AQA

A-LEVEL
Chemistry

7405/2 - Paper 2 Organic and Physical Chemistry
Mark scheme

June 2018

Version/Stage: 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.

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

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

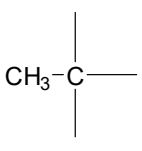
Where students are asked to draw organic structures, unless a specific type is required in the question and stated in the mark scheme, these may be given as displayed, structural or skeletal formulas or a combination of all three as long as the result is unambiguous.

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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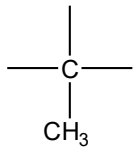

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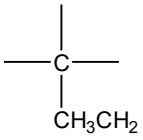

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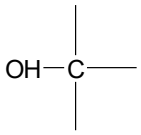

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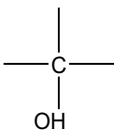

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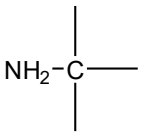

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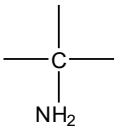

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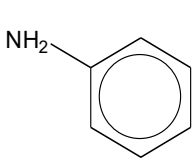

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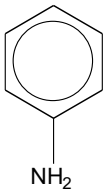

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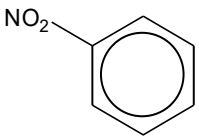

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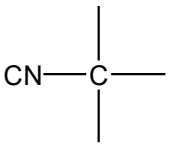

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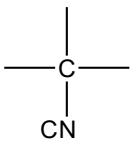

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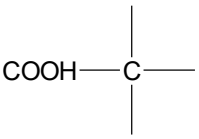

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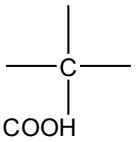

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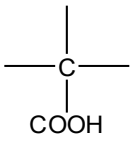

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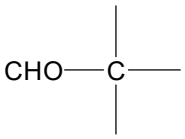

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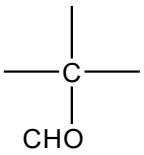

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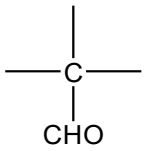

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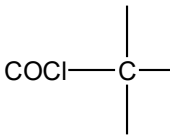

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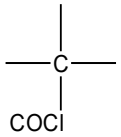

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- Representation of CH_2 by C–H_2 will be penalised
- Some examples are given here of **structures** for specific compounds that should **not** gain credit (but, exceptions may be made in the context of balancing equations)

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	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

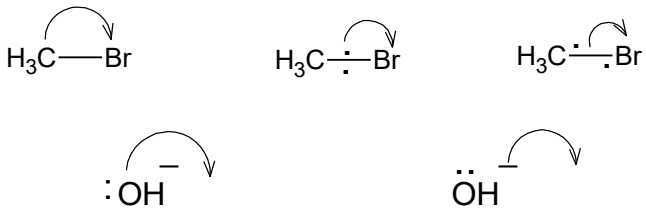
As a general principle, non-IUPAC names or incorrect spelling or incomplete names should **not** gain credit. Some illustrations are given here.

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**

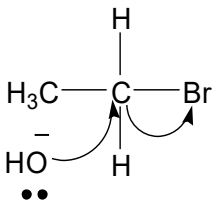
3.14 Organic reaction mechanisms

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.

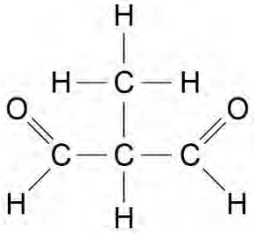
An answer which contains nothing of relevance to the question must be awarded no marks.

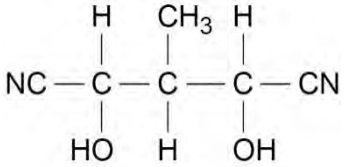
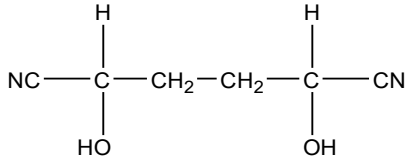
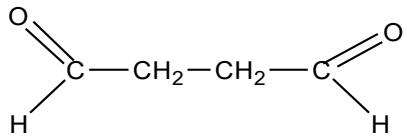
For other extended response answers:

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.

