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EDEXCEL A LEVEL CHEMISTRY: QUESTIONS BY TOPIC

Organic Chemistry II (17)

A Level Chemistry Topic 17

12 questions · 148 marks · Mark schemes included

Pearson Edexcel A Level Chemistry (9CH0), June 2017 - June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic; within each sub-topic they run from the lowest mark tariff to the highest.

Click any sub-topic heading or question row below to jump straight to it.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme.

Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

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QUESTIONS

12 questions · 148 marks · grouped by sub-topic



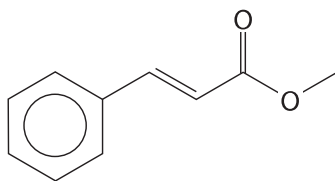
SUB-TOPIC 17(a)

CHIRALITY

2 questions in this sub-topic · 29 marks · lowest tariff first



4 Methyl cinnamate, $C_{10}H_{10}O_2$, is a white crystalline solid used in the perfume industry.



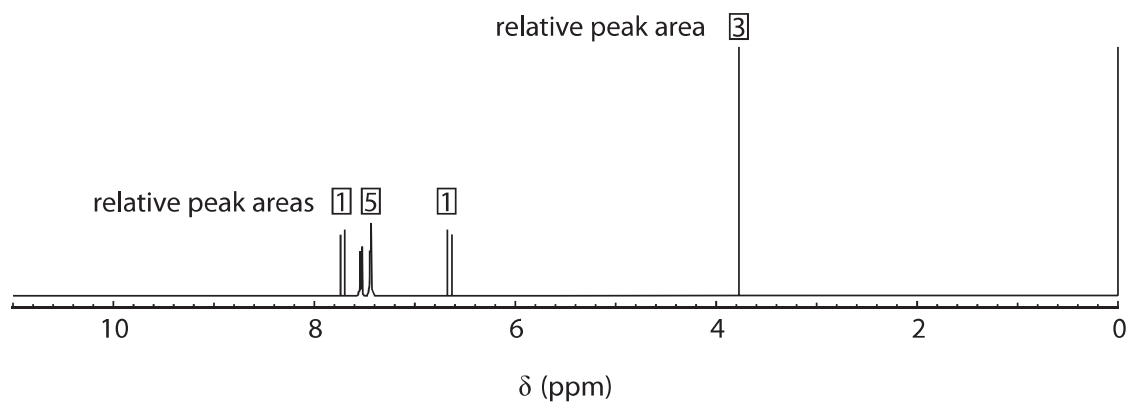
methyl cinnamate

(a) Calculate the mass of carbon in 2.34 g of methyl cinnamate.

(2)

(b) A sample of methyl cinnamate was analysed by high resolution proton NMR spectroscopy.

A simplified spectrum is shown.



(i) Name the compound responsible for the peak at a chemical shift of 0 ppm, stating its purpose.

(2)

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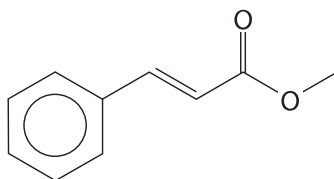
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- (ii) Identify the proton environment that causes the peak at a chemical shift of 3.8 ppm by circling it on the diagram shown. Fully justify your answer.

(3)



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- (c) Methyl cinnamate undergoes an addition reaction in the dark with bromine.

- (i) Draw the mechanism for the reaction between methyl cinnamate and bromine, Br₂.
Include curly arrows, and relevant lone pairs and dipoles.

(4)

- (ii) Deduce the number of optical isomers of the addition product that can exist.

(1)

- ☐ A 2
- ☐ B 3
- ☐ C 4
- ☐ D 8

- (iii) When plane-polarised light is passed through an optical isomer, the plane of polarisation is

(1)

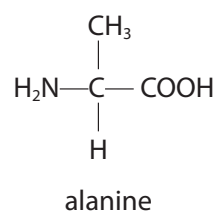
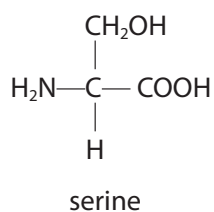
- ☐ A diffracted
- ☐ B reflected
- ☐ C refracted
- ☐ D rotated

(Total for Question 4 = 13 marks)



8 This question is about amino acids and related compounds.

The structures of two amino acids are shown.



(a) Both amino acids contain a chiral carbon atom.

(i) State what is meant by the term 'chiral carbon atom'.

(1)

.....

.....

.....

(ii) Draw diagrams of the two stereoisomers of **alanine**, showing their three-dimensional shape.

(2)

(b) Draw the **skeletal** formulae of the two dipeptides that could form when serine and alanine react.

(2)

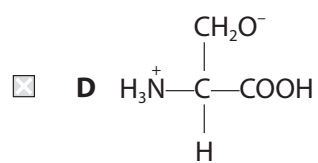
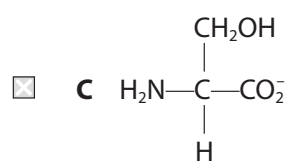
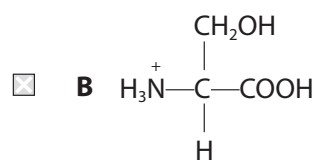
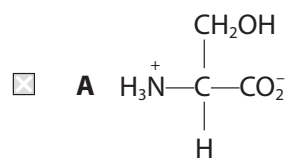
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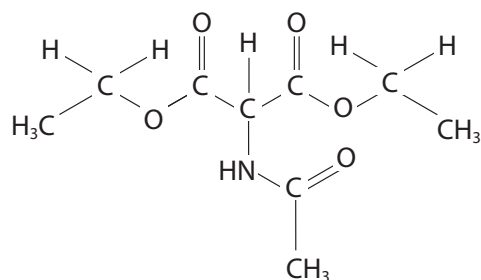
(c) Serine exists as a zwitterion.

What is the formula of this zwitterion?

(1)

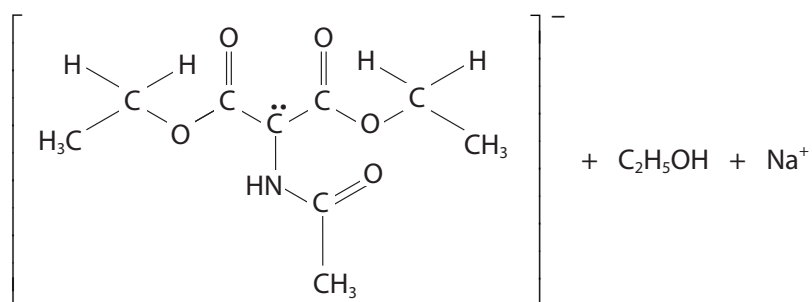


(d) Alanine can be synthesised as shown.

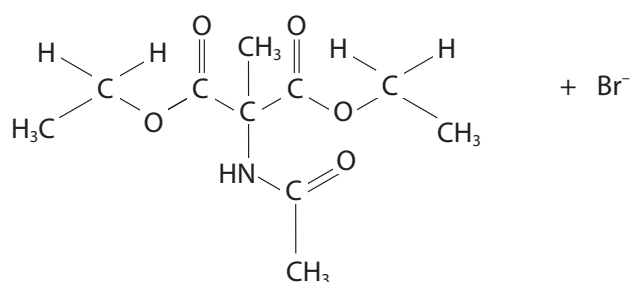


Compound **X**

Step 1 $\text{C}_2\text{H}_5\text{O}^-\text{Na}^+$

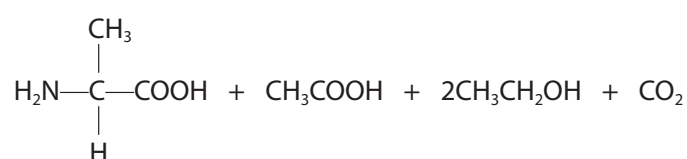


Step 2 CH_3Br



Compound **Y**

Step 3



- (i) Sodium ethoxide, $\text{C}_2\text{H}_5\text{ONa}$, needed in Step 1, is formed by the reaction of sodium with ethanol.

Write the equation for this reaction.
State symbols are not required.

(1)

- (ii) Name the **two** functional groups present in Compound **Y**.

(2)

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- (iii) Give the reagent needed and conditions required for Step 3.

(2)

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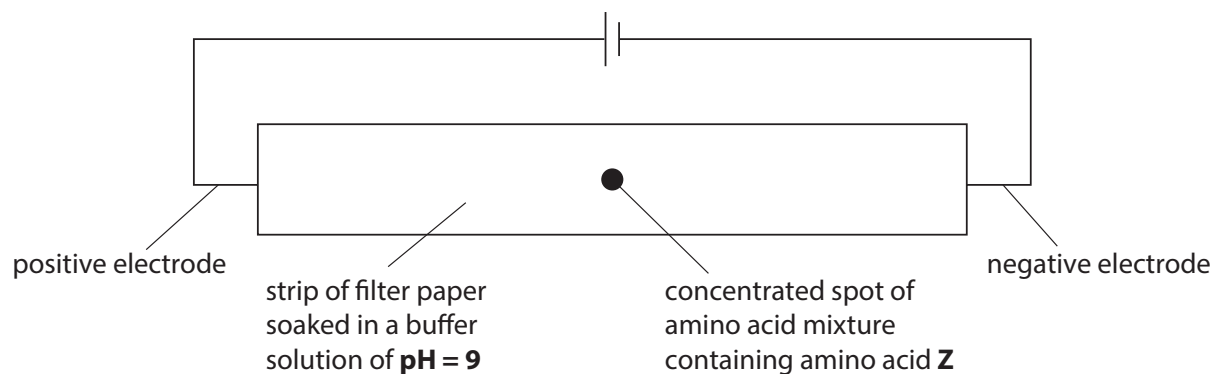
- (iv) Calculate the mass of Compound **X** required to make 15.0 g of alanine, assuming the overall yield of the synthesis is 55 %.

