Mark Scheme (Results)

Summer 2023

Pearson Edexcel GCE
In Chemistry (9CH0)
Paper 02: Advanced Organic and Physical Chemistry

Edexcel and BTEC Qualifications
Edexcel and BTEC qualifications come from Pearson, the world's leading learning company. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk for our BTEC qualifications.

Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

If you have any subject specific questions about this specification that require the help of a subject specialist, you can speak directly to the subject team at Pearson. Their contact details can be found on this link: www.edexcel.com/teachingservices.

You can also use our online Ask the Expert service at www.edexcel.com/ask. You will need an Edexcel username and password to access this service.

Pearson: helping people progress, everywhere
Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

Summer 2023
Question Paper Log Number P71913A
Publications Code 9CH0_02_2306_MS

General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

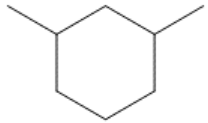
Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Answer	Additional Guidance	Mark
1(a)	• skeletal formula	Example of skeletal formula  Do not award displayed or structural formulae	(1)

Question number	Answer	Mark
1(b)	**The only correct answer is A** (C_nH_{2n-2}) ***B*** *is incorrect because C_nH_{2n} is the general formula of an alkene or a cycloalkane* ***C*** *is incorrect because C_nH_{2n+1} is the general formula of an alkyl group* ***D*** *is incorrect because C_nH_{2n+2} is the general formula of a straight chain or branched chain alkane*	(1)

Question Number	Answer	Additional Guidance	Mark
1(c)	An answer that makes reference to the following points: • you cannot control how many chlorine atoms will substitute **or** you cannot control the carbon atom on which the chlorine will substitute **or** a mixture of / side / unwanted / products will form **(1)** • need to separate the 1,2-dichlroethane from any other products made **(1)**	Allow names or formulae Allow a specific example of a correct unwanted product e.g chloroethane, 1,1,1-trichloroethane, 1,1-dichloroethane, 1-chlorobutane, butane Do not award H_2 Ignore Low yield, waste products, damage to ozone, dangers of UV, chain reaction, HCl	**(2)**

(Total for Question 1 = 4 marks)

Question number	Answer	Mark
2(a)	**The only correct answer is B** (a biofuel and renewable) ***A*** *is incorrect because ethanol is renewable using the fermentation process* ***C*** *is incorrect because ethanol is made from plants and is renewable using the fermentation process* ***D*** *is incorrect because ethanol is made from plants*	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(b)	• balanced equation	Example of equation $CH_3OH + 1½O_2 \rightarrow CO_2 + 2H_2O$ or $2CH_3OH + 3O_2 \rightarrow 2CO_2 + 4H_2O$ Allow fractions e.g. 3/2 O_2 Allow CH_4O for methanol Ignore state symbols	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(c)	• (red) phosphorus **and** iodine / P or P_4 **and** I_2 **or** phosphorus(III) iodide / PI_3	Allow name or formula but if both are given both must be correct. Allow potassium or sodium iodide / KI or NaI **and** phosphoric(V) acid / H_3PO_4 Allow white phosphorus and iodine Allow hydrogen iodide / HI Allow red phosphorus **and** PI_3 Ignore solvent Do not award phosphorus(V) iodide / PI_5 Do not award KI and /or H_2SO_4	**(1)**

Question number	Answer	Mark
2(d)(i)	**The only correct answer is B** (1485 – 1365, 2962 – 2853 and 3750 − 3200 cm^{-1}) ***A*** *is incorrect because 3300 − 2500 cm^{-1} is for an O-H in a carboxylic acid* ***C*** *is incorrect because 1669 – 1645 cm^{-1} for C=C in an alkene* ***D*** *is incorrect because 1740 – 1720 cm^{-1} is for C-O in an aldehyde and 3300 − 2500 cm^{-1} is for an O-H in a carboxylic acid*	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(d)(ii)	• 2 / two		**(1)**