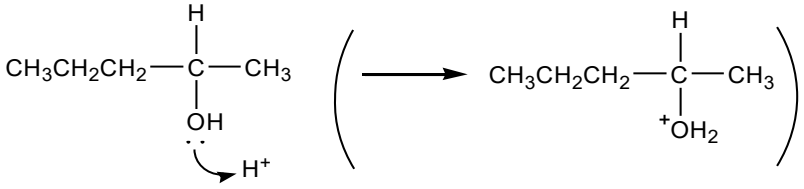
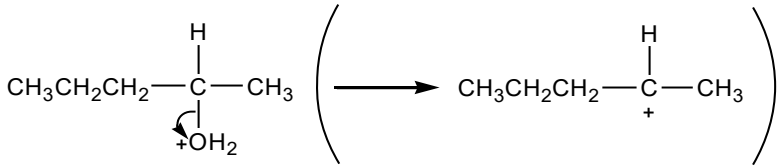
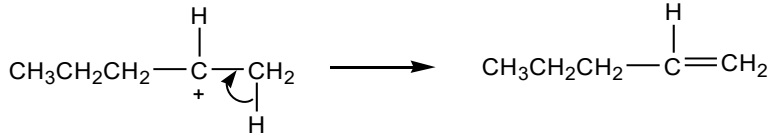
The mark schemes for some questions state that the maximum mark available for an extended response answer is limited if the answer is not coherent, relevant, substantiated and logically structured. During the standardisation process, the Lead Examiner will provide marked exemplar material to demonstrate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

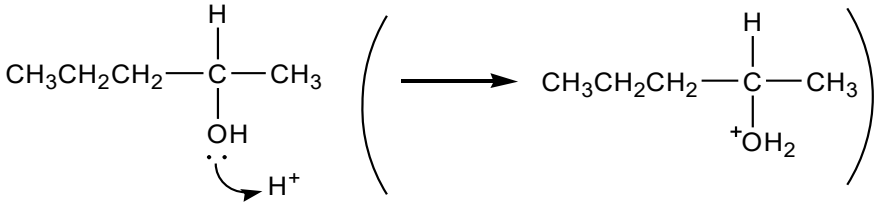
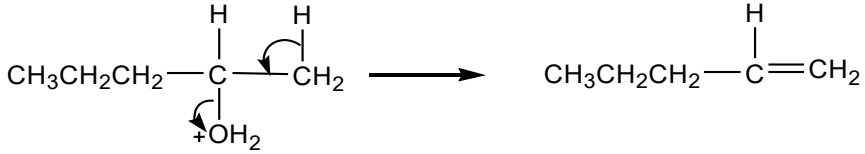
Question	Answers	Mark	Additional Comments/Guidance
01.1	$C_7H_{16} + 11O_2 \rightarrow 7CO_2 + 8H_2O$	M1	Ignore state symbols Allow multiples
01.2	Zeolite OR aluminosilicate Slight/moderate pressure $C_{16}H_{34} \rightarrow C_7H_{16} + C_6H_{12} + C_3H_6$	M1 M2 M3	Allow porous pot / aluminium oxide / alumina / silica / silicon dioxide Slightly above atmospheric – allow 1-5 atmospheres / 100-500kPa
01.3	$Cl\bullet + CH_3CH_2CH_2CH_3 \longrightarrow CH_3CH_2\overset{\bullet}{C}HCH_3 + HCl$ $CH_3CH_2\overset{\bullet}{C}HCH_3 + Cl_2 \longrightarrow CH_3CH_2CHClCH_3 + Cl\bullet$	M1 M2	If incorrect radical or ambiguous radical lose M1 but can award M2 for ecf in each equation. Allow equations in either order Allow dot anywhere on the second carbon Ignore extra initiation and termination steps
01.4	$Cl\cdot$ $Cl\cdot + O_3 \rightarrow ClO\cdot + O_2$ $ClO\cdot + O_3 \rightarrow Cl\cdot + 2O_2$ $Cl\cdot$ is regenerated (and causes a chain reaction in the decomposition of ozone)	M1 M2 M3 M4	Allow Cl or Chlorine in M1 and M4 Penalise absence of dot once in the equations Allow dot anywhere on the radical Apply the list principle in the equations and penalise initiation from Cl_2 Allow equations in either order. Ignore $Cl\cdot$ acts as a catalyst
Total		10	

