A-level
CHEMISTRY
7405/3

Paper 3

Mark scheme

June 2023

Version: 1.0 Final

236A7405/3/MS

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

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

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

AS and A-Level Chemistry
Mark Scheme Instructions for Examiners

1. General

The mark scheme for each question shows:

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

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

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

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

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

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

2. Emboldening

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

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

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

3. Marking points

3.1 Marking of lists

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

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

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

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

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

3.2 Marking procedure for calculations

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

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

3.3 Errors carried forward, consequential marking and arithmetic errors

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

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

3.4 Equations

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

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

3.5 Oxidation states

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

3.6 Interpretation of 'it'

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

3.7 Phonetic spelling

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

3.8 Brackets

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

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

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

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

3.10 Marking crossed out work

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

3.11 Reagents

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.

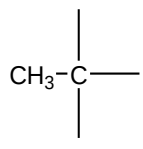
3.12 Organic structures

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

By way of illustration, the following would apply.



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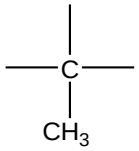

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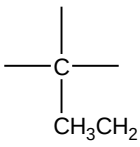

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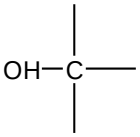

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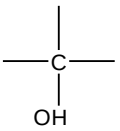

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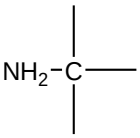

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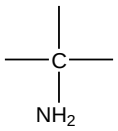

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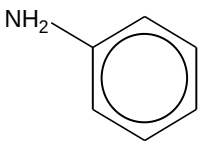

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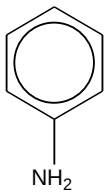

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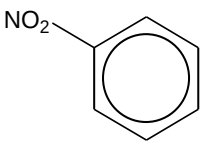

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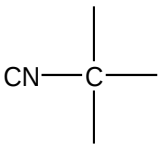

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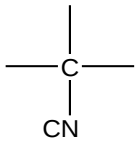

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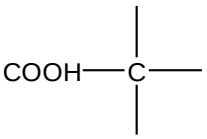

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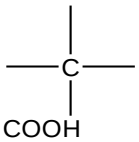

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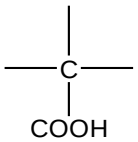

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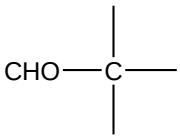

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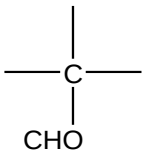

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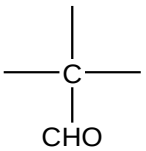

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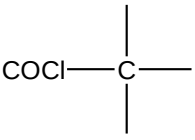

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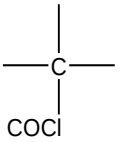


not allowed

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

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

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

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

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

3.13 Organic names

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

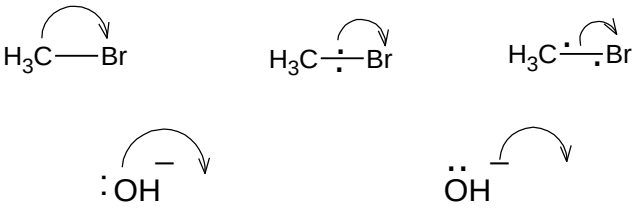
Unnecessary but not wrong numbers will **not** be penalised such as the number ‘2’ in 2-methylpropane or the number ‘1’ in 2-chlorobutan-1-oic acid.