Question Number	Answer	Additional Guidance	Mark
2(e)	• half-equation	Example of half-equation $CH_3CH_2OH + H_2O \rightarrow CH_3COOH + 4H^+ + 4e^-$ Allow multiples Allow $-4e^-$ on left hand side of equation Ignore missing charge on electron Ignore state symbols	**(1)**

(Total for Question 2 = 6 marks)

Question number	Answer	Mark
3(a)	**The only correct answer is D** (urea, $CO(NH_2)_2$) ***A*** *is incorrect because ethanamide has M_r of 59.037* ***B*** *is incorrect because ethanoic acid has M_r of 60.021* ***C*** *is incorrect because trimethylamine has M_r of 59.0733*	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(b)	• calculation of mol of gas **(1)** • calculation of molar mass **(1)**	Example of calculation mol of gas = $\frac{5.40}{24.0}$ = 0.225 (mol) molar mass = $\frac{9.90}{0.225}$ = 44.0 / 44 (g mol^{-1}) TE on mol gas Ignore SF except 1 SF Ignore units Correct answer with no working scores (2)	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(c)	• conversion of pressure, temperature and volume **(1)** • rearrangement of ideal gas equation **(1)** • calculation of n **(1)** • calculation of molar mass **and** answer to 2 / 3 SF **(1)**	Example of calculation pressure = $100.6 \times 10^3 = 1.006 \times 10^5$ Pa and temperature = 273 + 95.0 = 368 K and volume = $60.0 \times 10^{-6} = 6.00 \times 10^{-5}$ m^3 $n = \frac{pV}{RT}$ Allow values correctly substituted into $pV = nRT$ $n = \frac{1.006 \times 10^5 \times 6.00 \times 10^{-5}}{8.31 \times 368} = 1.9738 \times 10^{-3}$ TE on p, V and T Molar mass = $\frac{0.170}{1.9738 \times 10^{-3}}$ = (86.129) = 86 / 86.1(g mol^{-1}) TE on n Ignore units. If their final answer is less than 1 do not award the final mark	**(4)**

(Total for Question 3 = 7 marks)

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>4(a)</td><td>• calculation of mol of CO_2 (1)

• calculation of masses of C and H (1)

• calculation of mol and ratio of C : H (1)

• empirical formula (1)</td><td><u>Example of calculation</u>
mol CO_2 = $\frac{7.59}{44}$ = 1.725×10^{-1} / 0.1725 (mol)

mass C = 0.1725 × 12 = 2.07 (g)
or
$\frac{12}{44}$ x 7.59 = 2.07 (g) subsumes M1 as well
and
mass H = 2.50 – 2.07 = 0.43 (g)

<table><tr><td></td><td>C</td><td>H</td></tr><tr><td>mol</td><td>2.07/12
= 0.1725</td><td>0.43 /1
= 0.43</td></tr><tr><td>ratio</td><td>0.1725/0.1725
= 1</td><td>0.43/0.1725
= 2.4928</td></tr></table>
C_2H_5

Correct answer with no working scores 1
Correct answer with some working scores 4</td><td>(4)</td></tr>
</table>

Question number	Answer	Mark
4(b)(i)	**The only correct answer is A** (accepts a pair of electrons) ***B*** *is incorrect because electrophiles involve a pair of electrons, not an unpaired electron* ***C*** *is incorrect because nucleophiles donate a pair of electrons* ***D*** *is incorrect because nucleophiles donate a pair of electrons, not an unpaired electron*	**(1)**