Question	Answers	Mark	Additional Comments/Guidance
02.1	3-bromo-(2)-methylpropan-1-ol ONLY	1	3 and 1 are essential, 2 may be omitted, but any other number here is wrong Ignore hyphens and commas
02.2	Bromine is more electronegative than carbon C is partially positive / electron deficient Lone/electron pair (on the nucleophile) donated to the partially positive carbon	M1 M2 M3	Allow difference in electronegativity if polarity of bond shown M2 and M3 can be awarded from diagram that shows nucleophilic attack Allow lone pair attracted to / attacks the partially positive carbon
02.3		1	Must be displayed with all bonds shown

Question	Answers	Mark	Additional Comments/Guidance
02.4	 KCN & (dil) acid Allow  from  	1 1 1	Not need be displayed See General Marking instructions section 3.12 for penalties for incorrectly drawn bonds such as C–HO or C–NC etc. Allow HCN Ignore alcoholic solvents Penalise conc. HCl, H_2SO_4 or any HNO_3
Total		7	

Question	Answers	Mark	Additional Comments/Guidance
03.1	Aldehyde/propanal has <u>dipole-dipole</u> forces (between molecules) Alcohol/propan-1-ol AND Carboxylic acid/ propanoic acid have hydrogen bonding (between molecules). The forces between the molecules in aldehyde are weaker (than those in alcohol and acid so it will evaporate first.)	M1 M2 M3	If any 'covalent bonds broken' CE=0 for clip. Ignore Van der Waal forces Ignore reference to energy M3 only awarded following correct M1 OR M2 Allow converse for M3
03.2	Keep the temperature of the reaction mixture below the boiling point of propan-1-ol/below 97 °C Cool the distillate / collecting vessel	M1 M2	Allow temperature in range 49-96 inclusive Allow description of cooling the vessel Ignore reference to oxidising agents Penalise lid / sealed container
03.3	Add named carbonate/hydrogencarbonate OR magnesium to a sample of the distillate. Effervescence/fizz/bubbles would confirm presence of acid or converse	M1 M2	Incorrect chemical CE=0 Allow formula (mark on for incorrect formula) Allow blue litmus or correct named indicator Blue litmus turns red confirms acid present or converse Allow gas/CO_2 produced which turns lime water cloudy OR gas/H_2 produced which burns with a squeaky pop

