**8**	

Question	Marking guidance	Mark	Comments
5.1	5-hydroxypentanoic acid	1	
5.2		1	Also allow skeletal/displayed formulae
5.3		1	
5.4		1	Ignore brackets / ignore n Penalise more than one repeating unit
Total		**4**	

Question	Marking guidance	Mark	Comments
6	Name of Mechanism: (Nucleophilic) addition-elimination  	1 4	M1: Attack of lp on carbonyl carbon (penalise M1 if negative charge on oxygen of methanol) M2: breaking C=O bond (ignore partial charges, penalise incorrect charges) (allow M2 independent of incorrect M1) M3: structure of intermediate ion M4: lp on O and all three arrows (can be scored in two steps)
Total		**5**	

Question	Marking guidance	Mark	Comments
7.1	Reagents: concentrated HNO_3 and concentrated H_2SO_4 Equation: $2H_2SO_4 + HNO_3 \rightarrow NO_2^+ + 2HSO_4^- + H_3O^+$ Mechanism:  (1) structure of ion	2 1 3	Allow 1 for both reagents without concentrated Allow: $H_2SO_4 + HNO_3 \rightarrow NO_2^+ + HSO_4^- + H_2O$ (or via 2 equations) Penalise incorrect intermediate ion M1: arrow from delocalised ring to N in electrophile M2: structure of ion – horseshoe centred around C and + not too close to C M3: loss of H^+ (allow even if from incorrect intermediate) Ignore use of HSO_4^- to remove H^+
7.2	 	1	Do not allow the 2-nitro isomer Allow products with multiple NO_2 groups Allow 

7.3	Mass of methylbenzene = 10.0 x 0.870 = 8.70g Amount of methylbenzene = 8.70/92.0 = 0.0946 mol Max mass of 2-aminomethylbenzene = 0.0946 x 107.0 (=10.12g) OR actual moles of 2-aminomethylbenzene = 4.42/107.0 = 0.0413 % yield = 4.42/10.12 x 100 = 43.7% Or % yield = 0.0413/0.0946 x 100 = 43.7%	1 1 1 Accept correct alternative methods	M1: Calculates the amount of methylbenzene M2: Calculates the max theoretical mass of product or actual moles of product M3: Calculates % yield (allow 44%)

7.4	Delocalised ring is <u>electron rich</u> / <u>electron rich</u> pi-cloud Repels nucleophiles	1 1	 Mark independently

Total		**12**	

Question	Marking guidance	Mark	Comments
8.1	Proton donor / H^+ donor	1	
8.2	n(HCl) = 10.0 x 5.00 / 1000 = 0.0500 mol [diluted HCl] = 0.0500 x 1000/250 = 0.200 mol dm^{-3} pH = –log (0.200) = 0.70	1 1 1	Allow alternative methods e.g. 10/250 x 5 = 0.2 will score M1 and M2 Penalise more than / less than 2dp M3 ecf on incorrect M2
8.3	$K_w = [H^+][OH^-]$ Effect = K_w increases Explanation: Endothermic An increase in T shifts equilibrium to RHS / an increase in T increases dissociation	1 1 1 1	 If effect incorrect, then cannot score M4 M3 Independent
8.4	$[H^+] = K_w/[OH^-]$ $[H^+] = 1.0 \times 10^{-14}/0.125 = 8.0 \times 10^{-14}$ mol dm^{-3} pH = – log $[H^+]$ = 13.10	1 1	 M2 not conseq on M1 Allow 1dp or more

8.5	($[H^+] = 10^{-pH}$) ($[H^+] = 10^{-2.85}$) $[H^+] = 1.41 \times 10^{-3}$ (mol dm^{-3}) $Ka = [H^+][CH_3CH_2COO^-]/[CH_3CH_2COOH]$ ($[CH_3CH_2COOH] = [H^+]^2/Ka$) ($[CH_3CH_2COOH] = (1.41 \times 10^{-3})^2 / 1.35 \times 10^{-5}$) $[CH_3CH_2COOH] = 0.148$ mol dm^{-3}	1 1 1	M1: Calculation of $[H^+]$ M2: Ka expression (or rearranged Ka expression) M3: Calculation of concentration of acid (3 sf needed) Allow 0.147 or 0.148

8.6	$n(HA) = 0.250 \times 25/1000 = 6.25 \times 10^{-3}$ mol $n(NaOH) = 0.125 \times 10/1000 = 2.10 \times 10^{-3}$ mol $n(HA)$ in xs $= 6.25 \times 10^{-3} - 1.25 \times 10^{-3} = 4.15 \times 10^{-3}$ mol $[H^+] = 1.35 \times 10^{-5} \times 4.15 \times 10^{-3} / 2.10 \times 10^{-3}$ $[H^+] = 2.67 \times 10^{-5}$ mol dm^{-3} pH = 4.57	1 1 1 1 1	M1: moles of acid M2: moles of base M3: moles of acid in xs (if no subtraction then allow M1, M2 and M5 only) M4: $[H^+]$ M5: pH calc from their $[H^+]$ (allow 4.6 and more than 2dp)

8.7	Salt present reacts with added H^+ ions / equilibrium $HA \rightleftharpoons H^+ + A^-$ shifts to the left/to remove added H^+ $[H^+]$ remains approximately constant	1 1	 $[HA]/[A^-]$ remains approximately constant Allow $[H^+]$ increases by only a little

Total		**20**	