Question Number	Answer	Additional Guidance	Mark
4(b)(ii)	An explanation that makes reference to the following points: • benzene (is resistant to bromination because it) has **delocalisation** of **electrons** / **delocalised electrons** (in π bonds) **(1)** • benzene is (kinetically) stable **or** the activation energy for the reaction is high **(1)** • ethene (reacts readily because it) has localised electron density (in one π bond) / does not have delocalised electrons **or** increased / high electron density (of the double / π bond compared to benzene) **(1)** • which makes it more susceptible to / easier to undergo electrophilic attack (than benzene) **(1)**	Allow more energy is required to break up the structure of benzene Allow a (Friedel-Crafts) catalyst / halogen carrier / $AlCl_3$, $FeBr_3$ is needed Allow ethene has a C=C / (carbon – carbon) double bond Allow benzene is less susceptible to electrophilic attack (than ethene) Allow the π / double bond in ethene is weaker (than in benzene) Allow ethene is a better nucleophile (than benzene) Allow the Br_2 / Br-Br is more easily polarised (by ethene) Do not award electrophilic attack by Br^+ If no other mark scored allow (1) for 'benzene undergoes substitution and ethene undergoes addition'	**(4)**

(Total for Question 4 = 9 marks)

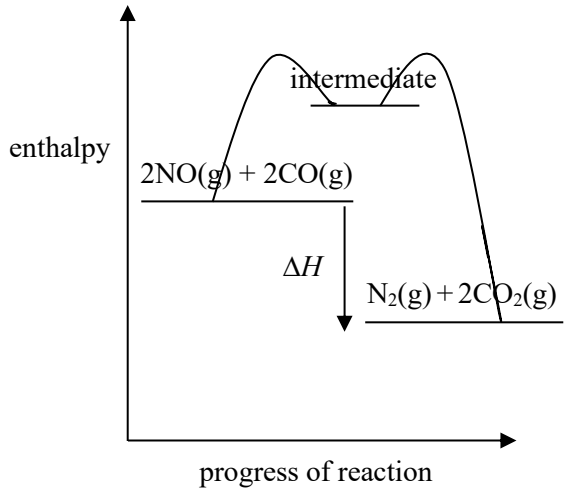
Question Number	Answer	Additional Guidance	Mark
5(a)(i)	An answer that makes reference to the following point: • there is a change / decrease in the number of (gas) molecules / moles (so there will be a change in the total gas pressure)	 If numbers are given, they must be correct (3 to 2) Ignore there is a change in the total volume of gas Ignore references to partial pressure	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(a)(ii)	An answer that includes: • temperature **and** volume	Do not award 'pressure'. Do not award 'heat' for temperature. Allow 'volume of container' Do not award 'volume of reactants'. Ignore catalyst Do not award if more than two factors given	**(1)**

Question number	Answer	Mark
5(b)(i)	**The only correct answer is D** (line **S**) ***A*** *is incorrect because [NO(g)] is decreasing during the reaction* ***B*** *is incorrect because [NO(g)] is decreasing during the reaction* ***C*** *is incorrect because [NO(g)] is decreasing during the reaction*	**(1)**

Question number	Answer	Mark
5(b)(ii)	**The only correct answer is B** (line **Q**) ***A*** *is incorrect because rate is directly proportional to* $[O_2(g)]$ ***C*** *is incorrect because rate is directly proportional to* $[O_2(g)]$ ***D*** *is incorrect because rate is directly proportional to* $[O_2(g)]$	**(1)**

Question number	Answer	Mark
5(c)	**The only correct answer is C** (2*z*) ***A*** *is incorrect because this is the rate if only the concentration of oxygen is halved* ***B*** *is incorrect because this is the rate if the concentration of nitrogen monoxide is doubled, the concentration of oxygen is halved and the reaction is first order with respect to nitrogen monoxide* ***D*** *is incorrect because this is the rate if only the concentration of nitrogen monoxide is doubled*	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(d)(i)		Example of reaction profile  	(3)
	• products line to the right and lower than reactants line **and** labelled **(1)**	Allow (unbalanced) formula of product or just 'product' Ignore missing state symbols	
	• single - headed arrow downwards **and** labelled **(1)**	Allow other labels, e.g. enthalpy change / energy change Do not award −ΔH but ΔH negative is awarded Do not award double-headed arrow Arrow should be close to the reactant line and finish close to the product line Ignore activation energy arrows	
	• two curves to show enthalpy with a catalyst **(1)**	Both curves must be above the reactants line Ignore missing line and / or label for intermediate	

