A-level
CHEMISTRY
7405/2

Paper 2 Organic and Physical Chemistry

Mark scheme

June 2024

Version: 1.0 Final

2 4 6 A 7 4 0 5 2 / M S

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.

No student should be disadvantaged on the basis of their gender identity and/or how they refer to the gender identity of others in their exam responses.

A consistent use of 'they/them' as a singular and pronouns beyond 'she/her' or 'he/him' will be credited in exam responses in line with existing mark scheme criteria.

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

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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 (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.

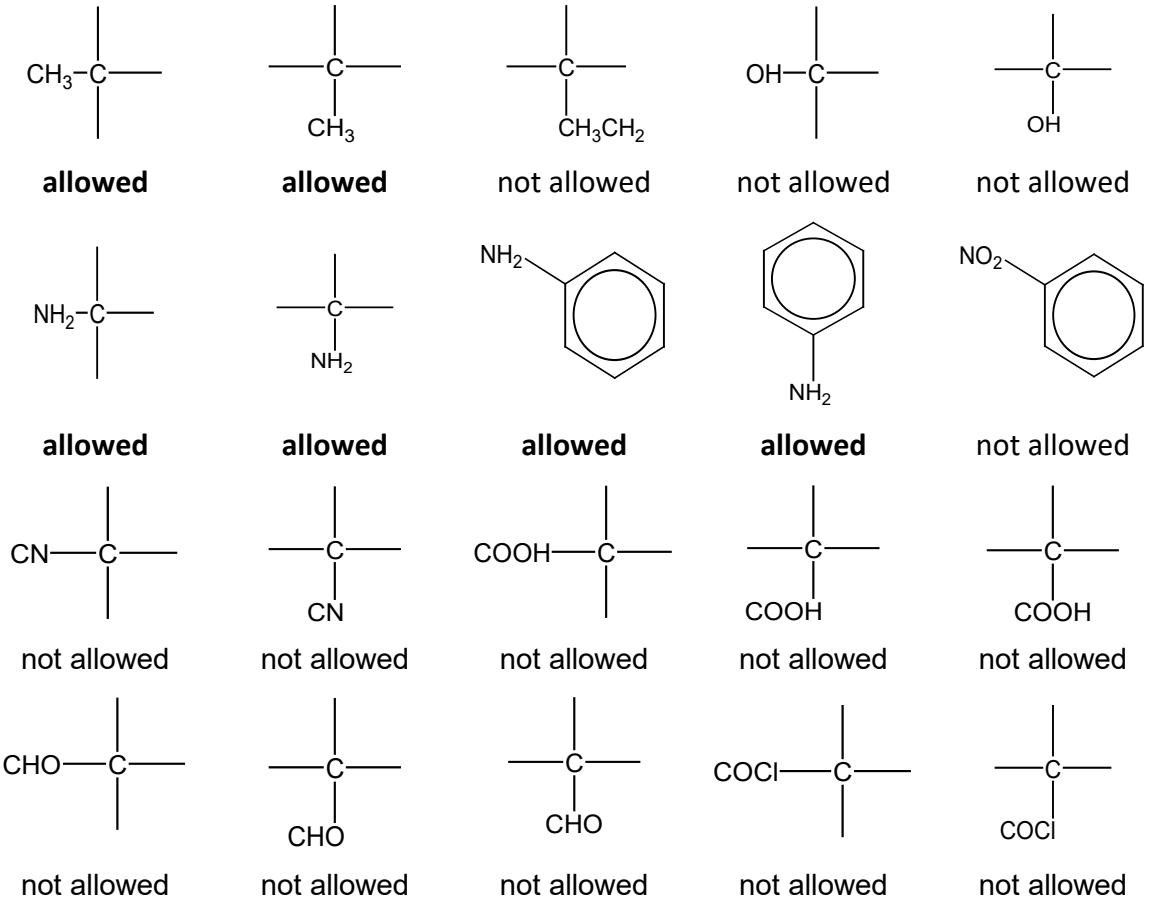
3.12 Organic structures

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.