(3)

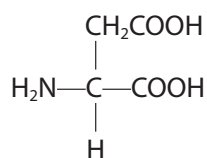


- (e) A mixture of amino acids can be separated using a technique called paper electrophoresis. A simplified diagram is shown.

The movement of the amino acid on the paper depends on any charge on the amino acid, and this is determined by the pH of the buffer solution.



Amino acid **Z** has the structure shown.



amino acid **Z**

Explain in which direction, if any, amino acid **Z** would move when a current flows in the circuit with a buffer solution of pH = 9.

(2)

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(Total for Question 8 = 16 marks)



SUB-TOPIC 17(b)

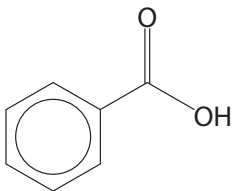
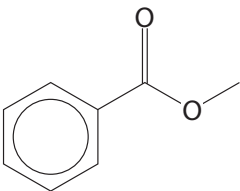
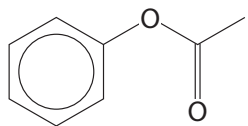
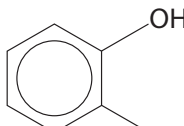
CARBONYL COMPOUNDS

4 questions in this sub-topic · 50 marks · lowest tariff first



4 This question is about the identification of some organic compounds.

(a) The skeletal formulae of four organic compounds are shown.

Compound P 	Compound Q 
Compound R 	Compound S 

(i) Which of these compounds can be hydrolysed to form methanol as one of the products?

(1)

- ☐ **A** Compound **P**
- ☐ **B** Compound **Q**
- ☐ **C** Compound **R**
- ☐ **D** Compound **S**

(ii) Which of these compounds produces carbon dioxide when it reacts with aqueous sodium hydrogencarbonate?

(1)

- ☐ **A** Compound **P**
- ☐ **B** Compound **Q**
- ☐ **C** Compound **R**
- ☐ **D** Compound **S**

(b) Compound **T**, $C_4H_{10}O$, is oxidised by acidified potassium dichromate(VI) to form compound **U**, C_4H_8O .

U gives an orange precipitate with 2,4-dinitrophenylhydrazine (Brady's reagent) but does **not** give a red precipitate when heated with Fehling's solution.

T reacts with ethanoyl chloride to form compound **V**, $C_6H_{12}O_2$.

Deduce the structures of compounds **T**, **U** and **V**. Justify your answers.

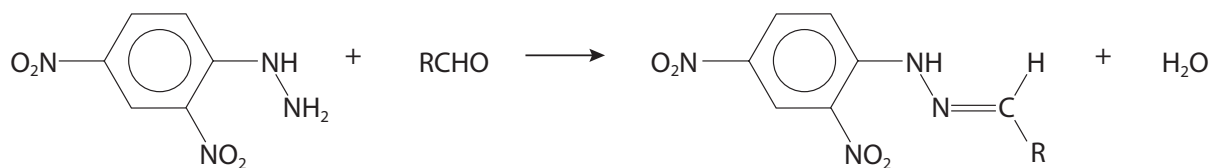
(6)

(Total for Question 4 = 8 marks)





(b) The reaction of 2,4-dinitrophenylhydrazine (2,4-DNPH) with a general aldehyde, RCHO , is shown.



(i) What is this type of reaction?

(1)

- ☐ **A** addition
- ☐ **B** condensation
- ☐ **C** hydrolysis
- ☐ **D** polymerisation

(ii) Draw the structure of the organic product of the reaction of 2,4-DNPH with benzaldehyde.

(1)

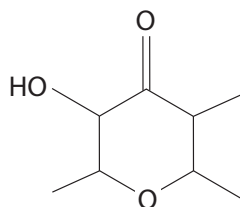
(Total for Question 6 = 8 marks)

6 Aldehydes and ketones are carbonyl compounds.

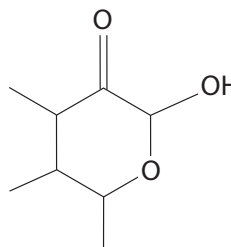
(a) Which of these compounds does **not** contain a ketone functional group?

(1)

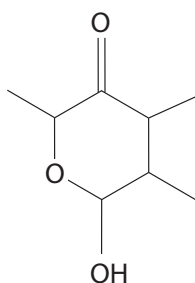
☐ A



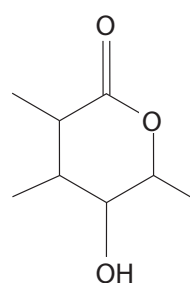
☐ B



☐ C



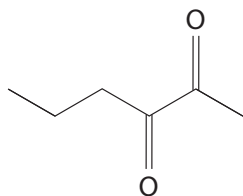
☐ D



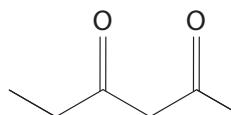
(b) Which of these compounds has both an aldehyde functional group **and** a ketone functional group?

(1)

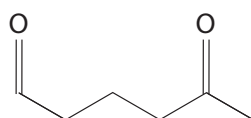
☐ A



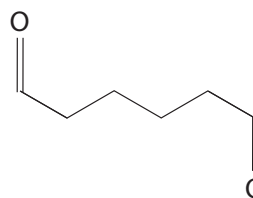
☐ B



☐ C

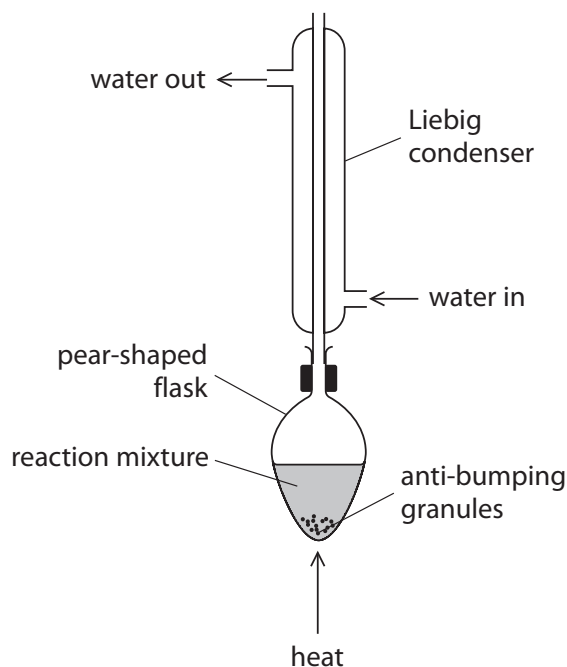


☐ D



(c) Propanal can be produced from the oxidation of propan-1-ol.

(i) A student assembled the apparatus shown for this oxidation.



Explain why the use of this apparatus would give a very low yield of propanal.

(2)

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(ii) The oxidising agent is acidified $\text{Na}_2\text{Cr}_2\text{O}_7$.

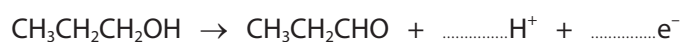
State the oxidation number of chromium in $\text{Na}_2\text{Cr}_2\text{O}_7$.

(1)

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(iii) Complete the ionic half-equation for the oxidation of propan-1-ol.

(1)



(iv) State how the use of anti-bumping granules gives smoother boiling.

(1)

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(v) Another student used the correct apparatus for this oxidation.
1.50 g of propan-1-ol produced 0.609 g of propanal.

Calculate the percentage yield of propanal by mass.

(3)



(d) The table contains data on propanone and ethanoic acid.

Substance	Molar mass / g mol^{-1}	Boiling temperature / $^{\circ}\text{C}$	Solubility in water
Propanone	58	56	completely miscible
Ethanoic acid	60	118	completely miscible

- (i) Explain, by reference to the data and any intermolecular forces involved, the difference in the boiling temperatures.

(4)

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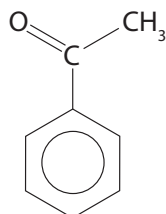
(ii) Explain, with the aid of a diagram, why propanone is completely miscible with water.

(2)

(Total for Question 6 = 16 marks)



- 8 Phenylethanone is an ingredient in many types of chewing gum.



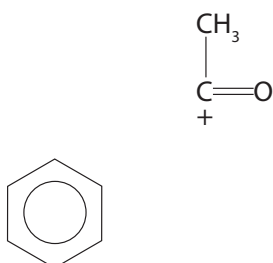
One method for the production of phenylethanone involves the reaction of benzene with ethanoyl chloride, CH_3COCl .

- (a) (i) Write the equation for the formation of the electrophile, CH_3CO^+ , from ethanoyl chloride using the catalyst aluminium chloride.

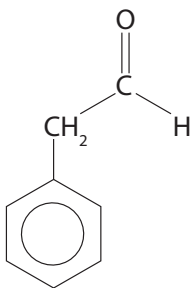
(1)

- (ii) Complete the diagram, including curly arrows, to show the mechanism for the reaction between this electrophile and benzene to produce phenylethanone. Include the regeneration of the catalyst.

(4)



- (b) Phenylethanone can be distinguished from its structural isomer, phenylethanal, in a number of different ways.



- (i) Which would react with phenylethanone but **not** with phenylethanal?

(1)

- ☐ A acidified sodium dichromate(VI)
- ☐ B alkaline iodine solution
- ☐ C Fehling's solution
- ☐ D Tollens' reagent

- (ii) Give the steps to show how 2,4-dinitrophenylhydrazine could be used to distinguish between phenylethanone and phenylethanal.

(4)

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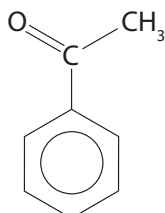
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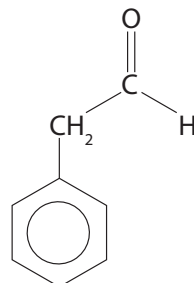
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- *(iii) Compare and contrast the high resolution proton NMR spectra of phenylethanone and phenylethanal.