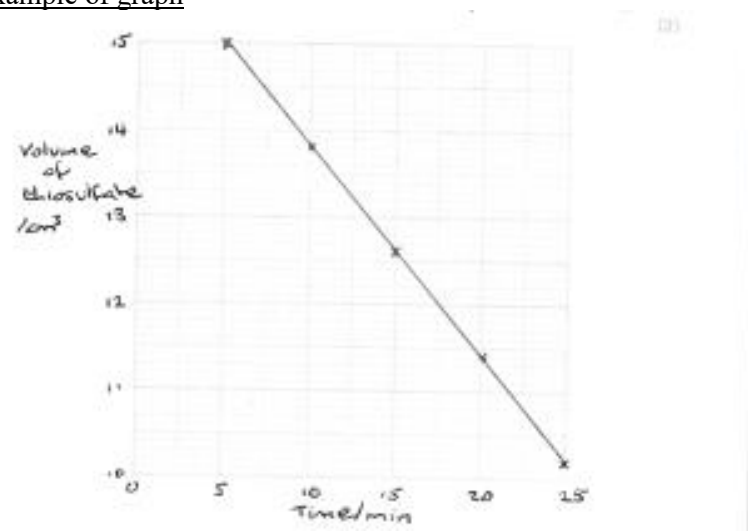
Question Number	Answer	Additional Guidance	Mark
5(d)(ii)	An explanation that makes reference to the following points: • a lower temperature can be used / no need for high(er) temperature (as the forward reaction is exothermic) there will be a higher equilibrium yield at lower temperature **(1)** • this reduces the cost of the **energy / fuel** needed **(1)**	Ignore reference to decreased pressure Ignore environmental issues (e.g. greenhouse gases) Ignore less heat. Ignore just 'to reduce cost' If no other mark is awarded, allow (1) for 'even though they are expensive, they are not used up so last a long time' / 'catalysts reduce the activation energy and speed up the reaction'	**(2)**

(Total for Question 5 = 10 marks)

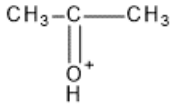
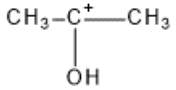
Question Number	Answer	Additional Guidance	Mark
6(a)(i)	An answer that makes reference to the following point: • use (a much) higher concentration (of propanone and acid (than iodine) **(1)**	Allow use a high concentration (of propanone and acid) Allow use a (large) excess (of propanone and acid) Ignore use a higher **volume** of propanone and acid	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(a)(ii)	An explanation that makes reference to the following point: • to neutralise the acid / H^+ **(1)** • so that the reactions is quenched / stopped **(1)**	Allow to remove / react with the acid / catalyst Allow to freeze the reaction Ignore 'slow down'	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	An answer that makes reference to the following point: • ($[I_2]$ / concentration (of iodine) is (directly) proportional to the volume of (sodium) thiosulfate / $Na_2S_2O_3$ / $S_2O_3^{2-}$	Allow reverse argument Allow they react in a specific ratio / quoted ratio / 2:1 Do not award equal to or inversely proportional to Do not award I^- / iodide (ions)	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	• axes with time on x axis **and** labelled, including units **and** suitable scale so that points cover at least half the axes in both directions **(1)** • points plotted correctly to (±½ square) **and** straight line through points **(1)**	Example of graph  Allow x axis to start at 5 Allow M2 if axes wrong way around in M1	**(2)**