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

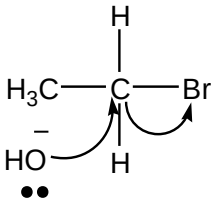
3.14 Organic reaction mechanisms

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

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



For example, the following would score zero marks



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

In free-radical substitution

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

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

3.15 Extended responses

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

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

Determining a level

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

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

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

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

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

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

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

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

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

For other extended response answers:

Where a mark scheme includes linkage words (such as 'therefore', 'so', 'because' etc), these are optional. However, a student's marks for the question may be limited if they do not demonstrate the ability to construct and develop a sustained line of reasoning which is coherent, relevant, substantiated and logically structured. In particular answers in the form of bullet pointed lists may not be awarded full marks if there is no indication of logical flow between each point or if points are in an illogical order. The mark schemes for some questions state that the maximum mark available for an extended response answer is limited if the answer is not coherent, relevant, substantiated and logically structured. During the standardisation process, the Lead Examiner will provide marked exemplar material to demonstrate answers which have not met these criteria. You should use these exemplars as a comparison when marking student answer.

Question	Answers	Additional comments/Guidelines	Mark
1.1	catalyst	**ALLOW** reduces E_a **IGNORE** speeds up reaction **IGNORE** provides alternative path **IGNORE** proton donor **IGNORE** dehydrating agent	1

Question	Answers	Additional comments/Guidelines	Mark
1.2	electric heater/heat mantle or (hot) water bath	**IGNORE** not with a Bunsen/naked flame / gently **ALLOW** hot water **ALLOW** heating/hot plate/ sand bath / oil bath **ALLOW** reference to flame/Bunsen if in context of heating a water bath **NOT** any indication of direct heat from Bunsen	1

Question	Answers	Additional comments/Guidelines	Mark
1.3	**M1** there is a bung/stopper (in the end of the condenser) **M2** idea of pressure build up **M3** water goes the wrong way through the condenser **M4** water does not fill the condenser / condenser is not cool enough	**owtte** **M2** stopper could be forced out **IGNORE** glass shatters / explodes water in at top / out at bottom **IGNORE** condenser is wrong way round **ALLOW** less condensing / vapour/gas/reactants/products will not condense / not as effective at cooling/condensing vapour/reactants/products escapes **IGNORE** uneven cooling **NOT** mixture in flask not cooled **ALLOW M1/M3** neck of flask not sealed owtte **M2/M4** vapour/reactants/products can escape **IGNORE** references to clamps	4

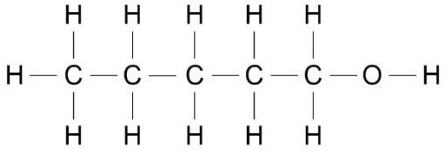
Question	Answers	Additional comments/Guidelines	Mark
1.4	**M1** to neutralise/react with/remove the <u>acid</u> **M2** carbon dioxide / gas is produced	**ALLOW** carboxylic/ethanoic and/or sulfuric **IGNORE** react with/neutralise the distillate/mixture **IGNORE** to act as a base **NOT** if incorrect acid named **ALLOW** effervescence / bubbles / fizzes **IGNORE** water vapour produced **NOT** if incorrect gas named **IGNORE** pressure build up (as in Q)	2

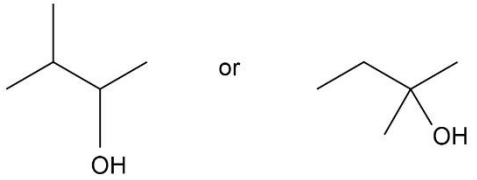
Question	Answers	Additional comments/Guidelines	Mark
1.5	**M1** ethyl ethanoate/it is immiscible with / insoluble in water **M2** ethyl ethanoate/it is less dense / has low<u>er</u> density (than water)	**ALLOW** water/solution and ethyl ethanoate/it do not mix, **OR** aqueous and organic layers do not mix **ALLOW** ethyl ethanoate/it is hydrophobic **IGNORE** references to polarity / intermolecular forces **IGNORE** different/low density **NOT** lighter **ALLOW** answers for either mark from either part	2

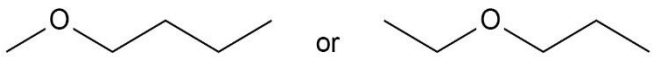
Question	Answers	Additional comments/Guidelines	Mark
1.6	to remove/absorb water / as a drying agent	**ALLOW** reacts with water **ALLOW** to dry the product/it **IGNORE** dehydrates **NOT** reference to crystals forming **NOT** to dry the reactants **NOT** to remove soluble impurities	1