You should use the Data Booklet.



Phenylethanone



Phenylethanal

(6)

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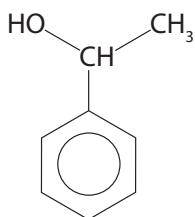
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(c) The compound 1-phenylethanol can be formed from phenylethanone.



Give the reagent and conditions that would be used to form 1-phenylethanol.

(2)

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(Total for Question 8 = 18 marks)

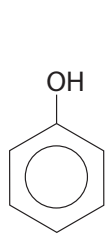
SUB-TOPIC 17(c)

CARBOXYLIC ACIDS

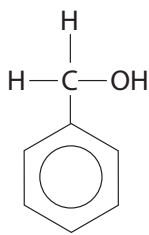
1 question in this sub-topic · 19 marks · lowest tariff first



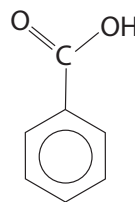
6 This is a question about the analysis of three aromatic substances with —OH groups.



phenol



phenylmethanol



benzoic acid

- (a) Write the equation for the **complete** combustion of phenol.
State symbols are not required.

(2)

- (b) When burned in air, these aromatic compounds undergo **incomplete** combustion.

- (i) Calculate the percentage composition by mass of carbon in both phenylmethanol and benzoic acid.

(3)

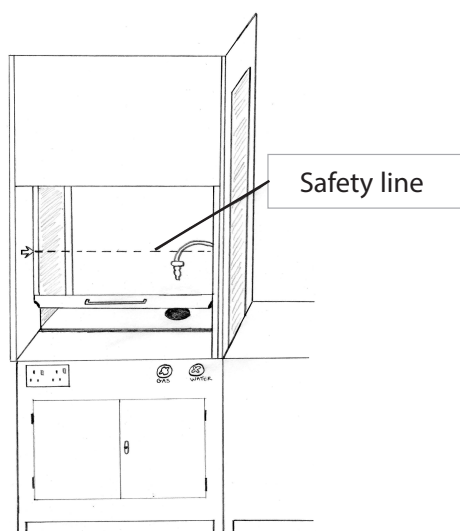
(ii) Give the expected observation when these aromatic compounds undergo incomplete combustion.

(1)

(iii) Identify another **type** of organic compound which will also produce the same observation as in (b)(ii).

(1)

(iv) These combustion experiments must be carried out in a fume cupboard.



Explain why the front window of the fume cupboard must be below the safety line even with the exhaust fan switched on.

(2)

(c) Spectroscopy is an effective means of distinguishing between molecules.

(i) Compare and contrast the infrared spectra of phenol, phenylmethanol and benzoic acid.

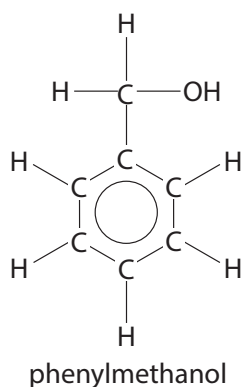
Include relevant bonds and their wavenumber ranges using the Data Booklet.

(5)

[illegible]

- (ii) Predict the number of peaks present, and their chemical shifts, in the ^{13}C nuclear magnetic resonance (NMR) spectrum of phenylmethanol. Use the information in the Data Booklet to help you.

(3)



- (iii) Give the formula of a fragment ion, with its m/z value, that you would expect to be present in the mass spectrum of benzoic acid but **not** in the mass spectrum of phenol or the mass spectrum of phenylmethanol.

(2)

(Total for Question 6 = 19 marks)



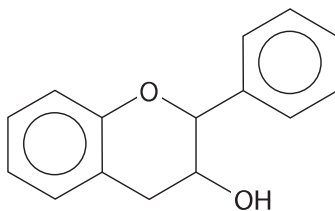
SUB-TOPIC 17(d)

CARBOXYLIC ACID DERIVATIVES

5 questions in this sub-topic · 50 marks · lowest tariff first



- 6 The compound flavan-3-ol is found in tea, fruit and wine.



- (a) Clearly label all the chiral carbon atoms in flavan-3-ol.

(1)

- (b) Give the molecular formula for flavan-3-ol.

(1)

- *(c) A sample of flavan-3-ol extracted from wine contained some ethanol. The sample was left in a flask, open to the air for several days. The contents were then analysed to identify any new compounds formed. Several new compounds were found to be present, including some with a distinctive fruity smell.

Identify **four** new organic compounds that could form under these conditions by considering the chemistry of alcohols. Justify your answers. Include the structure of two compounds formed from flavan-3-ol, one of which has a fruity smell.

(6)



(Total for Question 6 = 8 marks)

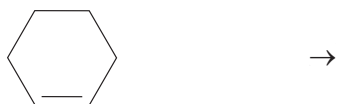
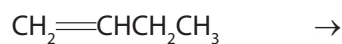


6 This is a question about polymerisation.

(a) But-1-ene and cyclohexene both form addition polymers.

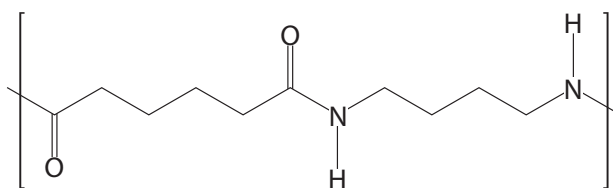
Draw a section of each polymer, showing **two** repeat units.

(2)



(b) Deduce the two monomers needed to produce the polyamide shown.

(2)

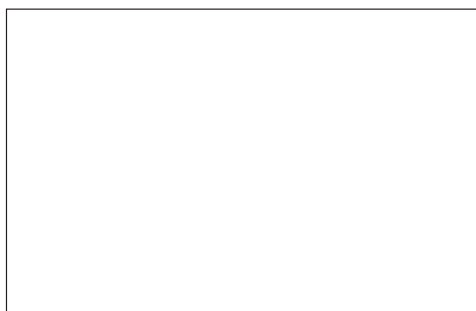
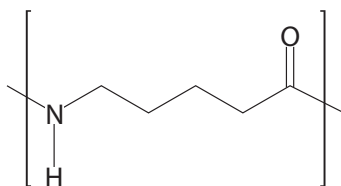


and



(c) Deduce the single monomer that could be used to produce the polyamide shown.

(1)



(d) PLA is a biodegradable polyester which is made from 2-hydroxypropanoic acid, $\text{CH}_3\text{CH}(\text{OH})\text{COOH}$.

(i) Draw the two enantiomers of 2-hydroxypropanoic acid.

(2)

(ii) State how separate samples of these two enantiomers could be distinguished in a laboratory.

(1)

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(iii) Biodegradable polyesters break down naturally.

State why this is an advantage.

(1)

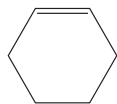
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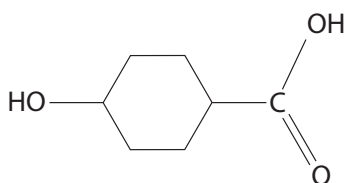
(Total for Question 6 = 9 marks)

*7 This question is about polymers.

(a) Compare and contrast how each of these monomers forms a polymer.



cyclohexene



4-hydroxycyclohexanecarboxylic acid

Include equations, showing the formation of a single repeat unit for each polymer.

(6)

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Handwriting practice area with 20 horizontal dotted lines.



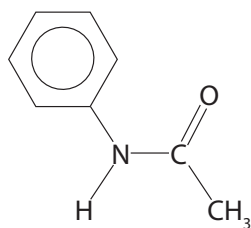
(b) Give three ways in which waste polymers can be utilised to improve their sustainability.

(3)

(Total for Question 7 = 9 marks)



- 7 Antifebrin was the trade name for N-phenylethanamide which was used as a painkiller until paracetamol was discovered.



Antifebrin

- (a) Some of the following reagents can be used to produce Antifebrin from benzene.

- | | |
|-----------------------------------|-------------------------------|
| • Aluminium chloride | • Hydrochloric acid, dilute |
| • Ammonia, concentrated | • Iron |
| • Benzene | • Nitric acid, concentrated |
| • Ethanal | • Nitric acid, dilute |
| • Ethanoic acid | • Propanone |
| • Ethanol | • Sodium chloride |
| • Ethanoyl chloride | • Sulfuric acid, concentrated |
| • Hydrochloric acid, concentrated | • Tin |

Selecting from only these reagents, devise a **three-step** synthetic pathway to convert benzene into Antifebrin. You should include the structures of the two intermediate compounds and the reaction conditions.

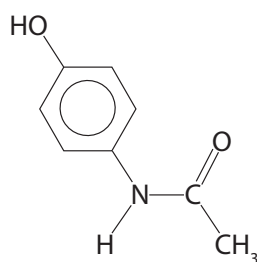
(5)

(b) What is the number of peaks in a C-13 NMR spectrum of Antifebrin?

(1)

- ☐ A 5
- ☐ B 6
- ☐ C 7
- ☐ D 8

(c) Paracetamol is structurally similar to Antifebrin, but has a hydroxy group attached directly to the benzene ring.



The bromination of the benzene ring in paracetamol occurs much more readily compared to the bromination of benzene.

Explain this increased reactivity.

(2)

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(d) A tablet with a total mass of 500 mg contained 3.10×10^{-3} mol of paracetamol.

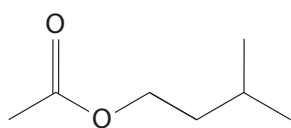
Calculate the percentage by mass of paracetamol in the tablet, quoting your answer to an appropriate number of significant figures.