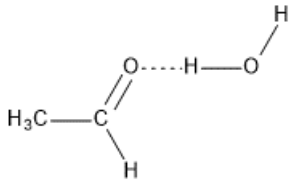
Question Number	Answer	Additional Guidance	Mark
6(b)(iii)	• (zero order) because graph is a straight line / linear **or** rate is constant	Allow the gradient is constant Do not award if their graph is a straight horizontal line Ignore through the origin This mark is dependent on the graph being a straight line with a constant gradient	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(c)(i)	• an equation that has **only** H^+ and CH_3COCH_3 on the left **(1)** • correct product **(1)**	Example of equation $CH_3COCH_3 + H^+ \rightarrow CH_3C(O^+H)CH_3$ **or** $CH_3COCH_3 + H^+ \rightarrow CH_3C^+(OH)CH_3$ Allow structural / skeletal formulae e.g. product shown as  or  Allow $C_3H_7O^+$ Do not award $CH_3COCH_4^+$	**(2)**

Question number	Answer	Mark
6(c)(ii)	**The only correct answer is A** (2.24×10^{-5}) ***B*** *is incorrect because 3.36×10^{-5} would be the rate if the reaction was zero order with respect to CH_3COCH_3 and first order with respect to H^+ and I_2* ***C*** *is incorrect because 4.48×10^{-5} would be the rate if the reaction was first order with respect to CH_3COCH_3, H^+ and I_2* ***D*** *is incorrect because 8.96×10^{-5} would be the rate if the reaction was first order with respect to CH_3COCH_3 and I_2 and zero order with respect to H^+*	**(1)**

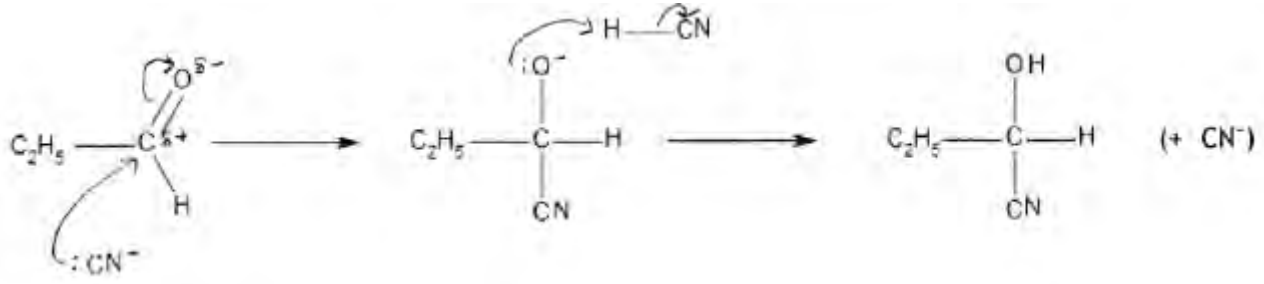
Question Number	Answer	Additional Guidance	Mark
6(c)(iii)	An explanation that makes reference to the following points: • rate will be the same **(1)** • because rate equation only involves propanone and acid / rate equation does not involve iodine / bromine **(1)**	Do not allow the rate would be constant. Allow the order with respect to bromine would be 0 / bromine would not be in the rate determining step M2 depends on correct M1	**(2)**

(Total for Question 6 = 12 marks)

Question Number	Answer	Additional Guidance	Mark
7(a)	An explanation that makes reference to the following points: • ethanal and ethanoic acid (are both soluble because they) can form hydrogen bonds (with water) **(1)** • diagram to show hydrogen bonding between **ethanal** and water **(1)** • ethanal (has a lower boiling temperature because it only) has (weak) London forces **and** dipole-dipole forces between molecules (1) • (ethanoic acid has a higher boiling temperature) because it forms intermolecular hydrogen bonds / hydrogen bonds between molecules **and** more energy is needed to overcome these / hydrogen bonds are the strongest intermolecular force / stronger than London Forces and dipole - dipole **(1)**	<u>Example of diagram</u> Allow H-bond for hydrogen bond  O--H−O bond angle should be about 180° Allow skeletal formulae Ignore dipoles and lone pair Do not award hydrogen bond from H of CHO to O of H_2O Allow van der Waals' / dispersion forces / attractions between temporary dipole and induced dipoles for London forces Allow less energy is needed to overcome intermolecular forces in ethanal (then ethanoic acid) for the 'and' statement	**(4)**