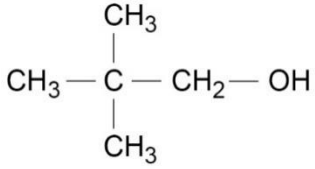
Question	Answers	Additional comments/Guidelines	Mark
1.7	**M1** mass of ethanol = 10 x 0.790 (= 7.90 g) **M2** amount of ethanol = $\frac{7.90}{46.0}$ (= 0.172 mol) **AND** amount of ethanoic acid = $\frac{5.25}{60.0}$ (= 0.0875 mol) **M3** (limiting reagent is) ethanoic acid **M4** (max amount of ethyl ethanoate = 0.0875 mol) max mass of ethyl ethanoate = 88.0 x 0.0875 (= 7.70 g) **M5** % yield = $\frac{5.47}{\mathbf{M4}}$ x 100 = 71.0% (70.6 to 71.1 to min 2sf)	Allow ECF at each stage **M1** scores from 0.172 mol of ethanol **M2** need to see numbers or sums for both substances **M2** 10/46 can only be ECF if 10 is identified as a mass **M3** ECF from **M2** if both amounts clearly shown and $n_{ethanol} < n_{ethanoic\ acid}$ **M4** independent of **M3** Alternative **M4 & 5** **M4** Amount of ethyl ethanoate formed = $\frac{5.47}{88.0}$ (=0.0622) **M5** % yield = $\frac{\mathbf{M4}}{0.0875}$ x 100 = 71.0% **Correct answer scores M4 and M5 but mark M1/2/3 separately** **M5** must show an attempt at mass or moles of ester formed divided by mass or moles of ester expected	5

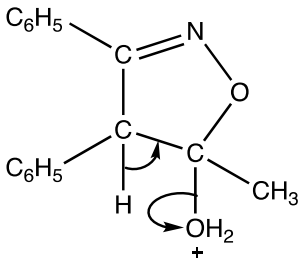
Question	Answers	Additional comments/Guidelines	Mark
1.8	reaction is an equilibrium/reversible	**ALLOW** losses during distillation/isolation/purification/transfer / incomplete distillation / side reactions / by-products **ALLOW** incomplete reaction **ALLOW** impurities/contamination/water present / not dry **IGNORE** water is also produced (during the reaction)	1

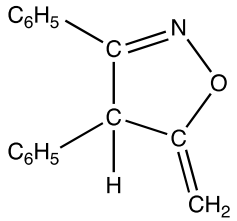
Question	Answers	Additional comments/Guidelines	Mark
2.1	Displayed formula of pentan-1-ol 	**NOT** pentan-3-ol **NOT** –OH	1

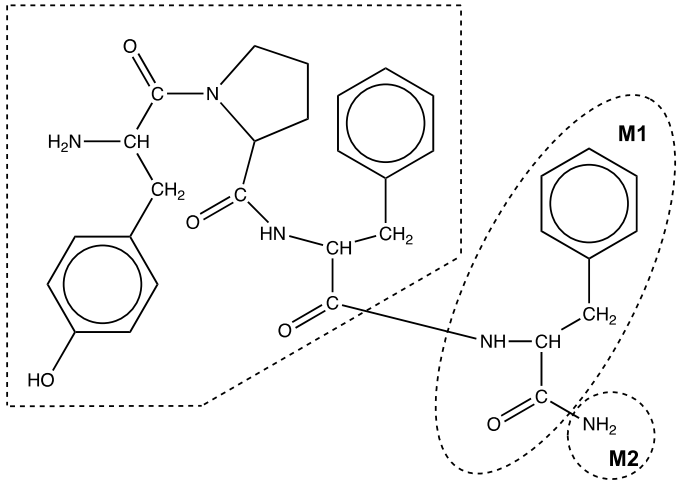
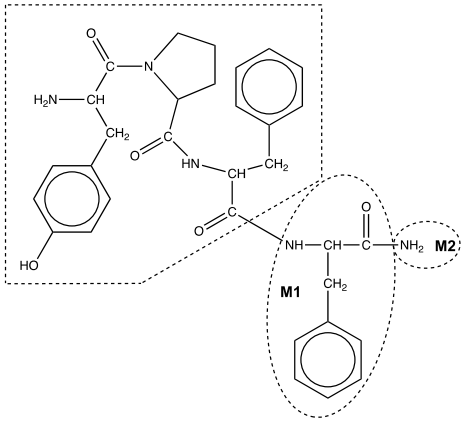
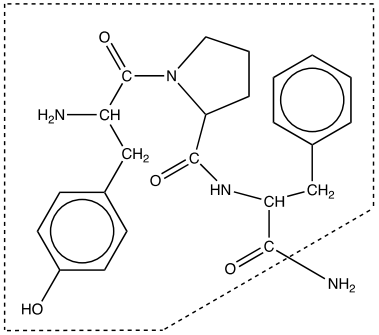
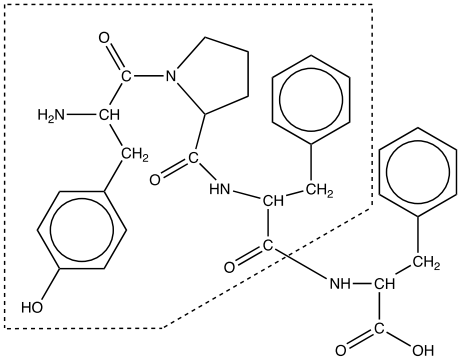
Question	Answers	Additional comments/Guidelines	Mark
2.2	Skeletal formula of 3-methylbutan-2-ol or 2-methylbutan-2-ol 	**IGNORE** numbers on C atoms **IGNORE** 'dots' at junctions **IGNORE** other non-skeletal structures **IGNORE** skeletal structure of pentan-2-ol **NOT** other incorrect skeletal structures **NOT** O–H **NOT** if bond clearly to H of OH	1

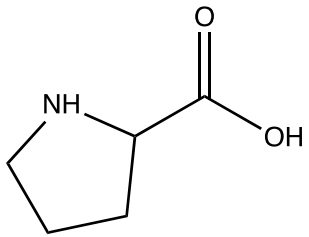
Question	Answers	Additional comments/Guidelines	Mark
2.3	one of these compounds 	Any structural representation of correct compound	1

Question	Answers	Additional comments/Guidelines	Mark
2.4		Any structural representation of correct compound	1

Question	Answers	Additional comments/Guidelines	Mark
2.5	 **M1** loss of H_2O: arrow from C–O bond to O **M2** loss of H^+: arrow from correct C–H bond to correct C–C bond **M3** elimination	**M1/M2** list principle for additional arrows on any structure **M1 NOT** if arrow to + **M3 IGNORE** acid-catalysed / dehydration **NOT** nucleophilic / addition / electrophilic	3

Question	Answers	Additional comments/Guidelines	Mark
2.6		Any structural representation of correct compound If skeletal CH_2 not needed Allow rings in place of C_6H_5	1

Question	Answers	Additional comments/Guidelines	Mark
3.1	 Alternative form  **M1** Phe structure drawn with correct peptide link **M2** amide group shown on end	**M1** if Phe drawn with COOH or $CONH_2$ **M2 ALLOW** if no Phe drawn i.e. if NH_2 only attached directly to C=O on diagram  Scores **M2** for ending in amide group  Scores **M1** for Phe group **M1** H needed on N of peptide link drawn unless C–CH–CH_2 drawn skeletal	2

Question	Answers	Additional comments/Guidelines	Mark
3.2		**ALLOW** zwitterion **ALLOW** -NH_2^+ and/or COO^- **ALLOW** with C shown in COOH group **ALLOW** without H on N **ALLOW** N–H **NOT** N–	1

Question	Answers	Additional comments/Guidelines	Mark
3.3	**M1** (aqueous) HCl / hydrochloric acid **M2** reflux/heat	Name or formula of any strong acid or alkali **ALLOW** warm / hot / high temperature for heat **NOT** T>200°C **IGNORE** conc as condition with acid/alkali **IGNORE** pressure **Alternative** **M1** protease/(poly)peptidase/peptase/named protease **IGNORE** enzyme **M2** warm **NOT** hot / high temperature / T>50°C	2

Question	Answers	Additional comments/Guidelines	Mark
3.4	**M1** lid/cover (on beaker) **Then any 2 from these 3** • prevents escape of vapour (from beaker) / evaporation of solvent (from beaker) • so atmosphere in beaker is saturated with solvent vapour owtte • to reduce evaporation from the plate	**ALLOW** (for bullet point 3) so solvent can rise up plate **ALLOW** (for bullet point 3) to avoid plate drying out	3

Question	Answers	Additional comments/Guidelines	Mark
3.5	Difference in the balance between solubility in solvent/mobile phase and attraction to/retention on stationary phase	**ALLOW** difference between (relative) affinity/attraction for solvent and stationary phase **ALLOW** absorption/adsorption for retention on stationary phase	1

Question	Answers	Additional comments/Guidelines	Mark
3.6	**M1** ninhydrin **M2** amino acids are colourless / to make the amino acids visible	**ALLOW** iodine **IGNORE** UV **IGNORE** stated final colour e.g. “turns the amino acids purple” is not enough on its own **IGNORE** clear	2

Question	Answers	Additional comments/Guidelines	Mark
3.7	0.54	**ALLOW** 0.53 – 0.55 (to min two sig figs)	1

<table>
<tr><th>Question</th><th>Answers</th><th>Additional comments/Guidelines</th><th>Mark</th></tr>
<tr>
<td>4</td>
<td>
<table>
<tr><td colspan="2">This question is marked using Levels of Response. Refer to the Mark Scheme Instructions for Examiners for guidance.</td></tr>
<tr><td>Level 3
5–6 marks</td><td>All stages are covered and the explanation of each stage is correct and virtually complete (ie two from stages 2 and 3 and three from stage 1).

Answer communicates the whole explanation, including equations, coherently and shows a logical progression through all three stages.</td></tr>
<tr><td>Level 2
3–4 marks</td><td>All stages are covered (NB ‘covered’ means min two from stage 1) but the explanation of each stage may be incomplete or may contain inaccuracies.
OR
two stages covered and the explanations are generally correct and virtually complete (i.e. two from stages 2 and/or 3 and/or three from stage 1).

Answer is coherent and shows some progression through all three stages. Some steps in each stage may be incomplete.</td></tr>
<tr><td>Level 1
1–2 marks</td><td>Two stages are covered (NB ‘covered’ means min two from stage 1) but the explanation of each stage may be incomplete or may contain inaccuracies.
OR
only one stage is covered but the explanation is generally correct and virtually complete (i.e. two from stages 2 and/or 3 and/or three from stage 1).

Answer shows some progression between two stages.</td></tr>
<tr><td>0 mark</td><td>Insufficient correct chemistry to gain a mark.</td></tr>
</table>
</td>
<td>
Indicative Chemistry content

Stage 1 IDs (Allow ppts if shown as products in equations or on the table)
(Allow names – with oxidation states for Fe compounds)

(1a) BOTH red-brown ppts from L = $Fe(H_2O)_3(OH)_3$ / $Fe(OH)_3$

(1b) green ppt from M = $Fe(H_2O)_4(OH)_2$/$Fe(OH)_2$ for NH_3
AND M = $FeCO_3$ with Na_2CO_3

(1c) white ppt with L = AgCl AND
white ppt with M = $BaSO_4$

(1d) L = $FeCl_3$ AND M = $FeSO_4$

Stage 2 Reactions with sodium carbonate (ALLOW if any 3+ compared with any 2+)

(2a) carbon dioxide is gas produced from L (could come from equation)

(2b) Fe^{3+} / $Fe(H_2O)_6^{3+}$ (in L) is more acidic than Fe^{2+} / $Fe(H_2O)_6^{2+}$ (in M) ora

(2c) Fe^{3+} is smaller / has higher charge / greater charge density of Fe^{3+} / is more polarising (makes ion a better proton donor)
</td>
<td>6</td>
</tr>
</table>

		Stage 3 Equations **(ECF from incorrect 3+ ion in L and/or 2+ ion in M)** (3a) $Fe(H_2O)_6^{3+} + 3NH_3 \rightarrow Fe(H_2O)_3(OH)_3 + 3NH_4^+$ **AND** $2Fe(H_2O)_6^{3+} + 3CO_3^{2-} \rightarrow 2Fe(H_2O)_3(OH)_3 + 3CO_2 + 3H_2O$ (3b) $Fe(H_2O)_6^{2+} + 2NH_3 \rightarrow Fe(H_2O)_4(OH)_2 + 2NH_4^+$ **AND** $Fe(H_2O)_6^{2+} + CO_3^{2-} \rightarrow FeCO_3 + 6H_2O$ **OR** $Fe^{2+} + CO_3^{2-} \rightarrow FeCO_3$ (3c) $Ag^+ + Cl^- \rightarrow AgCl$ **AND** $Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4$	

Question	Answers	Additional comments/Guidelines	Mark
5.1	**M1** energy transferred = 2.4 x 100 (= 240 kJ / 240000 J) **M2** amount of water vaporised = $\frac{103}{18}$ (= 5.72 mol) **M3** $\Delta H_{vap} = \frac{\textbf{M1 in kJ}}{\textbf{M2}}$ = (+)41.9 / 42.0 (kJ mol^{-1})	**M1 IGNORE** sign **ALLOW** ecf in **M3** (if $q = mc\Delta T$ used for incorrect **M1** then a value **in kJ** could score ecf in **M3**) **ALLOW** 41.9 to 42.11 to two or more sig figs **M3 NOT** if negative Correct answer = 3 marks	3

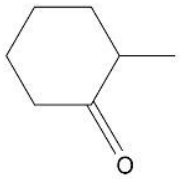
Question	Answers	Additional comments/Guidelines	Mark
5.2	**M1** O **AND** N more electronegative than C and/or H (so all have polar bonds) **M2** CH_3CH_2OH and CH_3OCH_3 both v-shaped/non-linear/bent **AND** $CH_3CH_2NH_2$ (trigonal) pyramidal **M3** shapes are not symmetrical (so molecules are polar) **M4** O more electronegative than N (so ethylamine is least polar)	**ALLOW** 'different electronegativities' PLUS diagrams labelled δ+ and δ- **ALLOW** angular for v-shaped in **M2** Diagrams from **M2** do not require lone pairs **ALLOW M3** if diagrams in **M2** show asymmetry Correct diagrams of the three shapes gives **M2** and **M3**	4

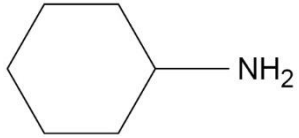
Question	Answers	Additional comments/Guidelines	Mark
5.3	**M1** hydrogen bonding in CH_3CH_2OH and $CH_3CH_2NH_2$ **AND** (permanent) dipole-dipole forces in CH_3OCH_3 **M2** hydrogen bonding stronger (than other (intermolecular) forces) **M3** hydrogen bonding stronger in CH_3CH_2OH than in $CH_3CH_2NH_2$	**IGNORE** van der Waals' / temporary/induced dipole-dipole forces **M1 NOT** any reference to breaking covalent bonds **M3 ALLOW** reference to O being more/most electronegative (than N) OR ethanol has greater dipole moment / more polar than ethylamine If none of M1, M2 or M3 have been awarded: **ALLOW** one mark for an indication that higher boiling point = stronger intermolecular forces but **NOT** if reference to breaking covalent bonds	3

Question	Answers	Additional comments/Guidelines	Mark
6.1	**M1** amount of HCl = 0.010 mol **AND** amount $Ca(OH)_2$ ($= \frac{0.6}{74.1}$) = 0.00810 **M2** 0.00810 mol of $Ca(OH)_2$ requires 0.0162 mol HCl **OR** 0.01 mol of HCl requires 0.005 mol of $Ca(OH)_2$ **NB** There must be an indication that 0.005 is the amount of $Ca(OH)_2$ needed and not just 0.01/2	Alternative: **M1** amount of HCl = 0.010 mol amount of $Ca(OH)_2$ needed = 0.0050 mol **NB** There must be an indication that 0.005 is the amount of $Ca(OH)_2$ needed and not just 0.01/2 **M2** mass of $Ca(OH)_2$ needed = 0.0050 x 74.1 = 0.3705 g (so 0.6 g is excess)	2

Question	Answers	Additional comments/Guidelines	Mark
6.2	**M1** 0.400 g dm^{-3} means 0.400 ÷ 74.1 (= 0.00540 mol dm^{-3}) **M2** $[OH^-]$ = **M1** x 2 (= 0.0108 mol dm^{-3}) **M3** $[H^+] = 6.80 \times 10^{-15}$ ÷ **M2** (= 6.30×10^{-13} mol dm^{-3}) **M4** pH = –log$[H^+]$ **M5** = –log **M3 with answer to 2dp** (= 12.20)	Correct answer to 2 dp = 5 marks **ALLOW** 12.21 for 5 marks **M4 ALLOW** if calculation shown containing a number that has been calculated as $[H^+]$	5

Question	Marking Guidance	Mark	Comments
07	C	1 (AO2)	**C** | 12 | 13 | 10 ⬭
08	B	1 (AO2)	166.0
09	A	1 (AO1)	graphite
10	C	1 (AO1)	$Ba(s) + Cl_2(g) \rightarrow BaCl_2(s)$
11	D	1 (AO1)	total number of particles present
12	C	1 (AO1)	The proportion of successful collisions increases because the catalysed reaction has a lower activation energy.
13	D	1 (AO2)	6.87×10^{-4}
14	B	1 (AO1)	magnesium in MgO
15	B	1 (AO1)	Intermolecular forces are overcome.
16	B	1 (AO1)	HCO_3^-
17	D	1 (AO2)	adding 10 cm^3 of 1.0 mol dm^{-3} HCl
18	C	1 (AO2)	1.00×10^{-4}
19	B	1 (AO2)	Sodium has the lowest melting point.

20	A	1 (AO1)	ammonia and ammonium chloride
21	B	1 (AO1)	a colourless solution with effervescence
22	D	1 (AO1)	I^-
23	A	1 (AO1)	$[CoCl_4]^{2-}$ is square planar.
24	C	1 (AO1)	$FeSO_4$
25	C	1 (AO2)	They have no effect on the value of the equilibrium constant.
26	D	1 (AO3)	Step 5 H_2 with a nickel catalyst
27	C	1 (AO1)	decomposition of ozone
28	A	1 (AO2)	0.133
29	B	1 (AO3)	
30	D	1 (AO1)	Ozone absorbs ultraviolet radiation.
31	A	1 (AO2)	propene
32	D	1 (AO1)	$C_6H_5CH(OH)CH_3 + [O] \rightarrow C_6H_5COCH_3 + H_2O$
33	A	1 (AO1)	comparing fingerprint regions of their infrared spectra

34	A	1 (AO1)	
35	C	1 (AO1)	Enzymes work equally well on both optical isomers of a substrate.
36	D	1 (AO2)	replacement of two Cl^- ligands