(2)

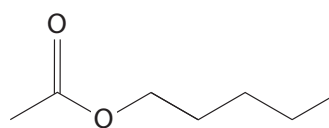
(Total for Question 7 = 10 marks)



- 8 Esters have many uses due to their characteristic aromas and often have common names. For example, isoamyl acetate is referred to as banana oil and amyl acetate has a scent similar to apples.



isoamyl acetate



amyl acetate

- (a) What is the number of peaks in a ^{13}C NMR spectrum of isoamyl acetate and of amyl acetate?

(1)

		isoamyl acetate	amyl acetate
☒	A	5	6
☒	B	6	6
☒	C	6	7
☒	D	7	7

- (b) State the molecular formula of amyl acetate.

(1)

- (c) Deduce the structural formula of the carboxylic acid that could be used to form both isoamyl acetate and amyl acetate.

(1)

- (d) Deduce the **name** of the alcohol that forms isoamyl acetate.

(1)

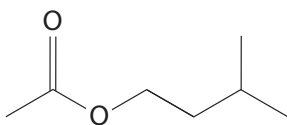
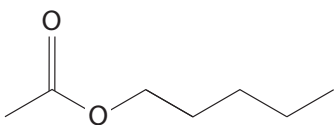
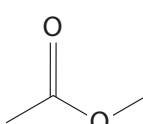
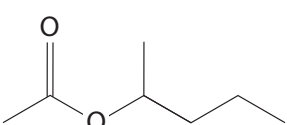
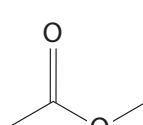
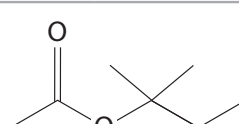
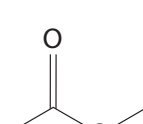
- (e) Give the systematic name for amyl acetate.

(1)

(f) The carboxylic acid used to make isoamyl acetate and amyl acetate can also be used to make six further ester isomers. The structures of two of these esters, **A** and **B**, are shown.

- (i) Complete the **skeletal** formulae of **three** of the remaining esters. Names are **not** required.

(3)

 isoamyl acetate	 amyl acetate	
 ester A		
 ester B		

- (ii) Write an equation to show the formation of ester **A** from an acyl chloride and an alcohol.

(2)

(g) Esters can be hydrolysed by heating under reflux with aqueous acid or alkali.

Compare and contrast these two methods of hydrolysis for amyl acetate.

(4)

(Total for Question 8 = 14 marks)



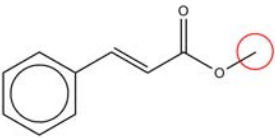
MARK SCHEMES

official Pearson Edexcel mark schemes



Question Number	Answer	Additional Guidance	Mark
4(a)	- calculation of molar mass of methyl cinnamate (1) - calculation of mass of carbon (1)	<u>Example of calculation</u> molar mass = 162 (g mol⁻¹) 2.34 x (120/162) = 1.73333 = 1.73 (g) TE on incorrect molar mass for M2 Correct answer with no working scores 2 marks Ignore SF except 1	(2)

Question Number	Answer	Additional Guidance	Mark
4(b)(i)	An answer that makes reference to the following points: - peak due to tetramethylsilane (1) - so (chemical) shifts (due to other hydrogen atoms) can be compared (1)	Allow TMS / Si(CH₃)₄ Name must be correct if given Allow "a reference" / "a standard" "calibration" Ignore "to allow other molecules to be compared"	(2)

Question Number	Answer	Additional Guidance	Mark
4(b)(ii)	An answer that makes reference to the following points: • M1 circle around $-\text{CH}_3$ group in $-\text{OCH}_3$ (1) • M2 singlet as no neighbouring hydrogen atoms (1) • M3 peak area of 3 means there are 3 hydrogen atoms in this environment (1)	Allow 'protons' for hydrogen atoms  Award whole $-\text{OCH}_3$ circled Do not award if $\text{C}=\text{O}$ included in circle M1 is a stand alone mark Award "has no adjacent hydrogen atoms" Award "no hydrogens on adjacent carbon" Ignore "there is no adjacent C atom" Award "(relative) peak area of three for a $-\text{CH}_3$ group" For M3 must relate to (relative) peak area / integral Ignore references to chemical shift value for ester $\delta = 3.0$ to 4.0 (ppm) Ignore references to relative heights of peaks Comment M2 and / or M3 dependent on $-\text{CH}_3$ group being included in the circled group	(3)

Question Number	Answer	Additional Guidance	Mark
4(c)(i)	M1 arrow from double bond to (δ^+)Br in Br₂ (1) M2 arrow from bond in Br₂ to Brδ^- (1) M3 structure of carbocation (1) M4 arrow from lone pair on Br$^-$ to C$^+$ in carbocation and final product (1)	<u>Example of mechanism</u> See below Penalise lack of dipole only once in M1 and M2 Award C$^+$ in intermediate on either C from the double bond Do not award M3 if four bonds are shown on carbocation Br atoms can be shown either upwards or downwards in final product Award (0) if just electrophilic substitution mechanism given. If both electrophilic substitution and addition shown allow 2 max Penalise errors in structure of methyl cinnamate once only in either M3 or M4 Do not award M4 if the two Br atoms have been added to the same carbon atom in the addition product Penalise use of half arrows once only	(4)



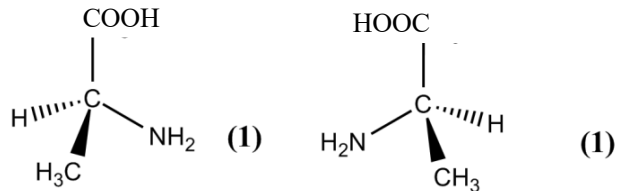
Question Number	Answer	Mark
4(c)(ii)	The only correct answer is C (4) <i>A is not correct because 2 chiral centres form in reaction, so 4 possible combinations of +/- forms</i> <i>B is not correct because 2 chiral centres form in reaction, so 4 possible combinations of +/- forms</i> <i>D is not correct because 2 chiral centres form in reaction, so 4 possible combinations of +/- forms</i>	(1)

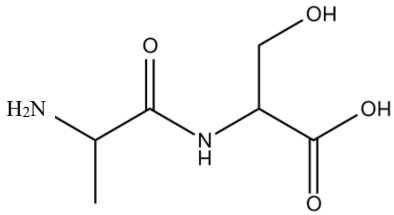
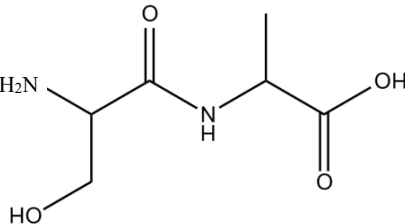
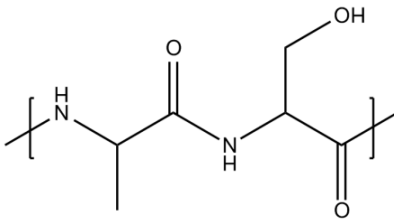
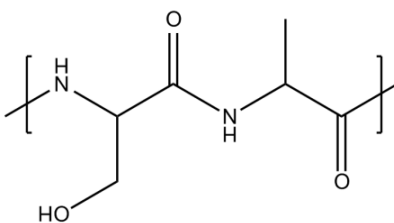
Question Number	Answer	Mark
4(c)(iii)	The only correct answer is D (rotated) <i>A is not correct because diffracted is the wrong term</i> <i>B is not correct because reflected is the wrong term</i> <i>C is not correct because refracted is the wrong term</i>	(1)

(Total Question 4 = 13 marks)



Question Number	Answer	Additional Guidance	Mark
8(a)(i)	An answer that makes reference to the following point: a carbon atom with four different atoms / groups (of atoms) attached	Allow resulting molecule has non-superimposable mirror images Allow a carbon atom with four different functional groups attached Ignore a carbon atom with four different species attached Do not award 'molecules' for atoms / groups	(1)

Question Number	Answer	Additional Guidance	Mark
8(a)(ii)		Allow 1 mark for 2 tetrahedral mirror images shown with only lines and no wedges / dashed lines Allow 1 mark for 2 tetrahedral mirror images shown with two similar wedges on each structure Accept dashed line for dashed wedges Ignore connectivity	(2)

Question Number	Answer	Additional Guidance	Mark
8(b)	 	Allow 1 mark for 2 correct structures shown as structural or displayed formulae Ignore displayed NH₂, NH, or OH groups Penalise missing hydrogen atoms on amide group once only Penalise NH group shown as part of chain once only (1) Allow 1 if both dipeptides shown as correct polymer repeat units  and 	(2)

Question Number	Answer	Mark
8(c)	The only correct answer is A $\left(\begin{array}{c} \text{CH}_2\text{OH} \\ \\ \text{H}_3\text{N}^+ - \text{C} - \text{CO}_2^- \\ \\ \text{H} \end{array} \right)$ <i>B is not correct because the CO₂H group has not lost a proton</i> <i>C is not correct because the NH₂ group has not gained a proton</i> <i>D is not correct because the CH₂OH group has lost a proton</i>	(1)



Question Number	Answer	Additional Guidance	Mark
8(d)(i)	balanced equation	<u>Examples</u> $\text{C}_2\text{H}_5\text{OH} + \text{Na} \rightarrow \text{C}_2\text{H}_5\text{ONa} + \frac{1}{2}\text{H}_2$ $\text{C}_2\text{H}_5\text{OH} + \text{Na} \rightarrow \text{C}_2\text{H}_5\text{O}^-\text{Na}^+ + \frac{1}{2}\text{H}_2$ $\text{C}_2\text{H}_6\text{O} + \text{Na} \rightarrow \text{C}_2\text{H}_5\text{ONa} + \frac{1}{2}\text{H}_2$ $\text{C}_2\text{H}_6\text{O} + \text{Na} \rightarrow \text{C}_2\text{H}_5\text{O}^-\text{Na}^+ + \frac{1}{2}\text{H}_2$ Allow multiples Allow displayed / skeletal / molecular formulae Ignore state symbols even if incorrect Do not award $\text{C}_2\text{H}_5\text{OH} + \text{Na} \rightarrow \text{C}_2\text{H}_5\text{O}^\delta-\text{Na}^{\delta+} + \frac{1}{2}\text{H}_2$	(1)

Question Number	Answer	Additional Guidance	Mark
8(d)(ii)	An answer that makes reference to the following point: - ester (1) (<i>N</i>-substituted) amide (1)	If 3 answers given and 2 are correct, award 1 mark If 4 or more answers given and 2 are correct award 0 marks Ignore structures, even if incorrect	(2)

Question Number	Answer	Additional Guidance	Mark
8(d)(iii)	An answer that makes reference to the following points: - hydrochloric acid / HCl(aq) (1) (heat under) reflux (1)	Ignore references to concentrated / dilute Allow HCl Allow correct name or formulae of any strong acid e.g. HNO_3, H_2SO_4, Allow phosphoric acid / H_3PO_4 Allow NaOH followed by any identified strong acid Ignore H^+ / H_3O^+ / catalyst Mark independently	(2)



Question Number	Answer	Additional Guidance	Mark
8(d)(iv)	- calculation of moles of alanine - scale to 100 % - calculation of mass of compound X OR - scale mass of alanine to 100% - calculation of moles of alanine - calculation of mass of compound X OR - calculation of moles of alanine - calculate mass of X - scale to 100 %	<u>Example of calculation</u> (1) $15.0 \div 89.0 = 0.16854$ (mol) (1) $0.16854 \times (100 \div 55) = 0.30644$ (mol) (1) $0.30644 \times 217 = 66.496 = 66.5$ g (1) $15.0 \times (100 \div 55) = 27.273$ (g) (1) $27.273 \div 89.0 = 0.30644$ (mol) (1) $0.30644 \times 217 = 66.496 = 66.5$ g (1) $15.0 \div 89.0 = 0.16854$ (mol) (1) $0.16854 \times 217 = 36.573$ (1) $36.573 \times (100 \div 55) = 66.496 = 66.5$ g Correct answer no working scores 3 Ignore SF except 1 SF Allow TE throughout If no mark scored allow 1 mark for 2 correct M_r values, 89 and 217	(3)



Question Number	Answer	Additional Guidance	Mark
8(e)	An explanation that makes reference to the following points: - would move towards the positive electrode / to the left and as it will form a negative ion (1) (as basic pH means) the acid groups will both lose a proton / has two COO⁻ groups (1)	Note The negative charge on the ion and loss of both hydrogen ions from the COOH groups can both be awarded from a correct diagram of the ion Do not award zwitterion Allow the acid groups will both lose a hydrogen (ion) M2 can be awarded from diagram / amended structure in question	(2)

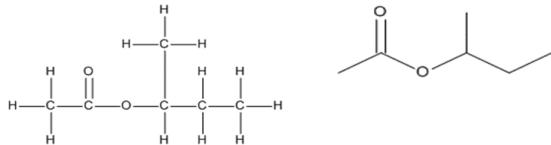
(Total for Question 8 = 16 marks)



Question number	Answer	Mark
4(a)(i)	The only correct answer is B (Compound Q) <i>A is incorrect because this is not hydrolysed</i> <i>C is incorrect because this is hydrolysed to form phenol and ethanoic acid</i> <i>D is incorrect because this is not hydrolysed</i>	(1)

Question number	Answer	Mark
4(a)(ii)	The only correct answer is A (Compound P) <i>B is incorrect because it is an ester and does not react with sodium hydrogencarbonate</i> <i>C is incorrect because it is an ester and does not react with sodium hydrogencarbonate</i> <i>D is incorrect because it is not acidic enough to react with sodium hydrogencarbonate</i>	(1)



Question Number	Answer	Additional Guidance	Mark
4(b)	Structures: - T: structure of butan-2-ol (1) - U: structure of butanone (1) - V: structure of 1-methylpropyl ethanoate (1) Justification: - U is a ketone because it gives an orange precipitate with 2,4-dinitrophenylhydrazine and does not give a precipitate with Fehling's solution (1) - T is a secondary alcohol because it was oxidised to / formed a ketone (1) - V is an ester as alcohols react with acyl chlorides / ethanoyl chloride to form esters (1)	<u>Examples of structures</u> Ignore names, even if incorrect T: $\text{CH}_3\text{CH}_2\text{CHOHCH}_3$ Ignore connectivity of OH group in displayed formula U: $\text{CH}_3\text{CH}_2\text{COCH}_3$ V:  Allow skeletal formulae or any combination of displayed and structural formulae Do not award C_4H_9 from alcohol Allow butyl ethanoate if T is butan-1-ol Allow U is a carbonyl compound because it gives an orange precipitate with 2,4-dinitrophenylhydrazine and is not an aldehyde as it does not give a precipitate with Fehling's solution	(6)

(Total for Question 4 = 8 marks)



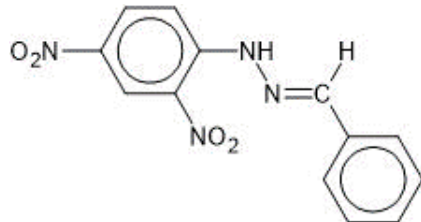
Question Number	Answer	Additional Guidance	Mark																				
*6(a)	This question assesses the student’s ability to show a coherent and logically structured answer with linkages and fully sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows 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 <table><tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr><tr><td>Answer shows a coherent 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>	Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points	6	4	5-4	3	3-2	2	1	1	0	0		Number of marks awarded for structure of answer and sustained lines of reasoning	Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2	Answer is partially structured with some linkages and lines of reasoning	1	Answer has no linkages between points and is unstructured	0	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, a response with four 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 were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and zero marks for linkages). More than one indicative marking point may be made within the same comment or explanation	(6)
Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points																						
6	4																						
5-4	3																						
3-2	2																						
1	1																						
0	0																						
	Number of marks awarded for structure of answer and sustained lines of reasoning																						
Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2																						
Answer is partially structured with some linkages and lines of reasoning	1																						
Answer has no linkages between points and is unstructured	0																						



	Indicative content For benzaldehyde • IP1 – Fehling’s test or Benedict’s test / Tollens’ reagent/ acidified dichromate(VI) • IP2 – red precipitate / silver mirror/ green For phenylethanone • IP3 – Iodine and NaOH/alkaline iodine • IP4 – (pale) yellow precipitate For benzoic acid • IP5 – any named carbonate/hydrogencarbonate (solution) • IP6 – effervescence / bubbles / fizzing	If more than one test given for a compound both/all must be correct for IP1, 3 and 5 The correct observation must match the test given for IP2, 4 and 6. The correct test must match the correct compound Allow silver precipitate/solid/mirror Allow IP2 for a ‘near miss’, i.e. missing ‘acidified’ for potassium dichromate and goes green Allow iodoform/haloform test Allow antiseptic smell Allow IP4 for ‘near miss’, i.e. missing alkaline or NaOH gives yellow ppt If formula given, must be correct Allow ‘metal carbonate’ Allow add a named alcohol (and acid) and warm (1) and fruity smell (1) for IP 5 and IP 6 Allow PCl_5 (1) and misty/steamy fumes (1) for IP 5 and IP 6 Allow IP6 for a ‘near miss’, i.e. add carbonate ions and bubbles of gas Ignore use of 2,4-DNP	
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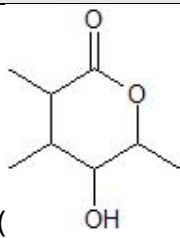


Question Number	Answer	Mark
6(b)(i)	The only correct answer is B (condensation) <i>A is not correct because water is not a product of an addition reaction</i> <i>C is not correct because hydrolysis involves water as a reactant and not as a product</i> <i>D is not correct because a polymer is not produced in this reaction</i>	(1)

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	structure	 Ignore connectivity of N-N bond Allow C₆H₅ for phenyl group Allow either cis or trans isomers	(1)

(Total for Question 6 = 8 marks)



Question Number	Answer	Mark
6(a)	 The only correct answer is D () <i>A is not correct because there is a ketone group present</i> <i>B is not correct because there is a ketone group present</i> <i>C is not correct because there is a ketone group present</i>	(1)

Question Number	Answer	Mark
6(b)	 The only correct answer is C () <i>A is not correct because there are two ketone groups but no aldehyde group</i> <i>B is not correct because there are two ketone groups but no aldehyde group</i> <i>D is not correct because there are two aldehyde groups but no ketone group</i>	(1)

Question Number	Answer	Additional Guidance	Mark
6(c)(i)	An explanation that makes reference to - propanal is condensed back (to the pear-shaped flask) (1) - so propanal is (further) oxidised (to propanoic acid) or propanal is more readily oxidised than propan-1-ol (1)	Allow aldehyde for propanal Allow 'apparatus is reflux' Allow propanal is not being removed /distilled off (from the oxidising agent) Ignore just 'reacts further' Do not award reference to propanal being completely oxidised	(2)

Question Number	Answer	Additional Guidance	Mark
6(c)(ii)	(+)VI	Allow (+) six / (+)6 / six (+) / 6(+)	(1)

Question Number	Answer	Additional Guidance	Mark
6(c)(iii)	balanced equation	<u>Example of equation</u> $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH} \rightarrow \text{CH}_3\text{CH}_2\text{CHO} + 2\text{H}^+ + 2\text{e}^-$	(1)

Question Number	Answer	Additional Guidance	Mark
6(c)(iv)	provides a surface for bubbles to form / enables smaller bubbles to form / provides nucleation sites for bubbles or to prevent large bubbles forming	Allow distribution of heat more evenly / to prevent superheating Ignore mixing / to stop bumping / spitting / explosion / liquid splashing out / vigorous reaction / loss of reactants Do not award reference to large gas molecules	(1)

Question Number	Answer	Additional Guidance	Mark
6(c)(v)	• (M1) evaluation of number of moles of propan-1-ol (1) Method one using masses for percentage calculation • (M2) evaluation of maximum mass of propanal (1) • (M3) percentage yield (1) or Method two using moles for percentage calculation • (M2) evaluation of actual moles of propanal (1) • (M3) percentage yield (1)	<u>Example of calculation</u> $n(\text{propan-1-ol}) = (1.50 \div 60) = 0.025 \text{ (mol)}$ $n(\text{propan-1-ol}) = n(\text{propanal})$ $\text{max } m(\text{propanal}) = (0.025 \times 58) = 1.45 \text{ (g)}$ $\% \text{Yield} = ((0.609 \div 1.45) \times 100) = 42 \%$ $n(\text{propanal}) = (0.609 \div 58) = 0.0105 \text{ (mol)}$ $\% \text{Yield} = ((0.0105 \div 0.025) \times 100) = 42 \%$ Allow TE at each stage Ignore SF except 1SF Penalise incorrect M_r values once only Correct answer without working scores (3)	(3)

Question Number	Answer	Additional Guidance	Mark
6(d)(i)	An explanation that makes reference to the following points: - similar molar masses so the number of electrons is similar/same resulting in similar London forces (1) - propanone (and ethanoic acid) form permanent dipole(-dipole) forces (1) (only) ethanoic acid forms (intermolecular) hydrogen bonding (1) - which is stronger so requires more energy to break (giving a higher boiling temperature) (1)	Allow van der Waals' forces / dispersion forces / instantaneous dipole-induced dipole forces Ignore reference to ethanoic acid having greater London forces Ignore reference to hydrogen bonding to water by propanone Penalise abbreviation pd-d once only Ignore references to ethanoic acid dimerization Reference to energy must be linked to the breaking of hydrogen bonds	(4)

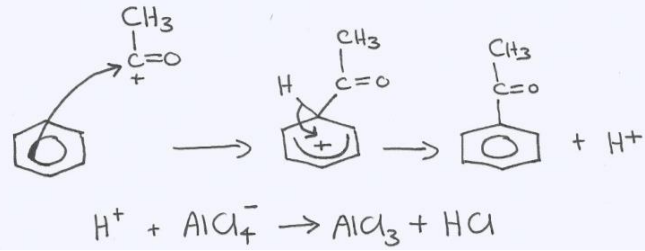


Question Number	Answer	Additional Guidance	Mark
6(d)(ii)	An explanation that makes reference to the following points: - forms hydrogen bonds with water (1) - diagram of hydrogen bond (1)	Allow H bonds for hydrogen bonds $ \begin{array}{c} \text{H}_3\text{C} \\ \diagdown \\ \text{C}=\text{O} \cdots \text{H}-\text{O}-\text{H} \\ \diagup \\ \text{H}_3\text{C} \end{array} $ Ignore bond angle and missing dipoles and missing lone pair Do not award incorrect dipoles Do not award incorrect propanone and/or water structure Do not award if second hydrogen bond drawn to the hydrogen of the CH₃	(2)

(Total Question 6 = 16 marks)



Question Number	Answer	Additional Guidance	Mark
8(a)(i)	$\text{CH}_3\text{COCl} + \text{AlCl}_3 \rightarrow \text{CH}_3\text{CO}^+ + \text{AlCl}_4^-$	Accept use of $\text{FeCl}_3/\text{Fe} + \text{Cl}_2$ Allow displayed formulae Do not award $\text{C}_2\text{H}_3\text{OCl}$ Ignore state symbols even if incorrect	(1)

Question Number	Answer	Additional Guidance	Mark
8(a)(ii)	- electron pair movement from ring to electrophile - formula of intermediate ion - curly arrow from C–H bond to reform delocalised ring - correct product and equation to show regeneration of catalyst and HCl	 Do not award curly arrow that ends at the CH_3 Allow arrow starting anywhere within the hexagon 'Horseshoe' to cover at least three carbon atoms and face the tetrahedral carbon and with some part of the plus sign inside 'horseshoe' Allow Kekulé diagrams Do not award dotted bonds unless part of a 3D structure Could be shown in reaction mechanism Ignore curly arrows	(4)

Question Number	Answer	Mark
8(b)(i)	The only correct answer is B (alkaline iodine solution) <i>A is not correct because this oxidising agent would react with phenylethanal and not with phenylethanone which is the wrong way round</i> <i>C is not correct because test is for aldehydes and so would react with phenylethanal and not with phenylethanone which is the wrong way round</i> <i>D is not correct because test is for aldehydes and so would react with phenylethanal and not with phenylethanone which is the wrong way round</i>	(1)

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	An answer that makes reference to the following points: - formation of yellow/orange/red (crystalline) precipitate (1) (Filter then) recrystallisation of products (1) - determination of melting temperature (1) - comparison (and hence identification) from use of database/known values (1)	Colour and state are both required Allow solid for ppt Ignore any conditions given with the use of 2,4-DNPH Penalise M3 if any reference to boiling temperature Award only in the context of melting temperature of the hydrazones or as a TE of boiling temperature Max 3 out of 4 if test is only carried out with one of the carbonyls	(4)



Question Number	Answer	Additional Guidance	Mark																				
*8(b)(iii)	This question assesses the 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 <table><tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr><tr><td>Answer shows a coherent 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>	Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points	6	4	5-4	3	3-2	2	1	1	0	0		Number of marks awarded for structure of answer and sustained lines of reasoning	Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2	Answer is partially structured with some linkages and lines of reasoning	1	Answer has no linkages between points and is unstructured	0	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, a response with four 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 were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and zero marks for linkages). 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. If there is any incorrect chemistry, deduct mark(s) from the reasoning. If no reasoning mark(s) awarded do not deduct mark(s). If there is no mention of protons/hydrogens in the response then deduct one structure and reasoning mark	(6)
Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points																						
6	4																						
5-4	3																						
3-2	2																						
1	1																						
0	0																						
	Number of marks awarded for structure of answer and sustained lines of reasoning																						
Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2																						
Answer is partially structured with some linkages and lines of reasoning	1																						
Answer has no linkages between points and is unstructured	0																						



	Indicative content Similarities IP1: aromatic hydrogens will give similar/same peaks IP2: both have a peak in the range 1.7-3.0 (ppm) (due to the hydrogen of the H-C-C=O type) Differences IP3 (Hydrogen environments): Phenylethanone has one less peak/hydrogen environment than phenylethanal IP4 (Splitting patterns): a singlet for phenylethanone but a doublet and a triplet in phenylethanal IP5 (Peak area ratios): relative peak (area) ratio in phenylethanone is 3 but in phenylethanal the peak (area) ratio is 2 to 1 IP6 (Chemical shifts): (Only) phenylethanal has an aldehyde (hydrogen) peak in the range 9 – 10.1 (ppm)	Ignore references to C¹³ nmr Accept annotations on a structure towards crediting the following IPs Allow either a single chemical shift value or a range within the stated values Penalise incorrect chemical shifts Both have peaks in the range 6.5-8.4 (ppm) Ignore any splitting description Ignore any splitting pattern given for this peak to award this mark Allow any difference of one in the number of peaks stated All these splitting patterns required for this IP Ignore the splitting pattern for this IP and ignore any peak areas given for the aryl hydrogens Ignore the splitting pattern for this IP	
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Question Number	Answer	Additional Guidance	Mark
8(c)	Reagent: lithium tetrahydridoaluminate(III) /LiAlH₄ (1)	Allow lithium aluminium hydride Accept sodium tetrahydridoborate /sodium borohydride/ NaBH ₄ In water/alcohol for 2 marks Ignore reference to addition of acid after use of LiAlH ₄ in dry ether Do not award with additional reagents	(2)
	Conditions: (dry) ether/ethoxyethane (1)	Ignore heat The mark for conditions is dependent on correct reagent or near miss such as incorrect formula LiAlH ₃ /LiAlH/LiAl	

(Total Question 8 = 18 marks)

Question Number	Answer	Additional Guidance	Mark
		<u>Example of calculation:</u>	(1)



Question Number	Answer	Additional Guidance	Mark
6(a)	- correct formula (phenol) (1) - balanced equation (1)	<u>Example of equation</u> $\text{C}_6\text{H}_5\text{OH} + 7\text{O}_2 \rightarrow 6\text{CO}_2 + 3\text{H}_2\text{O}$ Allow $\text{C}_6\text{H}_6\text{O}$ Do not award [0] Ignore state symbols even if incorrect	(2)

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	- mass of carbon in both substances (1) - molar masses of both substances (1) - calculation of percentages by mass of carbon (1)	<u>Example of calculation</u> $(12 \times 7 =) 84$ Phenylmethanol 108 and Benzoic acid 122 Phenylmethanol $(84 \div 108) \times 100 = 78\% / 77.8\% / 77.78\% / 77.7\%$ Benzoic acid $(84 \div 122) \times 100 = 68.85\% / 68.9\% / 69\%$ Ignore sf except 1 Allow TE on incorrect M_r values Allow (2) for 11.1% and 9.8% calculated using 12 not 84 Allow 'rescue' (1) for one substance completely correct	(3)

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	A description that makes reference to: black smoke	Allow Black fumes/soot/(yellow) smoky flame / grey smoke Ignore carbon particulates Do not award carbon monoxide/yellow flame	(1)

Question Number	Answer	Additional Guidance	Mark
6(b)(iii)	An answer that makes reference to Alkenes	Allow Cycloalkenes/cycloalkanes/alkynes/ carbon-carbon double bonds Ignore Ethene/named alkenes/named alkynes Do not award benzene/arenes	(1)

Question Number	Answer	Additional Guidance	Mark
6(b)(iv)	An explanation that makes reference to (window) above the safety line means the exhaust system is not strong enough to draw in the fumes (1) - so the toxic fumes will escape (into the laboratory) (1)	Allow reverse argument Allow reference to exhaust/fan not able to prevent gas escaping Allow poisonous/harmful/irritant/ carbon monoxide/soot for 'toxic fumes' Ignore reference to protection from splashing etc	(2)