Question Number	Answer	Additional Guidance	Mark
7(b)(i)	• curly arrow from lone pair on **C** of CN^- to C of C=O **(1)** • dipole on C=O **and** curly arrow from double bond to, or just beyond, O **(1)** • structure of intermediate **(1)** • curly arrow from lone pair on O to H of HCN **and** curly arrow from H–CN bond to anywhere on CN **(1)** **or** curly arrow from lone pair on O^- to H^+	Allow correct skeletal formulae throughout. Allow CN^- to attack C=O from any angle Allow CN bond displayed Ignore arrows showing the formation of CN^- from HCN, attack must be by CN^- Negative charge on O must be present. Allow if lone pair (s) on O missing. Do not award δ– on O. This mark can be awarded if no / incorrect charge on O (as already penalised above)	**(4)**

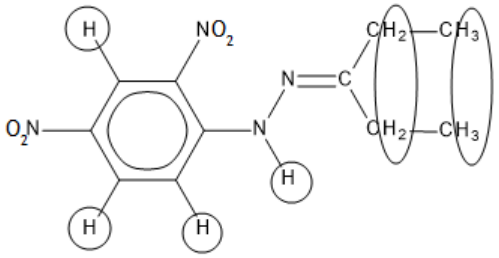
Example of mechanism:



Question Number	Answer	Additional Guidance	Mark
7(b)(ii)	An explanation that makes reference to the following points: a racemic mixture will form because • the compound is planar around C=O / carbonyl group / $C\delta^+$ **(1)** • and the CN^- ion / nucleophile can attack either side / above and below (the plane) **(1)** • so equal amounts / chance of the two isomers / enantiomers **(1)**	Do not allow just the molecule / propanal / intermediate is planar for M1 Allow CN without the negative charge as this has been assessed in 7bi Award one mark only for a statement that a racemic mixture will not form (because) a single enantiomer will form	**(3)**

Question Number	Answer	Additional Guidance	Mark
7(c)(i)	An answer that makes reference to the following points: • filter (under suction) **(1)** • recrystallise **(1)** • suitable method of drying **(1)**	Allow answers on the diagram Ignore filter while hot Comment Allow gravity filtration Allow description of recrystallisation to include dissolving in hot solvent and filtering (whether hot or cold) Allow to dry in a (warm) oven, on a radiator, sunny windowsill, dry between filter / tissue paper / desiccator Do not award use of a drying agent except with desiccator Do not award dry to constant mass Do not award dehydration No TE on points made against the incorrect step	**(3)**

Question Number	Answer	Additional Guidance	Mark
7(c)(ii)	An answer that makes reference to the following points: • **X** is cyclohexanone **(1)** • 156-8°C is just below / close to / within range of the melting temperature range of cyclohexanone **and** the IR absorption of 1717 is in the range (1720 – 1700 cm^{-1}) for (alkyl) ketones **(1)**	Allow 156-8°C / the melting point of the compound is close to the range of both cyclohexanone and propanal If the range of IR absorption is quoted it must be correct	**(2)**