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

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

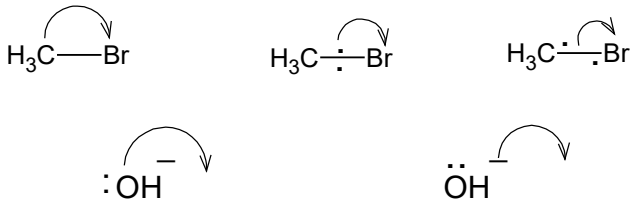
Unnecessary but not wrong numbers will **not** be penalised such as the number '2' in 2-methylpropane or the number '1' in 2-chlorobutan-1-oic acid.

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**

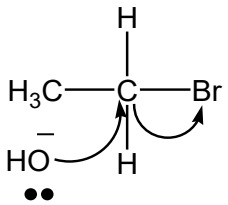
3.14 Organic reaction mechanisms

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.

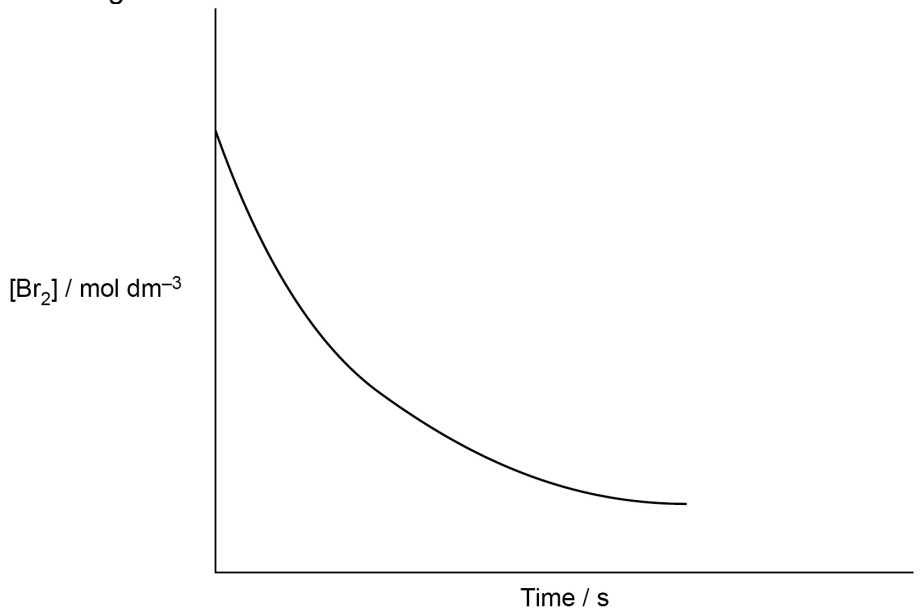
Indicative content in the mark scheme is provided as a guide for examiners. It is not intended to be exhaustive and you must credit other chemically valid points. Students may not have to cover all of the points mentioned in the indicative content to reach the highest level of the mark scheme. The mark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

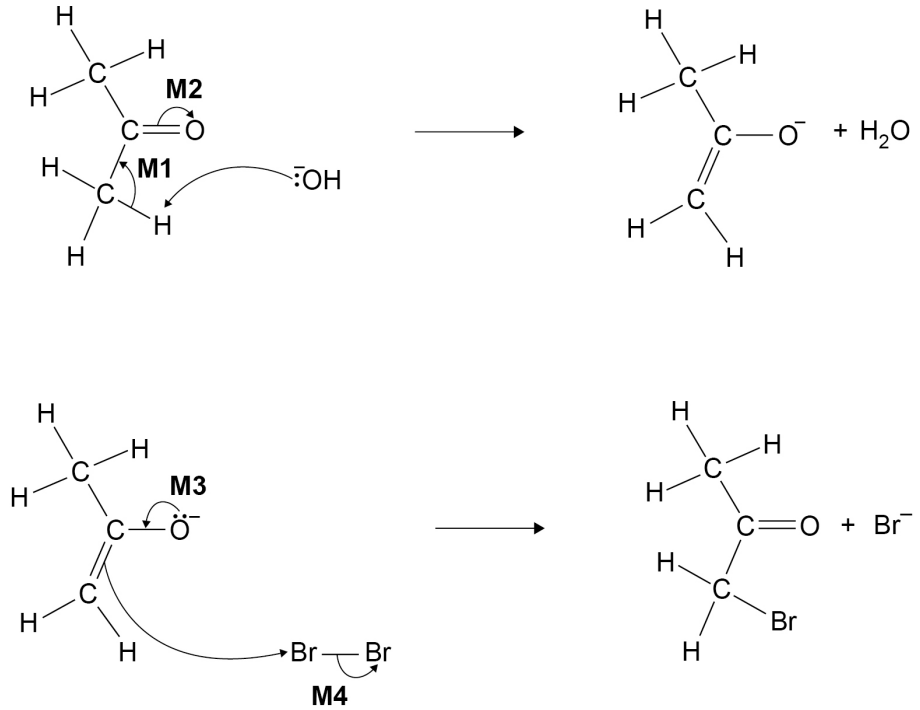
For other extended response answers:

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 answers.

Question	Answers	Additional Comments/Guidelines	Mark
01.1	Curve eg 	Curve with decreasing gradient	1 (1 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
01.2	M1 For $[OH^-] = 7.50 \times 10^{-2}$ M2 For rate = 2.75×10^{-11} M3 $k = \frac{\text{rate}}{[CH_3COCH_3][OH^-]}$ OR $k = \frac{2.75 \times 10^{-11}}{(1.5 \times 10^{-2}) \times (2.5 \times 10^{-2})}$ M4 $k = 7.3(3) \times 10^{-8}$ M5 units = $mol^{-1}dm^3s^{-1}$	M3 For rearranging rate equation Or For inserting correct numbers in rearranged equation If rearrangement upside down lose M3 but can score M4 for 1.36×10^7 as ECF M5 for $mol\ dm^{-3}\ s$ as ECF	5 (5 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
01.3	 M1 Arrow from C–H bond to C-C M2 Arrow from C=O bond to O M3 Arrow from lone pair on O to C–O bond M4 Arrow from Br–Br bond to Br	Dipoles must be correct if shown for M4	4 (4 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
01.4	Step 1 includes CH_3COCH_3 and OH^- <u>and</u> these are also in the rate equation Or Step 1 contains all the species in the rate equation	Br_2 not in step 1 <u>and</u> not in rate equation so it has to be step 1	1 (1 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
02.1	M1 mol P = 0.0145 + (2 × 0.0115) = 0.0375 M2 [P] = $\frac{\text{M1}}{0.025}$ = 1.50 mol dm^{-3}	ECF from incorrect M1	2 (2 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
02.2	M1 $K_c = \frac{[R][S]^3}{[P]^2\,[Q]}$ M2 $K_c = \frac{\left(\frac{0.0115}{0.045}\right)\left(\frac{0.0345}{0.045}\right)^3}{\left(\frac{0.0145}{0.045}\right)^2\left(\frac{0.0275}{0.045}\right)}$ or $= \frac{(0.256)(0.767)^3}{(0.322)^2(0.611)}$ M3 = 1.81 to 1.82 M4 units mol dm^{-3}	M1 Must be square brackets in expression M2 Inserts values and divides by volume in dm^3 M3 Evaluates expression If no use of volume lose M2 but can score M3 for 0.0817 M4 Allow consequential to their expression	4 (4 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
02.3	M1 equilibrium shifts to side with most moles M2 to oppose decrease in concentration of all reactants and products / dilution of everything OR M1 K_c is expressed as a function of concentrations and concentration equals amount over volume. M2 If Volume increases the amount of **R** and **S** must increase in order to keep K_c constant.	Allow M2 oppose the decrease in concentration of S $K_c = RS^3/P^2Q \times 1/V$ (where R,S etc are amounts) So, if V increases R and S must increase relative to P and Q to keep K_c constant	2 (2 x AO3)

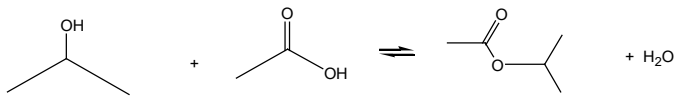
Question	Answers	Additional Comments/Guidelines	Mark
03.1	M1 + 3 C_2H_6 M2 Zeolite / Aluminosilicate / Aluminium oxide		2 (2 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
03.2	Option B		1 (1 x AO3)

Question	Answers	Additional Comments/Guidelines	Mark
03.3	Alkenes		1 (1 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
03.4	M1 Initial volume O_2 = 0.21 × 1350 = 283.5 (cm^3) M2 Volume of O_2 remaining = M1 – (6.5 × 20) = 153.5 cm^3 M3 Volume of CO_2 formed = 20 × 4 = 80 cm^3 M4 Total volume of gas left = M2 + M3 + (0.79 × 1350) = 1300 cm^3	Alternative route: M1 Vol Air decreases by 6.5 × 20 = 130 cm^3 M2 = 1220 cm^3 M3 Vol CO_2 produced = 4 × 20 = 80 cm^3 M4 Total Vol Air + CO_2 = 1220 + 80 = 1300 cm^3	4 (4 x AO2)

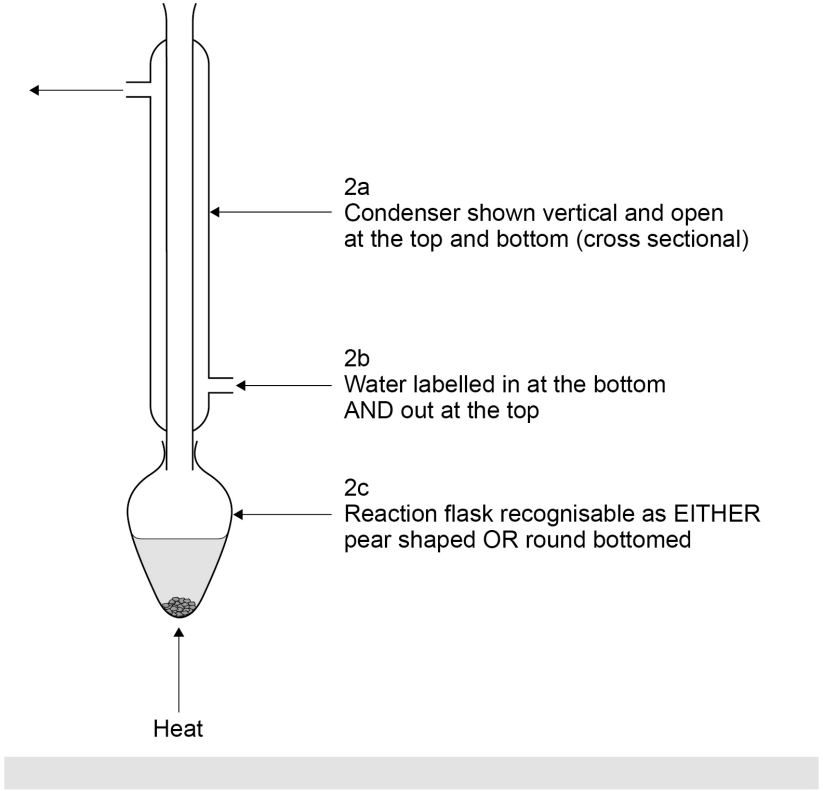
Question	Answers	Additional Comments/Guidelines	Mark
03.5	M1 Acid rain M2 CaO or $CaCO_3$	M1 Allow damages (limestone) buildings or statues / death of aquatic organisms / air pollution	2 (2 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
04.1	M1 $CH_3CH(OH)CH_3 + CH_3COOH \rightleftharpoons CH_3COOCH(CH_3)_2 + H_2O$ M2 Methyl ethyl ethanoate.	 Allow ECF from incorrect 5 carbon ester Allow other valid names 1-methylethyl ethanoate Isopropyl ethanoate 2-propyl ethanoate Propan-2-yl ethanoate	2 (1 x AO1, 1 x AO2)

Question	Answers		Additional Comments/Guidelines	Mark
04.2	This question is marked using Levels of Response. Refer to the Mark Scheme Instructions for Examiners for guidance.		Indicative Chemistry Content **Stage 1** 1a Measuring cylinder(s) for the propan-2-ol and ethanoic acid (size not required but if specified should be between 10 - 100 cm^3) Allow 10cm^3 / graduated pipette or burette 1b (Dropping/teat) pipette for sulfuric acid (NOT graduated or other qualification for pipette) **Stage 2 Diagram eg below to include** 2a Labelled <u>condenser</u> shown vertical and open at top and bottom i.e. in cross section 2b Labelled <u>water in</u> at the bottom and <u>water out</u> at the top of the vertical condenser 2c Labelled reaction <u>flask</u> recognisable as either pear shaped or round bottomed	6 (6 x AO3)
	Level 3 5–6 marks	All stages are virtually complete (virtually complete means one from stage 1 and two from stages 2 and 3) Answer communicates the whole explanation, including equations, coherently and shows a logical progression through all three stages		
	Level 2 3–4 marks	All stages are covered but the explanation of each stage may be incomplete or may contain inaccuracies (covered means one from a stage) **OR** two stages virtually complete (virtually complete means one from stage 1 or two from stages 2 and 3) Answer is coherent and shows some progression through all three stages. Some steps in each stage may be incomplete		
	Level 1 1–2 marks	Two stages are covered (covered means one from a stage) but the explanation of each stage may be incomplete or may contain inaccuracies **OR** only one stage is virtually complete (virtually complete means one from stage 1 or two from stages 2 and 3) Answer shows some progression between two stages		

			Stage 3 Safety Needs precaution AND reason for each suggestion 3a Use a fume cupboard / fume hood / well-ventilated lab space AND to avoid breathing in harmful / toxic / corrosive compounds 3b Wear gloves AND as compounds are corrosive 3c Add glass beads/chips (to the mixture before heating) / labelled as anti-bumping granules/chips AND to ensure smooth boiling / reduce size of bubbles 3d Use an electric heater/water bath AND as compounds are flammable	

	0 mark	Insufficient correct chemistry to gain a mark.		

04.2 (cont)	 2a Condenser shown vertical and open at the top and bottom (cross sectional) 2b Water labelled in at the bottom AND out at the top 2c Reaction flask recognisable as EITHER pear shaped OR round bottomed Heat	

Question	Answers	Additional Comments/Guidelines	Mark
04.3	M1 To neutralise / remove / react with (excess) acid M2 Remove stopper/bung OR tip the funnel upside down and open the tap M3 There will be a build up of pressure / gas / carbon dioxide OR M2 Allow add stopper M3 To prevent spillage	M3 must be linked to their precaution in M2	3 (1 x AO1, 2 x AO3)

Question	Answers	Additional Comments/Guidelines	Mark
04.4	Drying agent / To remove water	Not dehydrating agent	1 (1 x AO1)

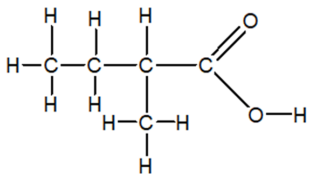
Question	Answers	Additional Comments/Guidelines	Mark
04.5	Compare boiling point to a data book/known value	Boils at sharp boiling point / over a narrow temp range	1 (1 x AO1)

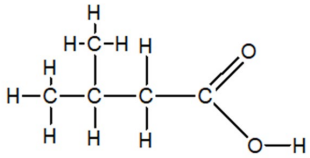
Question	Answers	Additional Comments/Guidelines	Mark
05.1	M1 Misty / white / steamy fumes M2 No visible change	M1 (immediate) White precipitate forms M2 White precipitate forms <u>slowly</u>	2 (2 x AO3)

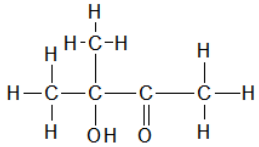
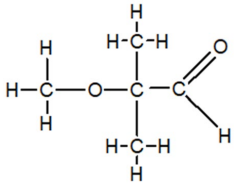
Question	Answers	Additional Comments/Guidelines	Mark
05.2	M1 Propanal AND (blue solution gives a brick) red precipitate If M1 incorrect, allow ECF for suitable tests on remaining liquids		3 (3 x AO3)

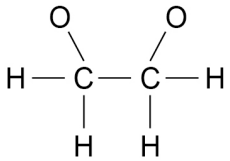
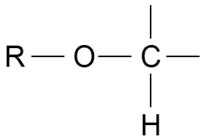
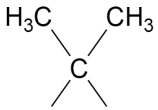
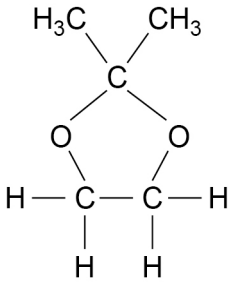
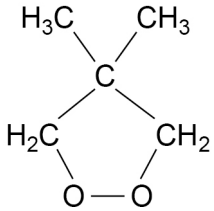
M2	(Warm with) acidified potassium dichromate (VI)	add Na	warm with a named carboxylic acid with conc H_2SO_4	(Warm with) acidified potassium manganate (VII)
M3	Propan-1-ol / alcohol AND (orange solution) goes green	Propan-1-ol/ alcohol AND effervescence	Propan-1-ol / alcohol AND fruity smell	Propan-1-ol / alcohol AND (purple solution) goes colourless

Question	Answers	Additional Comments/Guidelines	Mark
06.1	$C_4H_9COOH + NaHCO_3 \longrightarrow C_4H_9COONa + CO_2 + H_2O$		1 (1 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
06.2		$CH_3CH_2CH(CH_3)COOH$	1 (1 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
06.3	M1  M2 6:1:2:1 (Any order)	M1 $(CH_3)_2CHCH_2COOH$ M2 Allow ECF for a 5 carbon carboxylic acid	2 (2 x AO2)

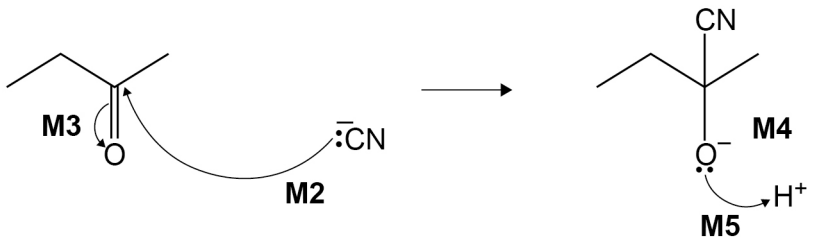
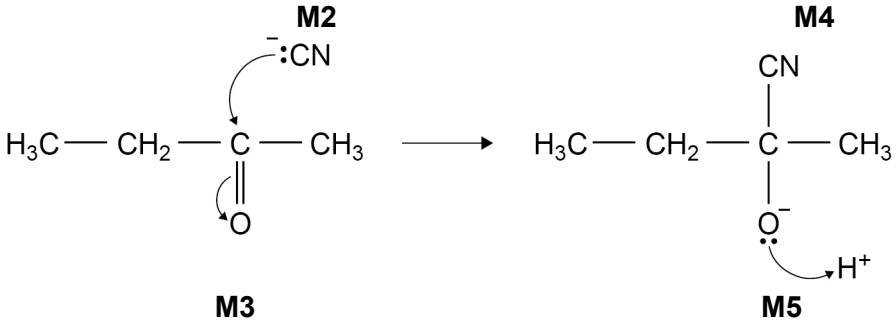
Question	Answers	Additional Comments/Guidelines	Mark
06.4	M1  Or  M2 Adjacent C has no (non-equivalent) H attached (so no splitting/spin-spin coupling takes place)	M1 $(CH_3)_2C(OH)COCH_3$ or $CH_3OC(CH_3)_2CHO$	2 (2 x AO2)

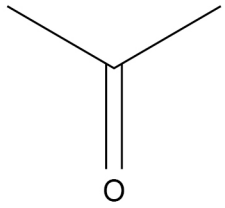
Question	Answers				Additional Comments/Guidelines	Mark
06.5		Scores M1 and M2	Allow M1 for			6 (1 x AO1, 5 x AO3)
		Scores M3 and M4	Allow M3 for	RCH_3		
		Scores M5		This structure also scores M5 		
	^{13}C peaks	= 3	M6	Allow ECF from their M5 of $C_5H_{10}O_2$		

Question	Answers	Additional Comments/Guidelines	Mark
07	M1 $\frac{2.62 \times 10^{-3}}{6.56 \times 10^{-4}}$ = 4 or $\frac{6.56 \times 10^{-4}}{2.62 \times 10^{-3}}$ = 0.25 M2 Hence $4CO_2$ + $4H_2O$ M3 So 4C and 8H in L M4 Hence 2O so $C_4H_8O_2$ $C_3H_4O_3$ scores 1 if no other mark scored	Alternative method M1 nH in L = 5.24×10^{-3} Hence mass H = 5.24×10^{-3} g M2 n C in L = 2.62×10^{-3} Hence mass C = $2.62 \times 10^{-3} \times 12$ = 3.144×10^{-2} g M3 Mass L = $6.56 \times 10^{-4} \times 88$ = 0.057728 g mass O = 0.057728 – ($5.24 \times 10^{-3} + 3.144 \times 10^{-2}$) = 0.021048 g M4 nO = 0.021048 / 16 = 1.3155×10^{-3} EF C H O 2.62×10^{-3} 5.24×10^{-3} 1.3155×10^{-3} 2 4 1 MF = (88/44) x C_2H_4O = $C_4H_8O_2$ $C_3H_4O_3$ scores 1 if no other mark scored	4 (4 x AO2)

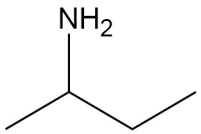
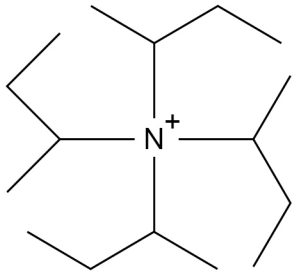
Question	Answers	Additional Comments/Guidelines	Mark
08.1	M1 Electrophilic Addition M2 HBr		2 (2 x AO1)

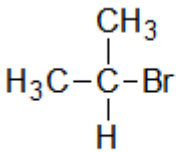
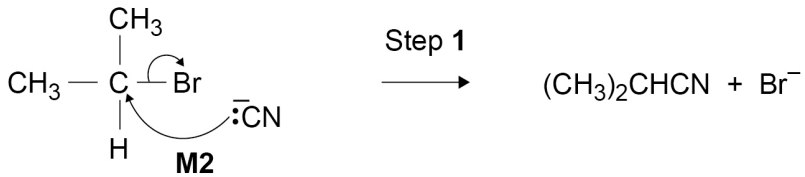
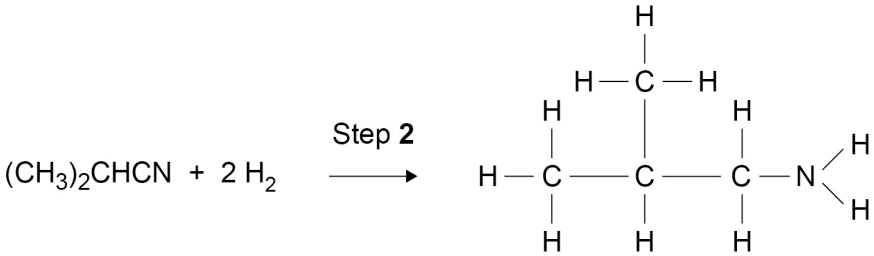
Question	Answers	Additional Comments/Guidelines	Mark
08.2	M1 Butan-2-ol or correct structure eg $CH_3CH(OH)CH_2CH_3$ M2 NaOH AND (warm) aqueous (Allow cold if stated)		2 (1 x AO1, 1 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
08.3	M1 HCN or KCN/H_2SO_4  M2 Arrow from lone pair on C to C of C=O M3 Arrow from C=O to O M4 Structure of intermediate including negative on O M5 Arrow from lone pair on O to H^+ OR  		5 (1 x AO1, 4 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
08.4	M1  planar/ flat M2 Equal chance (50/50) attack from above/below OWTTE M3 Giving equal amounts of both optical isomers/enantiomers	Allow planar carbonyl group Either side	3 (3 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
09.1	M1 CH_3NH_2 Shown as displayed or abbreviated structural formula M2 N-methyl ethylamine or N-methyl ethanamine For M2 allow alkyl groups reversed	For M2 Allow N-methyl aminoethane or N-methyl N-ethylamine or Methyl ethylamine Or Methyl ethanamine	2 (1 x AO1, 1 x AO2)

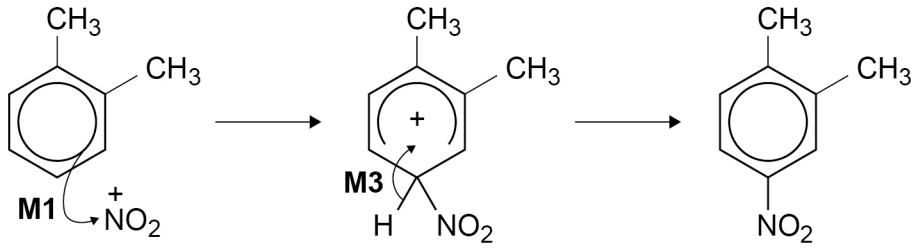
Question	Answers	Additional Comments/Guidelines	Mark
09.2	**M1**  **M2**  (Br^-) Note: If answers are non-skeletal penalise once only		2 (2 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
09.3	M1 For structure of 2 bromo propane  **M1** M2 For TWO correct curly arrows  **M2**  **M3** Amine **G** M3 Amine G has a <u>fully displayed</u> structure of Amine G		3 (3 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
09.4	M1 The lone pair on nitrogen in P is more available or more able to accept protons/H^+ M2 more alkyl groups are electron releasing/donating or greater (positive) inductive effect (of the alkyl groups)		2 (2 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
10.1	M1 Benzene is more stable than cyclohexatriene M2 The enthalpy of hydrogenation of benzene is (152 kJ mol^{-1}) less / less exothermic M3 Due to the delocalisation of electrons in benzene M4 Both are planar / hexagonal M5 Benzene has equal C-C bond lengths or regular hexagon whereas Cyclohexa-1,3,5-triene has bonds of different/varied length or the hexagon is distorted/irregular	M4 and M5 could be shown in a clear diagram	5 (2 x AO1 3 x AO3)

Question	Answers	Additional Comments/Guidelines	Mark
10.2	M1 Concentrated nitric acid AND concentrated sulfuric acid / conc. HNO_3 AND conc. H_2SO_4 M2 $HNO_3 + 2H_2SO_4 \longrightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$ OR $HNO_3 + H_2SO_4 \longrightarrow H_2NO_3^+ + HSO_4^-$ then $H_2NO_3^+ \longrightarrow NO_2^+ + H_2O$ OR $HNO_3 + H_2SO_4 \longrightarrow H_2O + NO_2^+ + HSO_4^-$		2 (1 x AO1 1 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
10.3	 **M2 – structure**	M1 Positive must be on N and arrow from inside hexagon to N or + on N M2 Structure showing horseshoe and positive charge. • Horseshoe centred on C1 but must not extend beyond C2 and C6 • + in intermediate not too close to C1 (allow on or "above" a line from C2 to C6) M3 Arrow from C-H bond back into hexagon	3 (3 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
10.4	Sn/HCl Ignore references to NaOH used after Sn/HCl BUT penalise if NaOH used at the same time as Sn/HCl	Allow H_2 with Pt/Ni Allow HCl with Fe	1 (1 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
10.5	Manufacture of dyes/(cationic) surfactants/fabric softener	Allow to make hair/fabric conditioner	1 (1 x AO1)

Question	Answers	Additional Comments/Guidelines	Mark
11.1	M1 Q = (mc ΔT = 60 × 4.18 × 52.1) = 13066.68 J M2 moles =($\frac{1.31}{136}$)= 0.00963 mol M3 $\frac{Q}{n}$ = $\frac{13066.68}{0.00963}$ = 1356541 (J mol^{-1}) M4 ΔH = –1360 kJ mol^{-1}	M3 = M1 / M2 M4 = - M3 /1000 Allow range –1355 to –1362	4 (1 x AO1, 3 x AO2)

Question	Answers	Additional Comments/Guidelines	Mark
11.2	Any 5 from the following: M1 Value from calorimetry less exothermic / lower / smaller (than method 1 value) M2 (Calorimetry =) because of heat / energy loss M3 (Calorimetry =) incomplete combustion M4 (Calorimetry =) some liquid hydrocarbon could have evaporated M5 Mean bond enthalpies values use enthalpies taken across a range of compounds M6 Value from bond enthalpy data ignores energy changes in vaporisation of the fuel or condensing the water	M1 Allow both are less (than method 1) M2 Copper absorbs some heat energy M6 Allow value from mean bond enthalpies does not include changes of state. M6 Allow value from mean bond enthalpies use gaseous states	5 (5 x AO3)