Question Number	Answer	Additional Guidance	Mark
6(c)(i)	An answer that makes reference to • (M1) (similarity) all have arene C–H absorptions Either 3030 (cm^{-1}) or 750 and/or 700 (cm^{-1}) (1) • (M2) only phenol and phenylmethanol have O–H 3750 - 3200 (cm^{-1}) (1) • (M3) only benzoic acid has O–H 3300 - 2500 (cm^{-1}) (1) • (M4) only benzoic acid has C=O 1700 - 1680 (cm^{-1}) (1) • (M5) only phenylmethanol has alkane C–H absorptions either 2962 - 2853 (cm^{-1}) or 1485 - 1365 (cm^{-1}) (1)	Bond and wavenumber ranges necessary for each mark Do not award 880/830/780 (cm^{-1}) Do not award –OH / C–OH by penalising once only in M2 and M3 All 5 correct bonds with no wavenumber ranges scores (3) 4 correct etc scores (2) and 3 correct etc scores (1) All 5 correct wavenumber ranges with no bonds or incorrect bonds scores (3) 4 correct etc scores (2) and 3 correct etc scores (1) Penalise any additional peaks once only Ignore references to different fingerprint regions	(5)

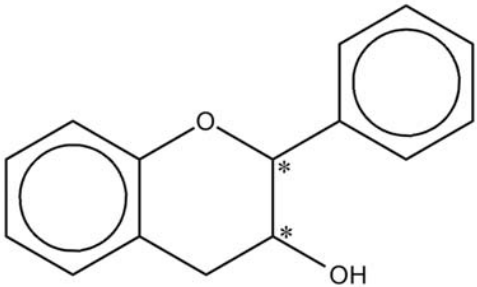


Question Number	Answer	Additional Guidance	Mark
6(c)(ii)	An answer that makes reference to • five peaks (in the ^{13}C NMR spectrum) (1) • (four) aromatic peaks within the chemical shift range of 165 - 105 (ppm) (1) • (one) peak (for the C-OH) within the chemical shift range of 75 - 55 (ppm) (1)	Allow any range within the stated ranges Penalise single values as opposed to ranges once only Accept annotations on diagram Penalise additional peaks once only when three or more types of peak are stated	(3)

Question Number	Answer	Additional Guidance	Mark
6(c)(iii)	An answer that makes reference to • suitable formula of fragment ion (1) • matching m/z value (1)	<u>Example of a suitable formula</u> $\text{C}_6\text{H}_5\text{COO}^+$ or $\text{C}_6\text{H}_5\text{CO}^+$ Do not award $\text{C}_7\text{H}_5\text{O}_2^+$ or $\text{C}_7\text{H}_5\text{O}^+$ $m/z = 121$ or 105 Allow COOH^+ (1) Do not award bond to the fragment, e.g. $-\text{COOH}^+$ $m/z = 45$ (1) No TE on incorrect fragment ions such as CH_3^+	(2)

(Total Question 6 = 19 marks)



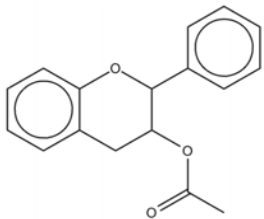
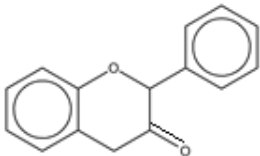
Question Number	Answer	Additional Guidance	Mark
6(a)			(1)

Question Number	Answer	Additional Guidance	Mark
6(b)	$C_{15}H_{14}O_2$	Allow symbols in any order e.g. $H_{14}O_2C_{15}$	(1)

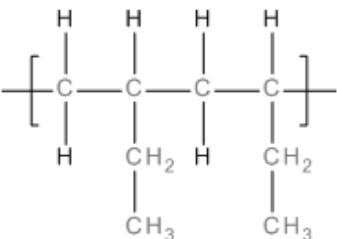
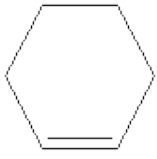
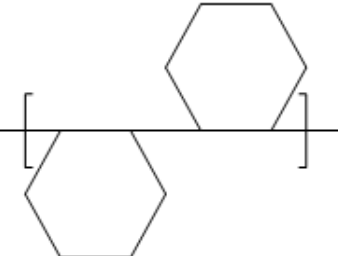
Question Number	Answer	Additional Guidance	Mark																								
*6(c)	This question assesses the student's ability to show a coherent and logically structured answer with linkages and fully sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and 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 <table><tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr><tr><td>Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout</td><td>2</td></tr></table>	Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points	6	4	5-4	3	3-2	2	1	1	0	0		Number of marks awarded for structure of answer and sustained lines of reasoning	Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2	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, a response with four 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 were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and zero marks for linkages). Typically <table><tr><th>Number of IPs</th><th>Reasoning mark</th></tr><tr><td>6 or 5</td><td>scores 2</td></tr><tr><td>4 or 3</td><td>scores 1</td></tr><tr><td>2 or 1 or 0</td><td>scores 0</td></tr></table>	Number of IPs	Reasoning mark	6 or 5	scores 2	4 or 3	scores 1	2 or 1 or 0	scores 0	(6)
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	Number of marks awarded for structure of answer and sustained lines of reasoning																										
Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2																										
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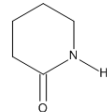
	Answer is partially structured with some linkages and lines of reasoning	1		
	Answer has no linkages between points and is unstructured	0		

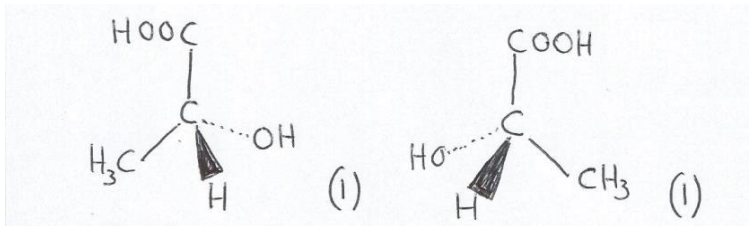
	Indicative content • IP1 any mention of oxidation of ethanol or oxidation of flavan-3-ol (by oxygen in the air) • IP2 for formation of either ethanoic acid or ethanal (from ethanol) • IP3 for formation of ethyl ethanoate (from the reaction between ethanol and ethanoic acid) • IP4 for structure / name of flavan-3-one • IP5 for (-OH group on) flavan-3-ol forms an ester with ethanoic acid • IP6 correct structure of the ester formed between flavan-3-ol and ethanoic acid  This is the structure of the ester formed between flavan-3-ol and ethanoic acid	Allow names or formulae but if both are given both must be correct  Comment For correct structure of the ester formed between flavan-3-ol and ethanoic acid award both IP5 and IP6 Do not award IP4 if the product is described as an aldehyde	
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(Total Question 6 = 8 marks)

Question Number	Answer	Additional Guidance	Mark
6(a)	(CH₂=CHCH₂CH₃→) (1)  (1)  	Accept skeletal, structural or displayed formulae or combination of which is clear, e.g. -C₂H₅ Brackets are not essential Ignore 'n' Ignore orientation of side chains Ignore bond length Ignore where bond goes to for the ethyl groups Penalise lack of 'end-bonds' once only Award 1 mark max if only one repeat unit given for each polymer Ignore more than 2 repeat units	(2)

Question Number	Answer	Additional Guidance	Mark
6(b)	- HOOC — (CH₂)₄ — COOH or ClOC — (CH₂)₄ — COCl - H₂N — (CH₂)₄ — NH₂ (1) (1)	Accept skeletal, structural or displayed formulae Penalise use of C₄H₈ once only Penalise missing H's once only The monomers can be in either order Do not award monofunctionality	(2)

Question Number	Answer	Additional Guidance	Mark
6(c)	$\text{H}_2\text{N} - (\text{CH}_2)_4 - \text{COOH}$	Accept skeletal, structural or displayed formulae Allow $\text{H}_2\text{N} - (\text{CH}_2)_4 - \text{COCl}$ Ignore connectivity Allow  Allow use of C_4H_8 here only Penalise missing hydrogens	(1)

Question Number	Answer	Additional Guidance	Mark
6(d)(i)	Allow 	Diagram must be 3-dimensional with either wedges or dashes to score 2 marks Ignore orientation of group at the top Ignore vertical bond to H of OH group	(2)

Question Number	Answer	Additional Guidance	Mark
6(d)(ii)	- They rotate the plane of plane-polarised light (equally) and in opposite/different directions - OR - Determine in which direction they rotate the plane of plane-polarised light	Allow one plane	(1)

Question Number	Answer	Additional Guidance	Mark
6(d)(iii)	Does not accumulate in the environment/does not occupy landfill	Accept answers that outline the benefit of avoiding other means of disposal such as incineration, use of toxic chemicals Ignore just less harm to environment/less harm to animal life/less pollution/less of an "eyesore"/less energy to break it down	(1)

(Total for Question 6 = 9 marks)

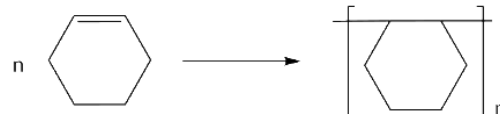
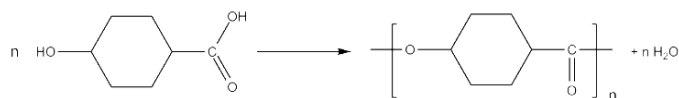