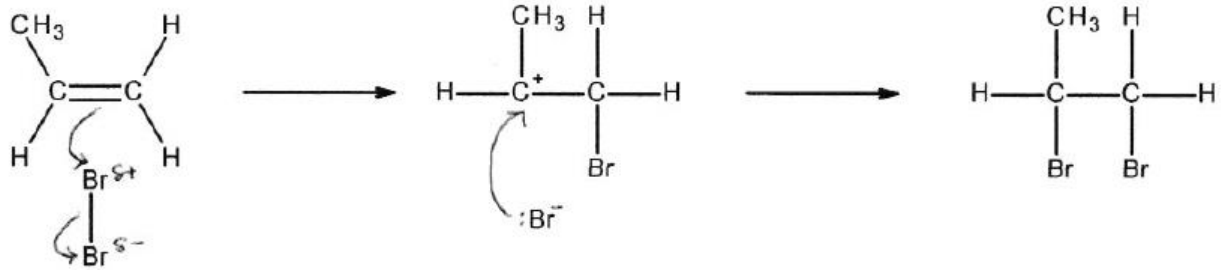
Question Number	Answer	Additional Guidance	Mark
7(c)(iii)	• benzene protons and nitrogen proton identified **(1)** • carbon protons identified **(**	Example of labelling  Allow any clear way of labelling the proton environments e.g. numbers 1 to 6 or letters A to F Do not award M1 if the nitrogen is circled as well at the hydrogen.	**(2)**

(Total for Question 7 = 18 marks)

Question number	Answer	Mark
8(a)	**The only correct answer is B** (3) ***A*** *is incorrect because pentane, 2-methylbutane and 2,2-dimethylpropane are the isomers of* C_5H_{12} ***C*** *is incorrect because pentane, 2-methylbutane and 2,2-dimethylpropane are the isomers of* C_5H_{12} ***D*** *is incorrect because pentane, 2-methylbutane and 2,2-dimethylpropane are the isomers of* C_5H_{12}	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(b)	An answer that makes reference to the following points: • curly arrow from C=C towards top Br • dipole on Br_2 • curly arrow from Br−Br bond to, or just beyond, lower Br • intermediate • lone pair on Br^- • curly arrow from lone pair towards C^+	Allow skeletal formulae throughout. Allow + on carbon 1 and Br on carbon 2 Do not award $Br^{\delta-}$ 6 points awarded 3 marks 4 or 5 awarded 2 marks 2 or 3 awarded 1 mark 1 or 0 awarded 0 marks	**(3)**

Example of mechanism



Question Number	Answer	Additional Guidance	Mark
8(c)(i)	An explanation that makes reference to the following points: • because sodium chloride (only) contains Cl^- ions **and** the initial attack is by an electrophile **(1)** • $Br^{\delta+}$ / bromine must attack first (so no dichloro-product can form) **(1)**	Allow these points shown on a labelled mechanism Allow (the first step involves an electrophile but) Cl^- is a nucleophile / not an electrophile / there is no Cl^+ / $Cl^{\delta+}$ Allow Cl^- only reacts when a carbocation has been formed Do not award Br^- Do not award **Br^+** must attack first.	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(c)(ii)	An explanation that makes reference to the following points: • because a secondary carbocation (intermediate) is formed **(1)** • more stable than a primary (carbocation intermediate) **(1)**	Allow answers referring to the mechanism Allow a correct diagram or description of the secondary carbocation Allow a correct diagram or description of the primary and/or the secondary carbocation with a comment about it being less stable / secondary being more stable for 2 marks	**(2)**

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr>
<td>8(d)*</td>
<td>This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

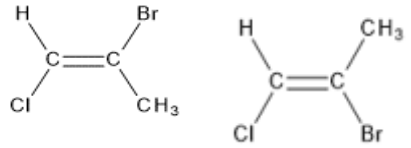
Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th></tr>
<tr><td>6</td><td>4</td></tr>
<tr><td>5–4</td><td>3</td></tr>
<tr><td>3–2</td><td>2</td></tr>
<tr><td>1</td><td>1</td></tr>
<tr><td>0</td><td>0</td></tr>
</table>

The following table shows how the marks should be awarded for structure and lines of reasoning.</td>
<td>Guidance on how the mark scheme should be applied:
The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points that is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning).
If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td>
<td>(6)</td>
</tr>
</table>