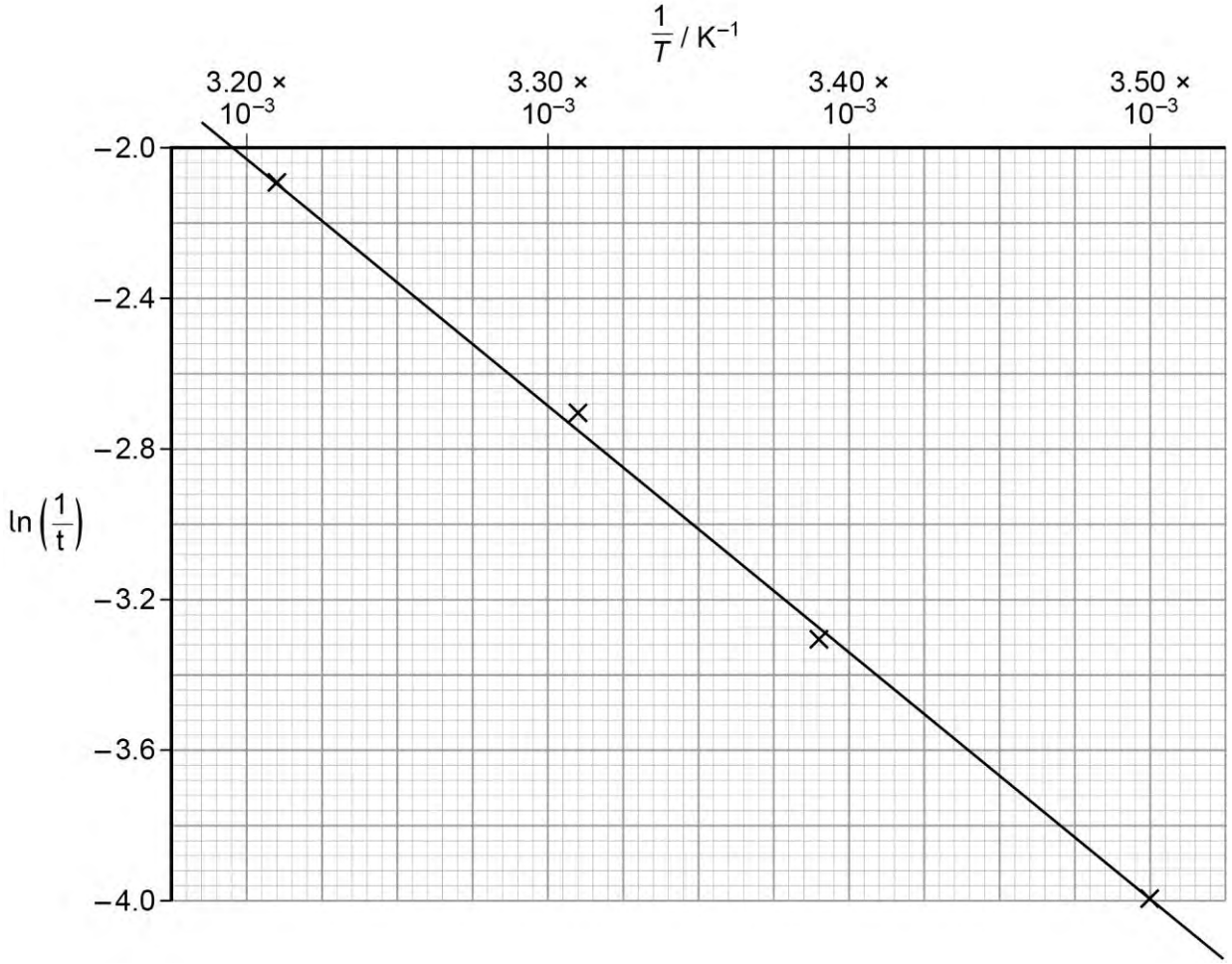
03.4	(Temperature difference = 15.1 °C) q = 150 × 4.18 × 15.1 or 9467.7 J or 9.4677kJ amount ethanol burned = 0.457/46.0 = 9.93 × 10^{-3} mol Heat change per mole = (M1/1000)/M2 = 952.99 kJ mol^{-1} ΔH = – 953 kJ mol^{-1} must be 3sfs and must be negative (allow range -953 to -954)	 M1 M2 M3	If ΔT wrong – AE mark on otherwise can only award M2 If use 457 in M1, can only score M2 If use 457 in M2 can score 2 for - 0.953 kJ mol^{-1} BEWARE if they miss conversion to kJ and also miss conversion to g, they get answer = - 953 which scores 1 +953 can score M1 and M2 Allow -950 or -960 for rounding to 2sf
03.5	Elimination Mechanism : Either (E1)   	M1 3	Penalise base elimination M2 for protonation of alcohol, i.e. lp plus arrow to H^+ or to H of H–O– in H_2SO_4 and from H-O bond to O M3 for protonated alcohol plus arrow showing loss of water M4 for arrow showing loss of H^+ From correct carbocation (E1) wrong alcohol used / alkene formed loses M4

	OR (E2)  		M2 for protonation of alcohol, i.e. lp plus arrow to H^+ or to H of H–O– in H_2SO_4 and from H-O bond to O M3 for protonated alcohol plus arrow showing loss of water M4 for arrow showing simultaneous loss of H^+ wrong alcohol used / alkene formed loses M4

03.6	*E*-pent-2-ene C=C bond cannot <u>rotate</u> **and** Each carbon in the double bond has (2) different groups attached.	M1 M2	Allow trans Allow (two) different groups on each/either side of the double bond.
Total		16	

Question	Answers	Mark	Additional Comments/Guidance
04.1	Initial amount of A = 6.4×10^{-3} Equ A = $6.4 \times 10^{-3} - 2x$ ∴ $x = 1.25 \times 10^{-3}$ B = $9.5 \times 10^{-3} - x = 8.25 \times 10^{-3}$ C = $2.8 \times 10^{-2} + 3x = 0.0318$ D = $x = 1.25 \times 10^{-3}$	M1 M2 M3 M4 M5	If M1 wrong can score max 3 If incorrect x can score max 3 Allow 2 or more sig figs
04.2	$K_c = \frac{[C]^3[D]}{[A]^2[B]}$ Units = mol dm^{-3}	1 1	Penalise ( ) but mark on in 4.2 & 4.3 If K_c wrong no mark for units
04.3 Can see 4.2	M1 for correct rearrangement $[A]^2 = \frac{[C]^3[D]}{K_c[B]}$ or $[A] = \sqrt{\frac{[C]^3[D]}{K_c[B]}}$ M2 for division of mol of B, C and D by correct volume $[A]^2 = \frac{[1.05/0.5]^3[0.076/0.5]}{116 \times [0.21/0.5]}$ or 0.0289 or 0.0290 M3 for final answer: [A] = 0.17 (must be 2 sfs)	M1 M2 M3	If K_c wrong in 4.2 can score 1 for dividing by correct volume If K_c correct but incorrect rearrangement can score 1 for dividing by correct volume
04.4	(All) conc fall: (ignore dilution) Equm moves to side with more moles To oppose the decrease in conc	1 1 1	OR K_c = mole ratio × 1/V If vol increases, mole ratio must increase To keep K_c constant If only conc of A falls CE=0 If pressure falls CE=0
Total		13	

Question	Answers	Mark	Additional Comments/Guidance
05.1	$k = \frac{2.4 \times 10^{-2}}{0.10 \times 0.20 \times (0.30)^2}$ (= 13.333) = 13 (must be 2 sfs) Units $\underline{mol^{-3}\ dm^{+9}\ s^{-1}}$	1 1 1	Mark is for insertion of numbers into a correctly re-arranged equation. Can be in any order
05.2 Marked with 5.1	Experiment 2 $[BrO_3^-]$ = 0.15 Experiment 3 rate = 0.26 or 0.27 Experiment 4 $[H^+]$ = 0.45 or 0.46	1 1 1	If k wrong in 5.1 : allow the expected answer OR values conseq to their k (allow mix & match) Ex 2 $[BrO_3^-]$ = 2/k Ext 3 rate = 0.02 × k Ex 4 $[H^+]$ = square root of (2.7/k)
05.3 **G**	1/T value 3.31(1) × 10^{-3} or 0.00331(1) ln(1/t) value –3.30 or –3.297	1 1	Must be 3 sig figs or more Not allow –3.29
05.4 Can see 05.3	M1 y axis labelled with values (no units) and plotted points use over half of the axis M2 points plotted correctly (see graph below) M3 best fit straight line (minimum 3 points plotted) M4 gradient = – 6.64 × 10^3 (K) or -6640 (K) M5 E_a = M4 × 8.31 M6 = 55.2 kJ mol^{-1}	1 1 1 1 1 1	 + - one small square for line of best fit Range - 6.5 × 10^3 to - 6.8 × 10^3 or -6500 to -6800 If gradient outside range then max 4 for M1,M2,M3 and M5 Range 54.0 - 56.5
Total			14


$\frac{1}{T}$ / K^{-1}
3.20 × 10^{-3}
3.30 × 10^{-3}
3.40 × 10^{-3}
3.50 × 10^{-3}
−2.0
−2.4
−2.8
−3.2
−3.6
−4.0
$\ln\left(\frac{1}{t}\right)$

<table>
<tr><th>Question</th><th colspan="2">Answers</th><th>Additional Comments/Guidance</th><th>Mark</th></tr>
<tr><td rowspan="5">06.1</td><td colspan="2">This question is marked using Levels of Response. Refer to the Mark Scheme Instructions for Examiners for guidance on how to mark this question.</td><td rowspan="5">Indicative chemistry content

Stage 1 Bonding
1a) Each C has three (covalent) bonds
1b) Spare electrons (in a p orbital) overlap (to form a π cloud)
1c) delocalisation

Stage 2 Shape
2a) Planar
2b) Hexagon/6 carbon ring/120° bond angle
2c) C–C bonds equal in length / C–C bond lengths between single and double bond

Stage 3 Stability
3a) Expected $\Delta H^{\ominus}$ hydrog^{n} of cyclohexatriene = –360 kJ mol^{-1}
3b) $\Delta H^{\ominus}$ hydrog^{n} benzene (is less exothermic) by 152 kJ mol^{-1}
3c) Benzene lower in energy than cyclohexatriene / Benzene is more stable</td><td rowspan="5">6</td></tr>
<tr><td>Level 3

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

Answer communicates the whole process coherently and shows a logical progression from stage 1 and stage 2 to stage 3.

Completely correct use of sign and language in Stage 3.</td></tr>
<tr><td>Level 2

3-4 marks</td><td>All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR two stages are covered and the explanations are generally correct and virtually complete.

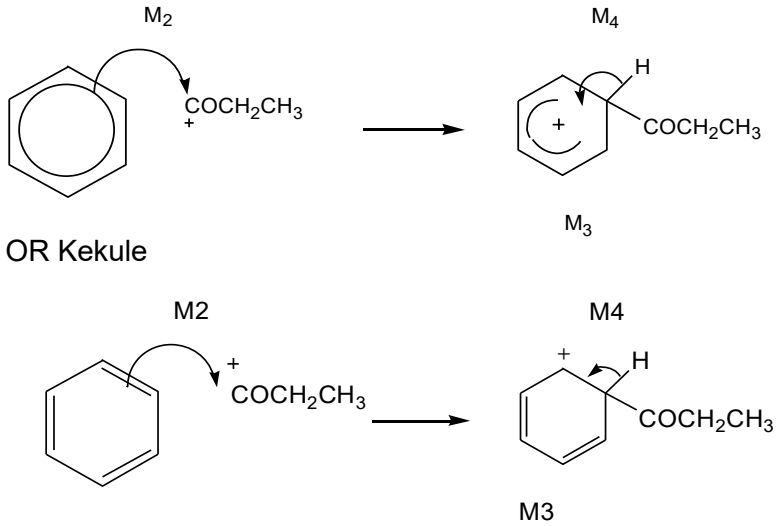
Answer is mainly coherent and shows a progression through the stages. Some steps in each stage may be incomplete.

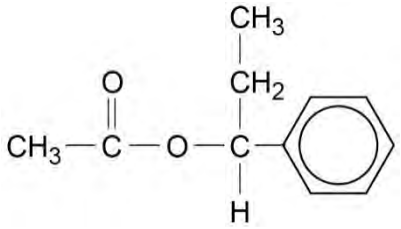
Some errors in use of sign and language in Stage 3.</td></tr>
<tr><td>Level 1

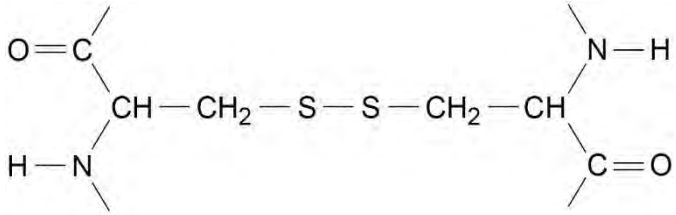
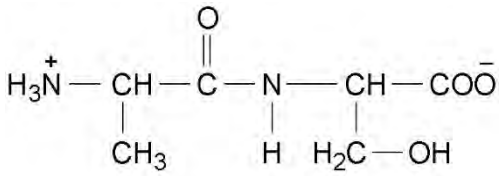
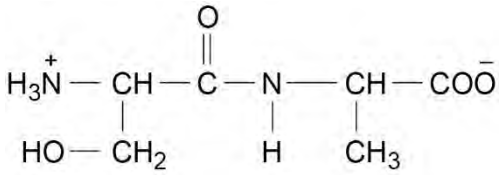
1-2 marks</td><td>Two stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies OR only one stage is covered but the explanation is generally correct and virtually complete.

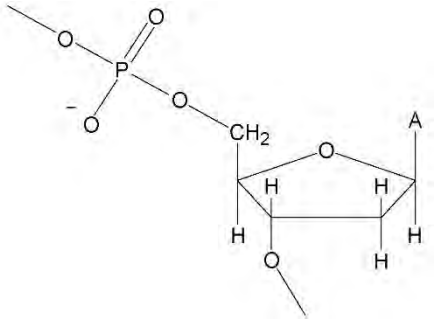
Answer includes some isolated statements but these are not presented in a logical order or show confused reasoning.</td></tr>
<tr><td>Level 0
0 marks</td><td>Insufficient correct chemistry to gain a mark.</td></tr>
</table>

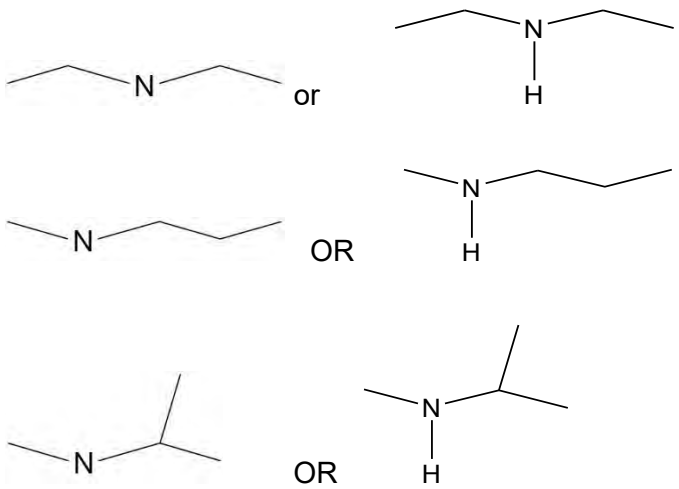
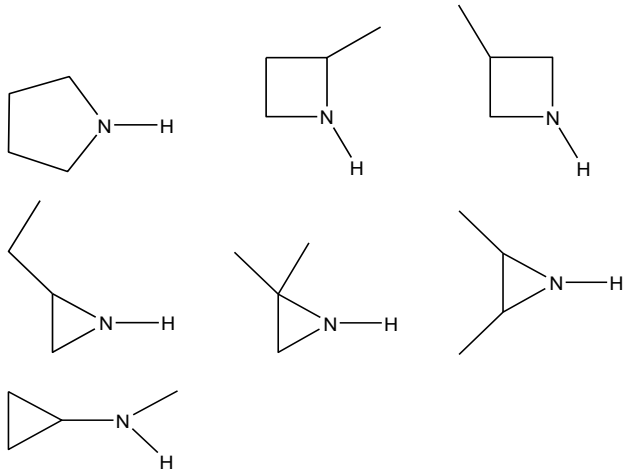
06.2	Value within range –239 to –121 Double bonds separated by one single bond / alternating (or shown in structure) Allows some delocalisation/overlap of p orbitals	1 1 1	If outside range including positive values CE=0 The wording ' close enough to allow delocalisation' would score M2 and M3 Ignore reference to hydration here
Total		9	

07.1	$AlCl_3 + CH_3CH_2COCl \longrightarrow CH_3CH_2-\overset{+}{C}=O + AlCl_4^-$		**M**1	Allow + on C or O in equation – But must be on C in mechanism
				M2 Arrow from inside hexagon to C or + on C M3 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) M4 Arrow from bond into hexagon (Unless Kekule) • Can allow M4 arrow independent of wrong M3 structure • + on H in intermediate loses M3 not M4 • Ignore Cl^- and $AlCl_4^-$ used in M4
07.2	1-phenylpropan-1-ol $NaBH_4$ / $LiAlH_4$ Nucleophilic addition	1-phenylpropan-1-ol H_2 with Ni/Pd/Pt Addition/hydrogenation	1 1 1	Both numbers needed for name Ignore solvents

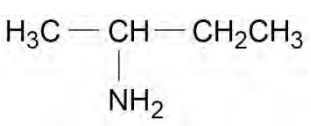
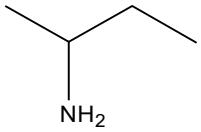
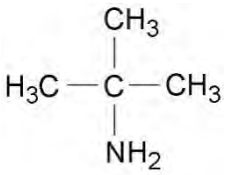
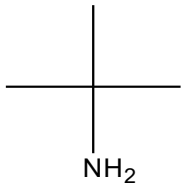
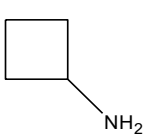
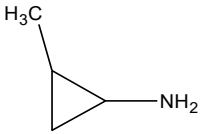
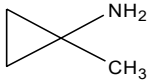
07.3	Misty fumes / steamy fumes (Nucleophilic) addition-elimination 	1 1 1	Allow sweet/fruity smell / white fumes Not smoke
Total		10	

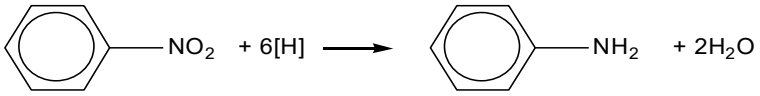
Question	Answers	Mark	Additional Comments/Guidance
08.1	electron deficient H (Which attracts) lone pair/electron pair on O	M1 M2	Allow H delta plus / slightly positive Penalise lone pair/electron pair donation
08.2		1	Penalise dashed/dotted S—S Ignore extra additions to structures
G 08.3	Tertiary or Quaternary	1	Allow 3° or 4° do not penalise minor error in spelling e.g. Quarternary
08.4	 OR 	1 1	Incorrect peptide bond CE=0 M1 for correct dipeptide M2 for correct charges Ignore additional dipeptide in working Allow –CONH— or –COHN—
Total		6	

Question	Answers		Mark	Additional Comments/Guidance
G 09.1	1 2 3 4 5 T G C A G		1	
Auto 09.2	13		1	
09.3		1 for completed 2-deoxyribose plus A 1 for correct phosphate joined to CH_2	1 1	Allow either OH or trailing bonds Don't penalise 'sticks' in 2-deoxyribose. If two phosphates shown CE=0 If CH_2 missing award 1 if no further errors If phosphate attached to oxygen on C3 award 1 if no further errors
Total			4	

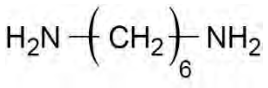
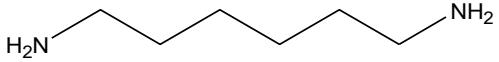
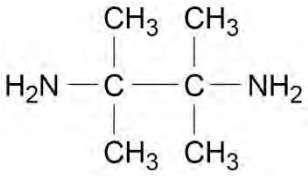
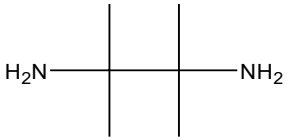
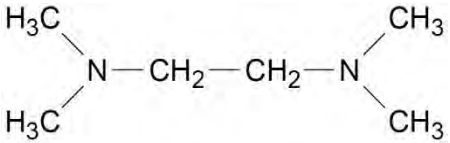
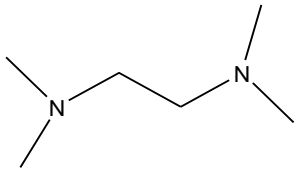
Question	Answers	Mark	Additional Comments/Guidance
A 10.1	C B A this order only	**1**	
10.2	Any three from  	2	**Must be skeletal** – allow with or without H on N All 3 correct score 2 (or one if not skeletal) Any two correct score 1 (or zero if not skeletal) Allow cyclic II° amines but NOT amines also containing other functional groups 

10.3	With halogenoalkane: further reaction (of primary amines) OR Impure product/mixture of products/lower atom economy With nitriles No further reaction OR Single product / higher atom economy	1 1	Ignore bi-product / yield

10.4	 or  or  or 	1	Allow cyclic I° amines but NOT amines also containing other functional groups   
10.5	$CH_3CH_2CH_2NH_2 + H_2O \rightleftharpoons CH_3CH_2CH_2NH_3^+ + OH^-$ (green) turns blue	1 1	Allow simple arrow Not C_3H_7 Allow blue-green, blue-purple

10.6	$C_6H_5NO_2 + 6[H] \rightarrow C_6H_5NH_2 + 2H_2O$ OR  $C_6H_5NH_2$ present as ionic salt OR $C_6H_5NH_3^+$ (Cl^-) OR phenyl ammonium (chloride)	1 1	Not H_2 Not molecular formulae Allow present as an ion But not phenylammonium hydroxide

Total		10	

Question	Answers	Mark	Additional Comments/Guidance
11.1	4 peaks Triplet Two H on adjacent C	1 1 1	 M3 dependent on correct M2
11.2	 or 	1	Not $-C_6H_{12}-$
11.3	 or 	1	
11.4	 or 	1	Not $-C_2H_4-$
Total		6	