Question Number	Answer	Additional Guidance	Mark																				
*7(a)	This question assesses the student’s ability to show a coherent and logically structured answer with linkages and fully sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows 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 <table><tr><th></th><th>Number of marks awarded for structure of answer and sustained lines of reasoning</th></tr><tr><td>Answer shows a coherent 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>	Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points	6	4	5-4	3	3-2	2	1	1	0	0		Number of marks awarded for structure of answer and sustained lines of reasoning	Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2	Answer is partially structured with some linkages and lines of reasoning	1	Answer has no linkages between points and is unstructured	0	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, a response with four 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 were no linkages between the points, then the same indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and zero marks for linkages).	(6)
Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points																						
6	4																						
5-4	3																						
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Answer shows a coherent logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2																						
Answer is partially structured with some linkages and lines of reasoning	1																						
Answer has no linkages between points and is unstructured	0																						



Indicative content

- **IP1** in both cases many monomers join (by covalent bonds to form polymers)
- **IP2** cyclohexene forms an addition polymer / the polymer is formed by an addition reaction
- **IP3** 4-hydroxycyclohexanecarboxylic acid forms a condensation polymer / the polymer is formed by a condensation reaction
- **IP4** no additional products from when cyclohexene polymerises, but water is also formed when 4-hydroxycyclohexanecarboxylic acid polymerises

• **IP5**• **IP6**

Allow both polymerisations require a catalyst
Allow both polymers are formed from a single type of monomer

Allow unsaturated monomer forms saturated polymer

Allow 'only 1 product in addition but two products in condensation'
Allow only one functional group is needed for addition polymerisation but two different functional groups are needed for condensation polymerisation
Allow cyclohexene polymerisation has 100% atom economy, 4-hydroxycyclohexanecarboxylic polymerisation has less than 100% atom economy

Ignore omitted or misplaced n in **IP5** and **IP6**

Allow 1 IP for IP5 and IP6 if both correct repeat units shown

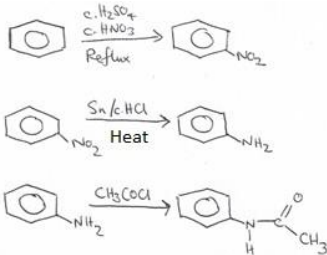
Allow 2 oxygen atoms on RHS and none on LHS for IP6 repeat unit



Question Number	Answer	Additional Guidance	Mark
7(b)	An answer that makes reference to the following points - recycling - incineration to release energy / generate electricity - use as a feedstock (for cracking)	(1) Allow re-use (1) Allow 'use as a fuel' (1) Allow 'break down into monomers' / 'hydrolyse to form monomers' / 'break down to form small(er) molecules' Ignore 'remove toxic waste gases from incineration' / developing biodegradable polymers	(3)

(Total Question 7 = 9 marks)



Question Number	Answer	Additional Guidance	Mark
7(a)	A synthetic pathway that consists of: (reagents and conditions for the nitration of benzene) conc. Nitric (HNO_3) and sulfuric acids (H_2SO_4) and 55°C/heat/reflux (1) - structure of nitrobenzene (1) (reduction of nitrobenzene) tin and conc. hydrochloric acid and heat/reflux (1) - structure of phenylamine (1) (reaction of phenylamine with) ethanoyl chloride (1)	Example of synthetic pathway  The compounds used can be stated or given within equations. Ignore any unbalanced, incorrect equations or reaction mechanisms Allow any single value or range between $50\text{--}60^\circ\text{C}$/warm/$<55^\circ\text{C}$ Intermediate marks are standalone Allow iron & c.HCl Do not award dilute Ignore subsequent addition of NaOH Penalise lack of heat once only in M1 and M3 Penalise just the names of intermediates once only Ignore heat Do not award use of AlCl_3	(5)

Question Number	Answer	Mark
7(b)	The only correct answer is B (6) A is not correct because four carbon atoms in the aromatic ring are non-equivalent and not just three, so the correct total of non-equivalent carbon atoms and therefore peaks is six C is not correct because there are two sets of equivalent carbon atoms in the aromatic ring and not just one which means that the correct total of non-equivalent carbon atoms and therefore peaks is six D is not correct because this is the total number of carbon atoms in antifebrin but carbon atoms 2 and 6 in the aromatic ring are equivalent, as are 3 and 5, which gives a correct total of six non-equivalent carbon atoms and therefore six peaks	(1)

Question Number	Answer	Additional Guidance	Mark
7(c)	An explanation that makes reference to the following points: • lone pair (of electrons) from the oxygen and will interact with the delocalised ring of electrons / increase the (pi/π) electron density of the benzene ring (1) • which increases the reactivity toward electrophiles (such as bromine)/ which means that the bromine is more easily polarised (1)	Allow reference to the lone pair (of electrons) from the nitrogen Ignore activation of ring Do not award charge density Allow $\text{Br}^+/\text{Br}^{\delta+}$ for electrophile Allow reference to benzene as being a stronger nucleophile Do not award references to electrophilic addition	(2)



Question Number	Answer	Additional Guidance	Mark
7(d)	- conversion of moles to mass of paracetamol (1) - conversion of answer into percentage to 2/3 SF (1)	<u>Example of calculation:</u> (mass of paracetamol = $3.10 \times 10^{-3} \times 151$ = 0.4681 (g) % = $(0.4681 \div 0.500) \times 100 = 93.62\%$) =94 (%) / 93.6 (%) Allow TE for second mark from incorrect molar mass as long as value derived from dividing by 0.500/500mg and percentage is less than 100% Correct answer without working scores 2	(2)

(Total for Question 7 = 10 marks)

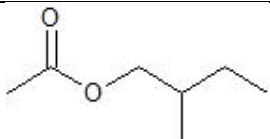
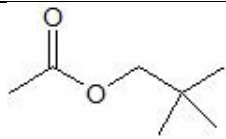
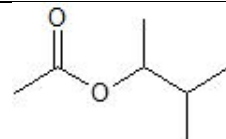
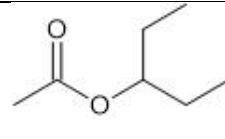
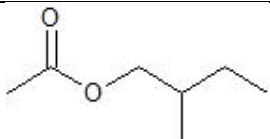
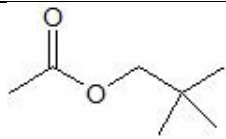
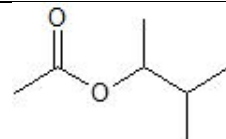
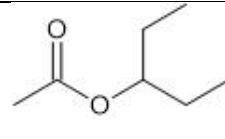
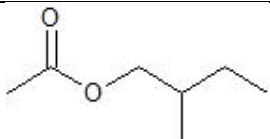
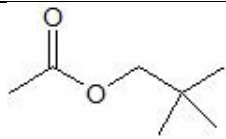
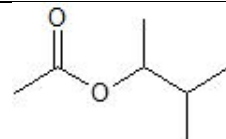
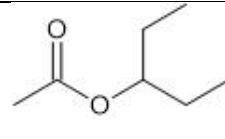
Question Number	Answer	Mark
8(a)	The only correct answer is C (6 7) <i>A is not correct because there are six non-equivalent carbons in isoamyl acetate and seven in amyl acetate</i> <i>B is not correct because all carbons of amyl acetate generate their own peak in the spectrum</i> <i>D is not correct because the two methyl groups on the branched chain are equivalent</i>	(1)

Question Number	Answer	Additional Guidance	Mark
8(b)	$C_7H_{14}O_2$	Accept atoms in any order	(1)

Question Number	Answer	Additional Guidance	Mark
8(c)	CH_3COOH	Allow displayed, skeletal or combination of Do not award molecular formula	(1)

Question Number	Answer	Additional Guidance	Mark
8(d)	3-methylbutan-1-ol	Allow 'methly' for methyl Allow name with missing hyphens Allow 3-methylbutane-1-ol Allow 3-methylbut-1-anol Allow 1-hydroxy-3-methylbutane Do not allow 3-methylbut-1-ol Ignore formulae even if incorrect	(1)

Question Number	Answer	Additional Guidance	Mark
8(e)	pentyl ethanoate	Allow pentanyl ethanoate	(1)

Question Number	Answer	Additional Guidance	Mark				
8(f)(i)	Any three of the following four structures <table border="1" data-bbox="421 970 1482 1177"> <tr> <td>  (1) </td><td>  (1) </td><td>  (1) </td><td>  (1) </td></tr> </table>	 (1)	 (1)	 (1)	 (1)	Accept formulae in any order Award (2) if 3 correct displayed/structural formulae given Award (1) if 2 correct displayed/structural formulae given	(3)
 (1)	 (1)	 (1)	 (1)				



Question Number	Answer	Additional Guidance	Mark
8(f)(ii)	An equation that has - ethanoyl chloride (1) - alcohol and ester+ HCl product (1)	<u>Example of equation</u>  Allow structural, displayed formulae in any combination Ignore connectivity to OH except horizontal Ignore state symbols even if incorrect If molecular formulae used then allow (1) for correct equation Allow (1) for a correct equation to form ester A from ethanoic acid e.g. $\text{CH}_3\text{COOH} + \text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_2\text{CH}_3 \rightleftharpoons \text{CH}_3\text{COOCH}(\text{CH}_3)\text{CH}_2\text{CH}_2\text{CH}_3 + \text{H}_2\text{O}$	(2)

Question Number	Answer	Additional Guidance	Mark
8(g)	An answer that makes reference to the following points: (similarity) - both make the (same) alcohol / pentan-1-ol (1) (differences) - acid hydrolysis is reversible, alkaline hydrolysis is irreversible (1) - acid hydrolysis produces the carboxylic acid/ ethanoic acid and alkaline hydrolysis produces the carboxylate / ethanoate (ion) (1) - the acid is a catalyst and the alkali is a reactant (1)	Points can be made in equations Accept acid hydrolysis is an equilibrium and alkaline hydrolysis goes to completion Allow just acid for carboxylic acid Allow salt for carboxylate Allow the acid will be regenerated /not used up but the alkali will be used up Ignore references to rate differences Ignore references to a need for the product of alkaline hydrolysis to be acidified which is different to acid hydrolysis	(4)

(Total Question 8 = 14 marks)