	<table><tr><td></td><td>Number of marks awarded for structure of answer and sustained line of reasoning</td></tr><tr><td>Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout.</td><td>2</td></tr><tr><td>Answer is partially structured with some linkages and lines of reasoning.</td><td>1</td></tr><tr><td>Answer has no linkages between points and is unstructured.</td><td>0</td></tr></table> **Comment:** Look for the indicative marking points first, then consider the mark for structure of answer and sustained line of reasoning	In general it would be expected that 5 or 6 indicative points would get 2 reasoning marks, and 3 or 4 indicative points would get 1 mark for reasoning, and 0, 1 or 2 indicative points would score zero marks for reasoning. **General points to note** If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s). e.g.	

	Indicative content • **IP1 – C=C** restricted rotation around C=C / double bond / pi bond • **IP2 – Attached atoms** the higher the atomic number of the attached atom, the higher the priority of the group **and** in the *E* isomer the highest priority atom on each carbon are on opposite sides of the double bond / in the *Z* isomer the highest priority atom on each carbon atom are on the same side of the double bond • **IP3 – Example of *E*/*Z*** Example of *E* isomer **and** *Z* isomer as labelled diagram • **IP4 – Optical isomerism** a non-superimposable mirror image / cannot be superimposed / contain a chiral centre / do not have a plane of symmetry • **IP5 – Example of optical isomers** Two 3-dimensional structures that are mirror images • **IP6 – Property** (optical isomers) rotate the plane of (plane-) polarised light (by equal amounts) in opposite directions	Ignore cis-trans Allow 'no rotation about C=C' Allow atomic mass / mass of group / heaviest  *E* isomer *Z* isomer Ignore chemical names even if incorrect Allow diagrams without labels but clearly identified in their explanation Allow have four different atoms or groups attached to a carbon atom  Do not award images that are not in 3D	

(Total for Question 8 = 14 marks)

Question Number	Answer	Additional Guidance	Mark
9(a)	An answer that makes reference to the following points • structure of **A** as 2-chloropropane **(1)** • structure of **B** as propan-2-ol **(1)** • structure of **C** as propanone **(1)** • structure of **D** as 2-propylmagnesium chloride **(1)** • structure of **E** as 2-methylpropanoic acid **(1)**	Allow displayed formulae, any combination of structural and displayed formulae or skeletal formulae Ignore names even if incorrect $CH_3CHClCH_3$ $CH_3CH(OH)CH_3$ Allow structure of propan-1-ol if **A** is 1-chloropropane CH_3COCH_3 Allow structure of propanal if **A** is 1-chloropropane Do not allow propanoic acid as the formula is incorrect. $CH_3CH(MgCl)CH_3$ Allow $CH_3CH(ClMg)CH_3$ $CH_3CH(CH_3)COOH$ TE throughout	**(5)**

Question Number	Answer	Additional Guidance	Mark
9(b)	• calculation of mol of NaOH **(1)** • calculation of mol HCl in 100 cm^3 **(1)** • calculation of mol HCl at start **(1)** • calculation of mol NH_3 reacted with HCl **(1)** • calculation of percentage of N in compound **(1)**	Example of calculation mol of NaOH = $\frac{15.5 \times 0.100}{1000} = 1.55 \times 10^{-3}$ / 0.00155 (mol) mol HCl = $4 \times 1.55 \times 10^{-3} = 6.2 \times 10^{-3}$ / 0.0062 (mol) mol HCl at start = $\frac{100 \times 0.225}{1000} = 2.25 \times 10^{-2}$ / 0.0225 (mol) mol NH_3 = 0.0225 – 0.0062 = 0.0163 / 1.63×10^{-2} (mol) mass N = $0.0163 \times 14 = 0.2282$ (g) and % N = $\frac{0.2282 \times 100}{1.19} = 19.176$ (%) Allow TE at each stage but M5 must be <100% Correct answer scores 5 Ignore SF except 1 SF	**(5)**

(Total for Question 9 = 10 marks)

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom