

- 1 Equal amounts of the four compounds are added to the same volume of water.

Which compound would produce the most acidic solution?

- A** CH_3CONH_2
- B** CH_3COOH
- C** $\text{CH}_3\text{COOCH}_3$
- D** CH_3COCl

Your answer

[1]

- 2 0.1 mol of $\text{HOOCCH}_2\text{COOH}$ are reacted with 0.1 mol of aqueous NaOH .

How many molecules of water are formed?

- A** 6.02×10^{22}
B 3.01×10^{22}
C 6.02×10^{23}
D 3.01×10^{23}

Your answer

[1]

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3 Which reagents could be used to prepare $\text{CH}_3\text{CH}_2\text{CONHCH}_3$?

- A $\text{CH}_3\text{CH}_2\text{COCl} + \text{CH}_3\text{NH}_2$
- B $\text{CH}_3\text{CH}_2\text{CONH}_2 + \text{CH}_3\text{Br}$
- C $\text{CH}_3\text{CH}_2\text{COONa} + \text{CH}_3\text{NH}_2$
- D $\text{CH}_3\text{CH}_2\text{COCH}_3 + \text{NH}_3$

Your answer

[1]

4 Which compound(s) is a/are structural isomer(s) of $\text{C}_6\text{H}_{12}\text{O}_2$?

- 1 hexanoic acid
- 2 ethyl butanoate
- 3 propyl propanoate

- A** 1, 2 and 3
- B** Only 1 and 2
- C** Only 2 and 3
- D** Only 1

Your answer

[1]

Turn over

- 5 Qualitative tests are carried out on the aromatic compound. The results are shown below.

Test	Acidity	$\text{Na}_2\text{CO}_3(\text{aq})$	2,4-DNP	Tollens' reagent
Observation	pH = 5	No observable change	Orange precipitate	No observable change

Determine the functional groups in the compound. Explain your reasoning.

Functional groups

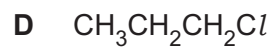
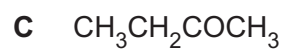
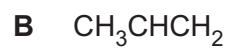
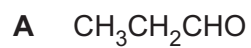
Explanation

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..... [3]

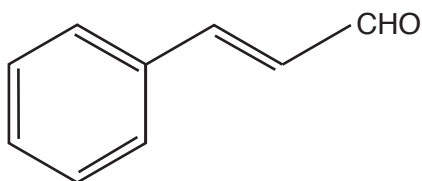
6 Which compound does **not** react with nucleophiles?



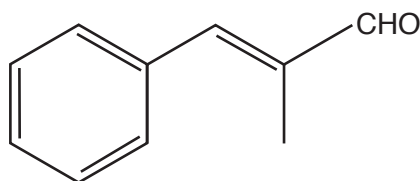
Your answer

[1]

- 7 A student plans to carry out some chemical tests on both cinnamaldehyde and methylcinnamaldehyde.



cinnamaldehyde



methylcinnamaldehyde

- (i) Suggest a suitable chemical test to confirm that both compounds contain an unsaturated carbon chain.

Your answer should include the reagent and observations.

.....
 [1]

- (ii) Describe a chemical test to confirm that both compounds contain an aldehyde functional group.

Your answer should include the reagent and observations.

.....
 [1]

- (iii) Describe a chemical test to confirm that cinnamaldehyde and methylcinnamaldehyde contain a carbonyl group.

How could the products of this test be used to distinguish between the two compounds?

Your answer should **not** include spectroscopy.

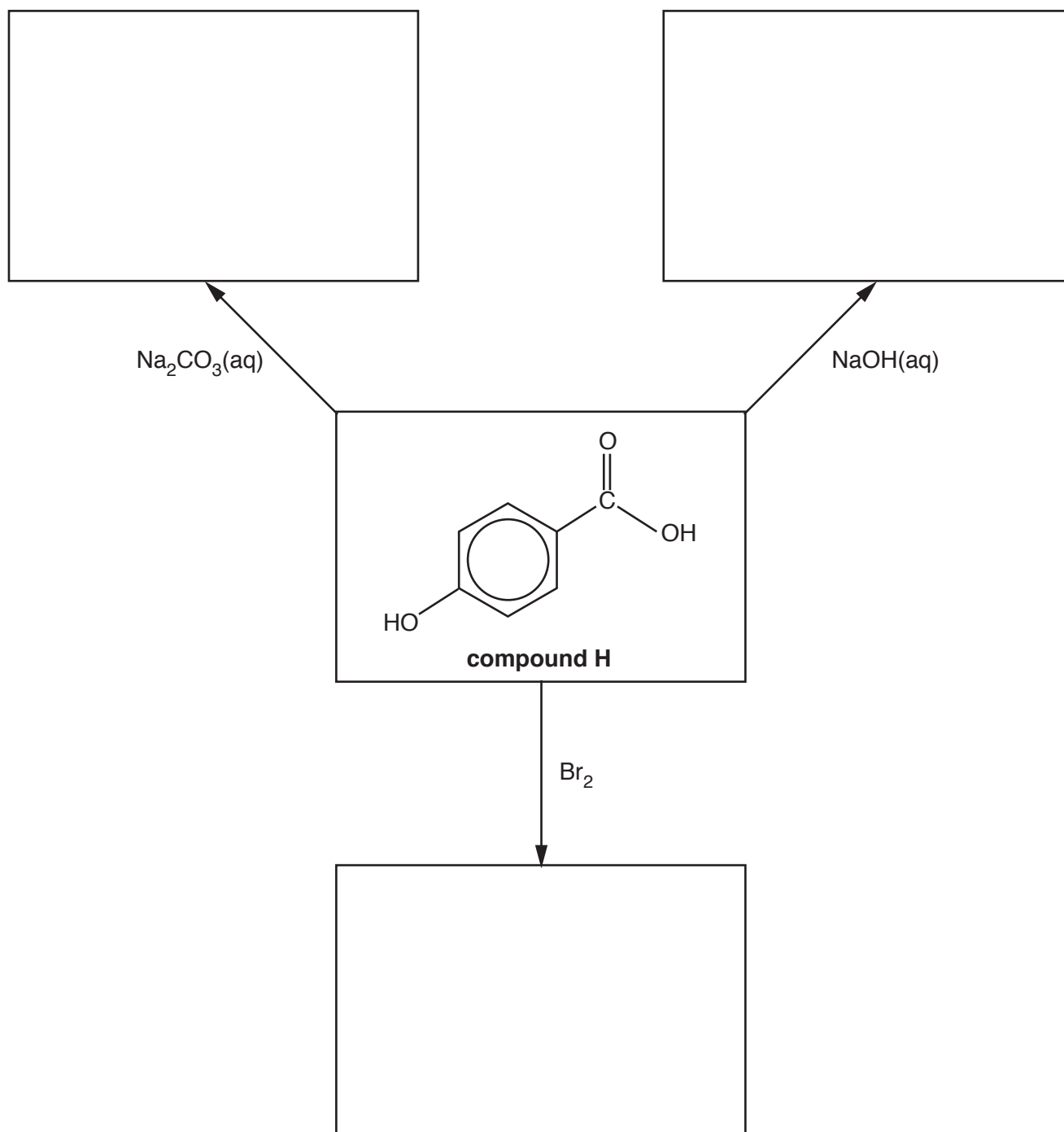
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 [3]

8 This question is about aromatic carboxylic acids and their derivatives.

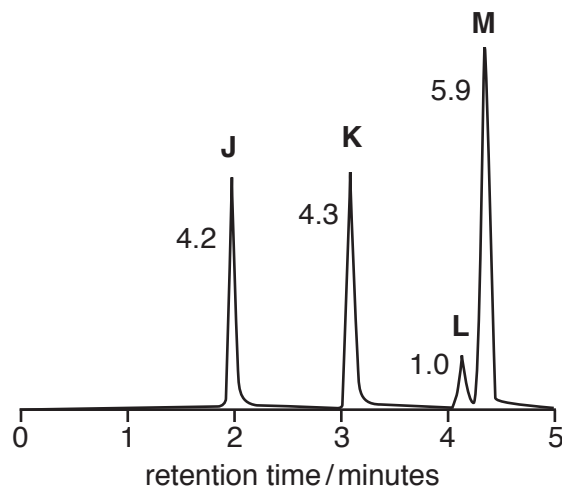
(a) The flowchart below shows some reactions of compound **H**.

In the boxes, draw the organic products of these reactions.



[3]

- 9 A cosmetic product containing four esters, **J**, **K**, **L** and **M**, is analysed by gas chromatography and mass spectrometry. The results are shown below.

Gas chromatogram

The numbers by the peaks are the relative molar proportions of the compounds in the mixture.

Mass spectrometry

ester	<i>m/z</i> of molecular ion peak
J	152
K	166
L	180
M	180

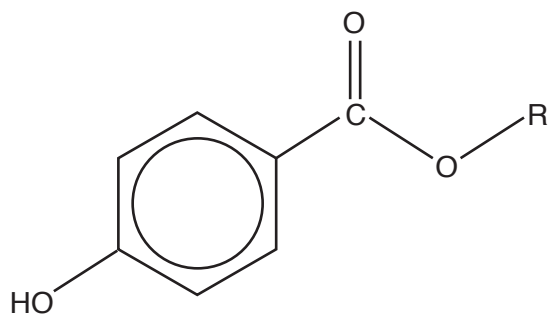
- (i) The concentration of ester **K** in the cosmetic product is $9.13 \times 10^{-2} \text{ g dm}^{-3}$.

Using the results, calculate the concentration, in mol dm^{-3} , of ester **M** in the cosmetic product.

Give your answer to **two** significant figures.

concentration of ester **M** = ... mol dm^{-3} [2]

(ii) A general structure for esters **J**, **L** and **M** is shown below.



Where 'R' is an alkyl group.

Use the mass spectrometry results to deduce possible structures for esters **J**, **L** and **M**.

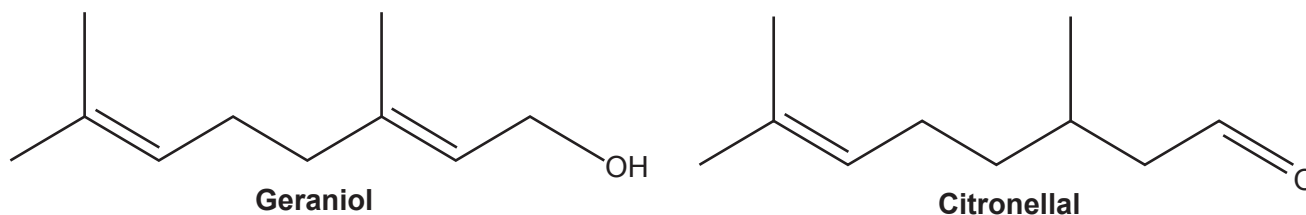
J	L	M
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[3]

10 A carbonyl compound is reacted with NaBH_4 .

Which compound(s) could be formed?

- 11 Geraniol and citronellal, shown below, are isomers present in 'citronella oil', used as an insect repellent.



- Geraniol and citronellal are structural isomers of each other.
- They also show stereoisomerism.

Describe how the observations from a chemical test would distinguish between geraniol and citronellal.

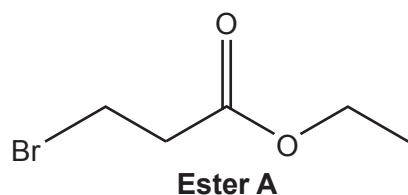
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12 This question is about esters.

(a) The structure of ester **A** is shown below.

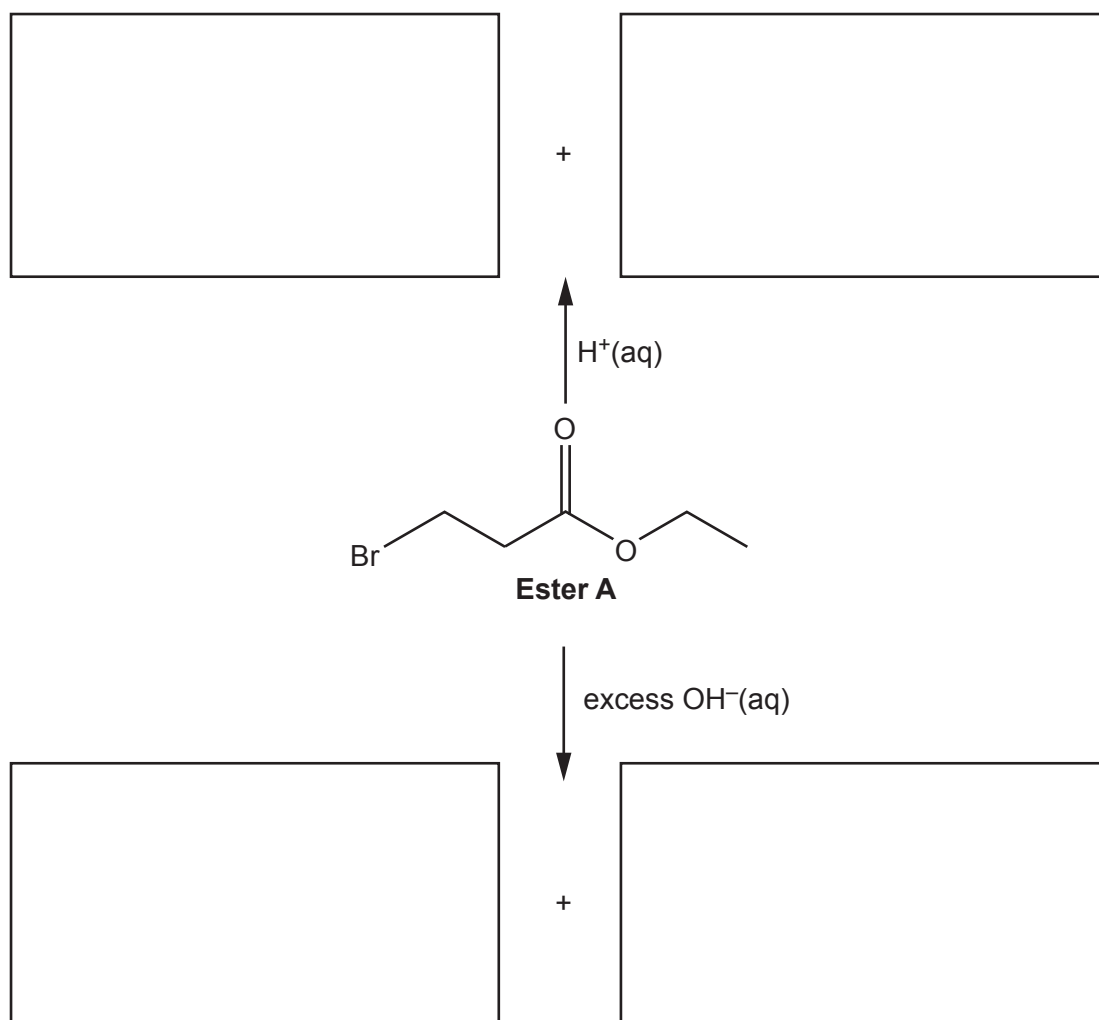


(i) What is the systematic name of ester **A**?

..... [1]

(ii) In the boxes, draw the organic products for the reactions of the functional groups in ester **A** shown below.

Each reaction forms two organic products.



[5]

(iii) Name the type of reactions of ester **A** shown in (ii).

..... [1]



- Purification details are **not** required.

[6]

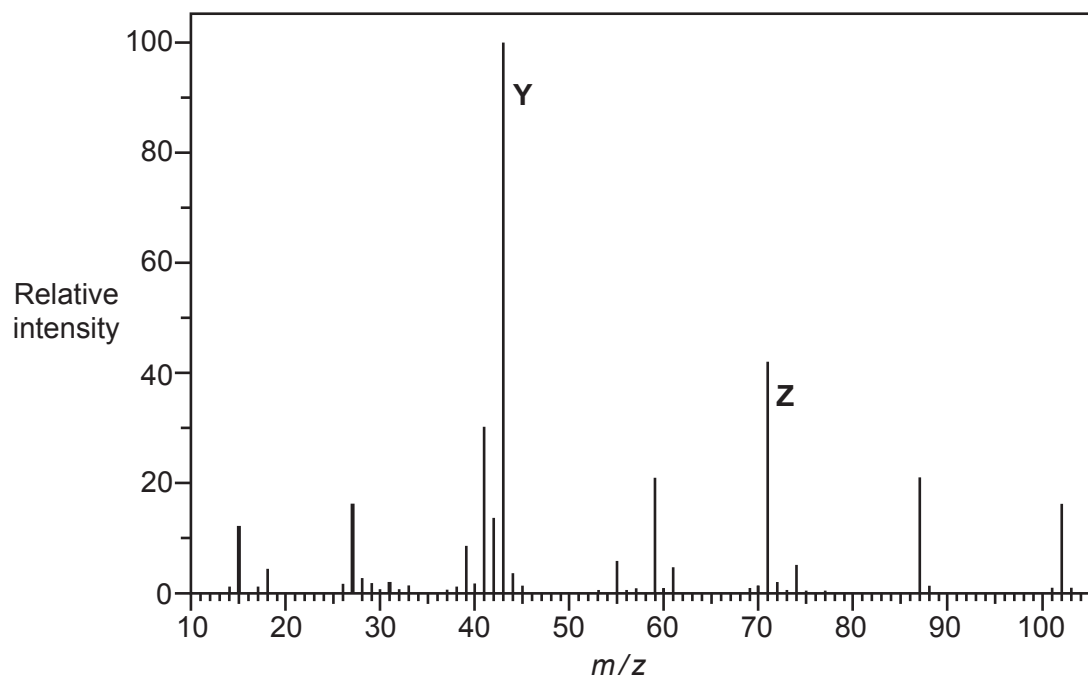
This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins or other markings on the paper.

Additional answer space if required

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(ii) The mass spectrum of ester **C** is shown below.



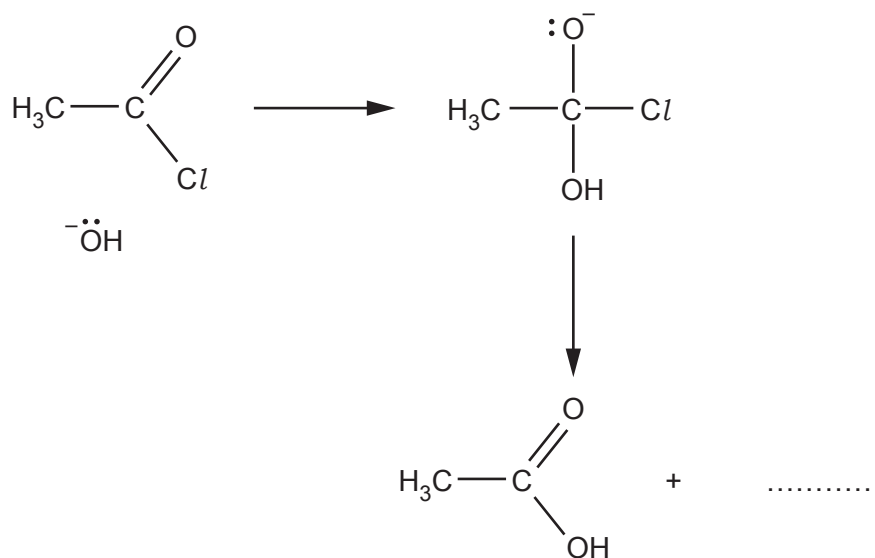
Suggest possible structures for the species responsible for peaks **Y** and **Z** in the mass spectrum.

Y	Z

[2]

14 An incomplete reaction mechanism is shown below.

(i) Complete the mechanism by adding curly arrows and any missing species.



[4]

(ii) What is the role of OH^- in this mechanism?

..... [1]

15 Which of these reagent(s) will **not** react with $\text{HOCH}_2\text{CH}_2\text{CH}_2\text{COOH}$?

- A NaCN in ethanol
- B $\text{C}_2\text{H}_5\text{OH}$ in the presence of an acid catalyst
- C $(\text{CH}_3\text{CO})_2\text{O}$
- D concentrated H_2SO_4

Your answer

☐

[1]

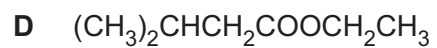
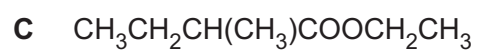
16 Which one of the following reacts with ethanoic acid **and** with phenol?

- A** Aqueous potassium hydroxide
- B** Bromine
- C** Calcium carbonate
- D** Methanol and an acid catalyst

Your answer

[1]

17 What is the structural formula of ethyl 3-methylbutanoate?



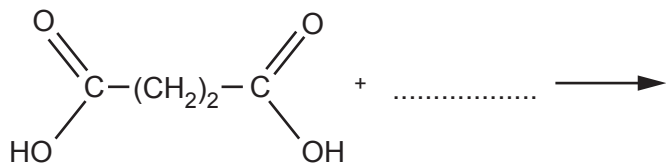
Your answer

[1]

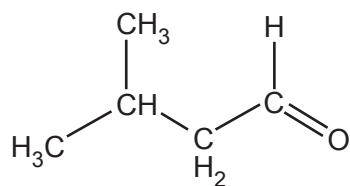
18

The diacyl dichloride is prepared from $\text{HOOC}(\text{CH}_2)_2\text{COOH}$.

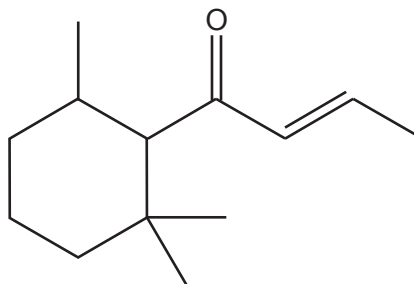
Complete the equation for the formation of a diacyl dichloride from $\text{HOOC}(\text{CH}_2)_2\text{COOH}$.

**[3]**

- 19 The carbonyl compounds, **F** and **G**, shown below, contribute to the flavour of coffee.



F



G

- (a) Compound **F** is a member of a homologous series.

- (i) Explain the term homologous series.

.....

 [2]

- (ii) Predict the molecular formula for the member of this homologous series containing 24 carbon atoms.

..... [1]

- (b) Describe suitable chemical tests, with observations, that would confirm the presence of the functional groups in **F** and **G**.

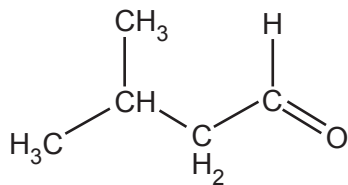
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 [4]

(c) Compound **F** reacts with HCN using NaCN(aq) and H⁺(aq).

(i) Outline the mechanism for the reaction of **F** with NaCN(aq) and H⁺(aq) and state the name of the mechanism. The structure of **F** has been provided.

Include relevant dipoles, lone pairs and the structure of the organic product.



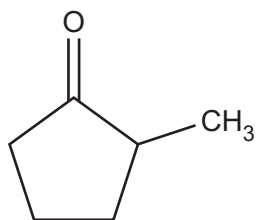
Name of mechanism: [5]

(ii) Explain why the mechanism in (c)(i) involves heterolytic fission.

.....

 [2]

- 20 2-Methylcyclopentanone, shown below, is reacted with $\text{NaCN(aq)/H}^+(\text{aq})$ to form an organic product.



2-methylcyclopentanone

Which statement is correct?

- A** In the mechanism, a CN^- ion accepts an electron pair.
- B** The mechanism is electrophilic addition.
- C** The organic product has one chiral centre.
- D** The organic product has the molecular formula $\text{C}_7\text{H}_{11}\text{NO}$.

Your answer

☐

[1]

- 21 $\text{CH}_3\text{CH}_2\text{COOCH}_3$ is heated with aqueous sodium hydroxide to produce two organic products.

What are the two organic products?

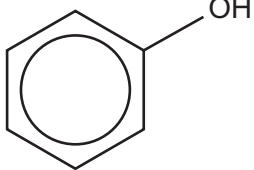
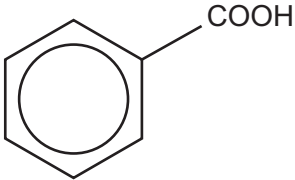
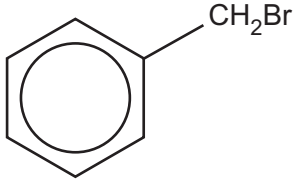
- A** $\text{CH}_3\text{CH}_2\text{COOH}$ and CH_3OH
- B** $\text{CH}_3\text{CH}_2\text{COONa}$ and CH_3OH
- C** $\text{CH}_3\text{CH}_2\text{COOH}$ and CH_3ONa
- D** $\text{CH}_3\text{CH}_2\text{COONa}$ and CH_3ONa

Your answer

[1]

22 Compounds **1**, **2** and **3** are heated with NaOH(aq).

Which compound(s) react(s)?

1	
2	
3	

- A** 1, 2 and 3
B Only 1 and 2
C Only 2 and 3
D Only 1

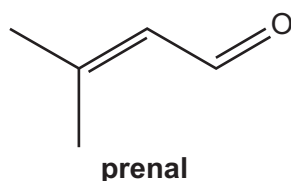
Your answer ☐

[1]

Turn over

23 This question is about organic synthesis.

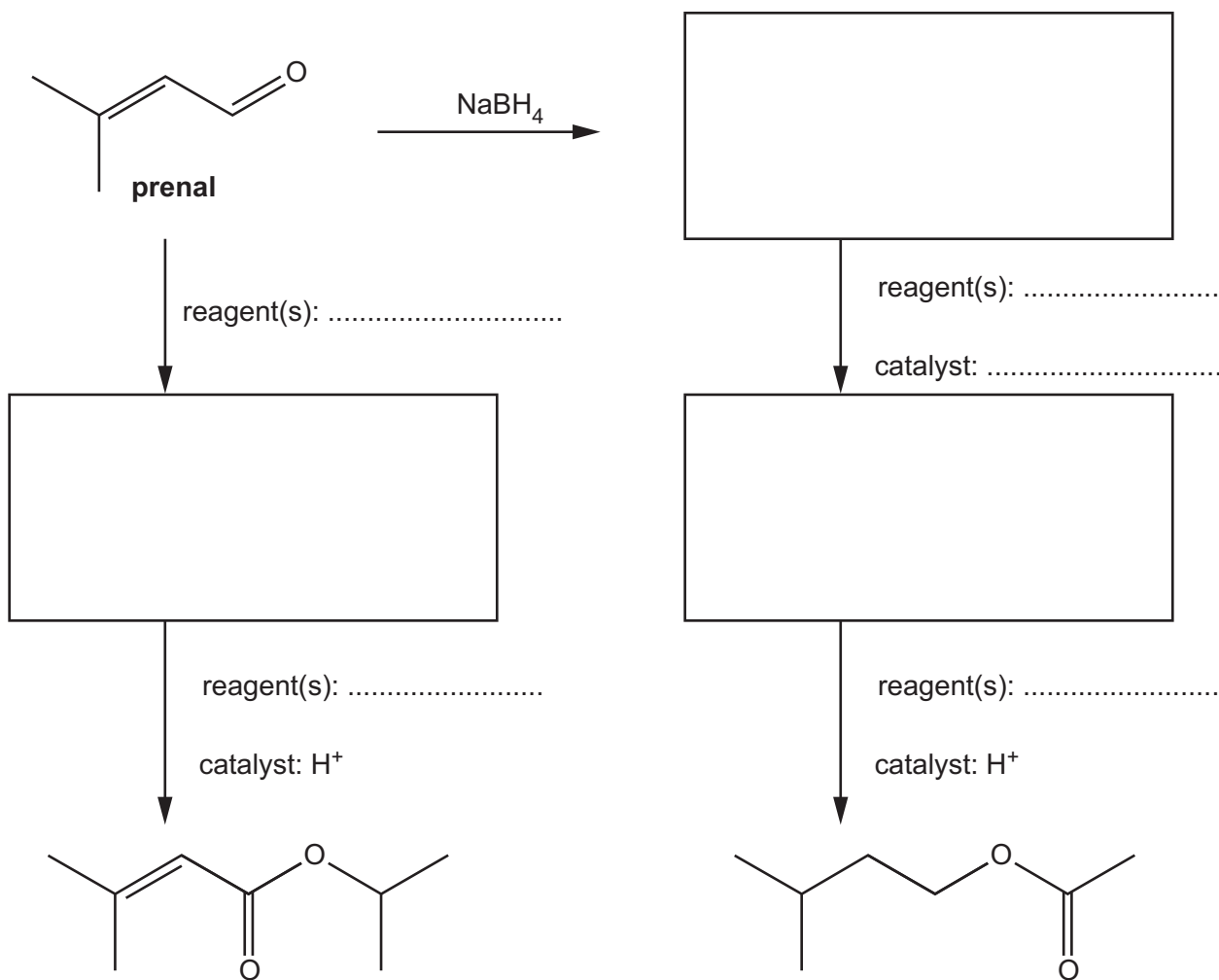
(a) Prenal, shown below, is used in the synthesis of some pharmaceuticals.



(i) What is the systematic name for prenal?

..... [1]

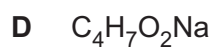
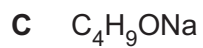
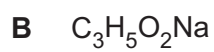
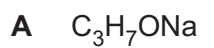
(ii) Complete the flowchart below for the synthesis of two compounds starting from prenal.



[7]

24 Butyl propanoate is hydrolysed by aqueous sodium hydroxide.

Which compound is one of the products of this hydrolysis?



Your answer

[1]

25 This question is about carbonyl compounds.

(a) (i) Describe a chemical test to confirm the presence of a carbonyl group.

How could the product of this test be used to identify the carbonyl compound?

Your answer should **not** include spectroscopy.

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..... [3]

(ii) Describe a chemical test that would identify whether a carbonyl compound is an aldehyde.

Your answer **should** include the reagent and observations.

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..... [1]

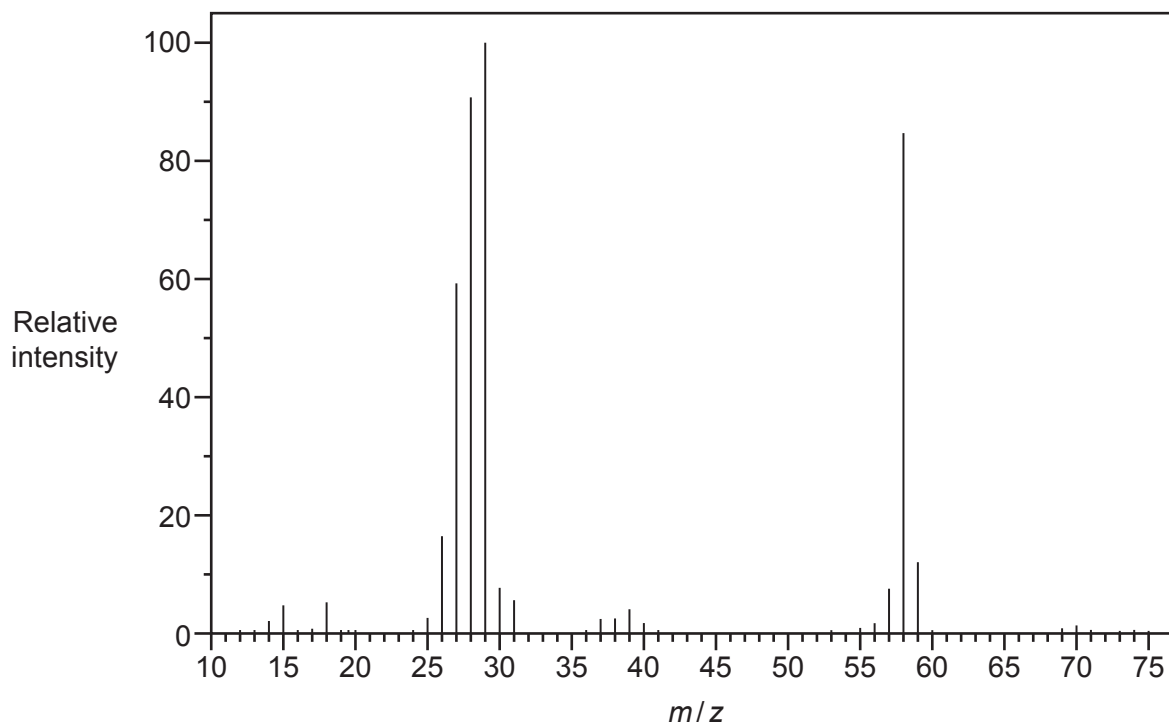
(b) A student is provided with two unknown carbonyl compounds, **F** and **G**.

The compounds are analysed and found to have identical percentage compositions by mass:

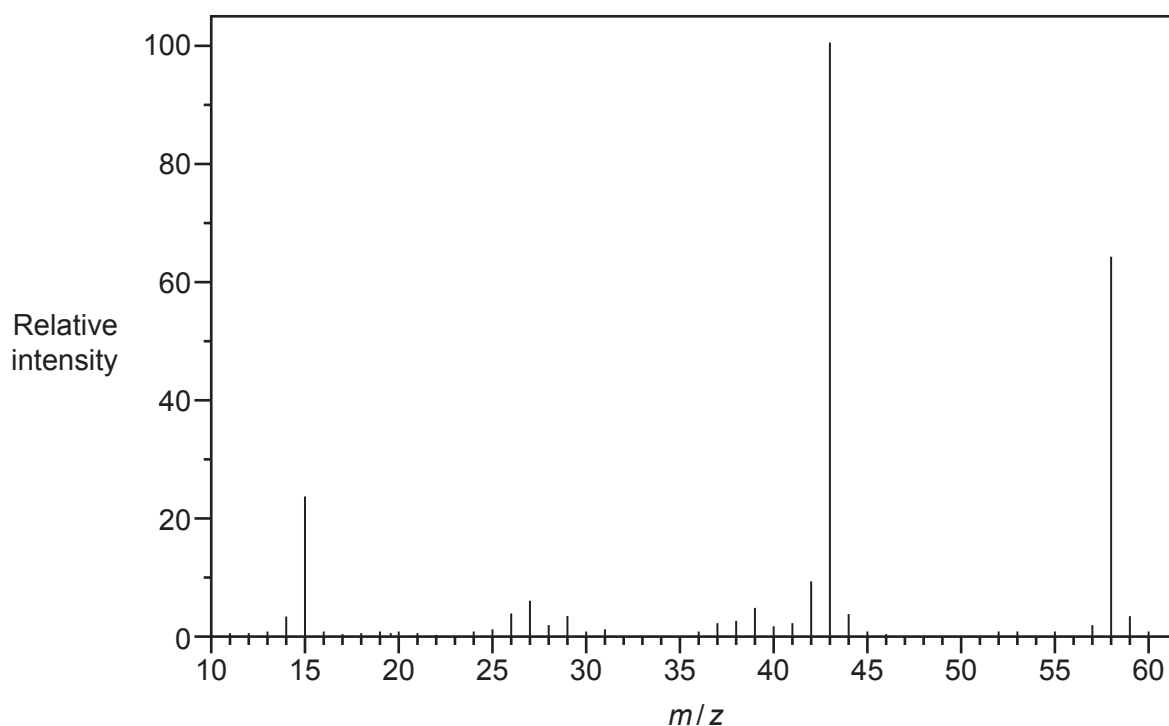
C: 62.07%; H: 10.34%; O: 27.59%

The mass spectra of the two compounds are shown below.

Mass spectrum of F



Mass spectrum of G



Use the results to identify the structures of the two compounds.

Include relevant peaks present in the mass spectrum of each compound.

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.....

F	G
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[4]

26 This question is about compounds that contain the carboxylic acid functional group.

(a) Carboxylic acids react with alkalis, metals and carbonates to form salts.

Write full equations for the following _{two} reactions. Show structures for organic compounds.

- the reaction of propanoic acid with aqueous potassium hydroxide:

- the reaction of aqueous methanoic acid with magnesium:

[2]

- 27 Acid anhydrides react in a similar way to acyl chlorides with phenols.

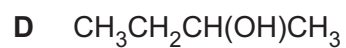
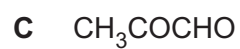
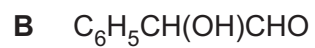
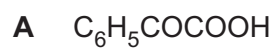
Benzoic anhydride is the acid anhydride of benzoic acid, $\text{C}_6\text{H}_5\text{COOH}$.

Benzoic anhydride reacts with butan-2-ol to form an ester.

Suggest an equation for this reaction. Show structures for organic compounds. Use C_6H_5 for any phenyl groups.

[2]

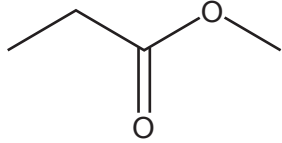
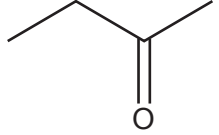
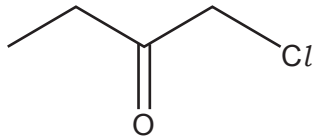
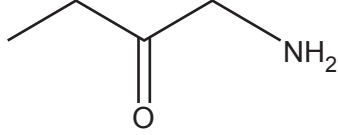
28 Which compound reacts with 2,4-dinitrophenylhydrazine but does **not** react with Tollens' reagent?



Your answer

[1]

29 Which compound reacts with ethanoyl chloride?

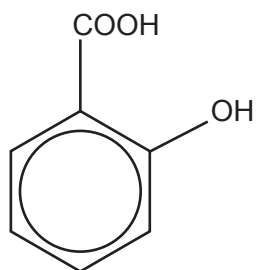
A	
B	
C	
D	

Your answer

[1]

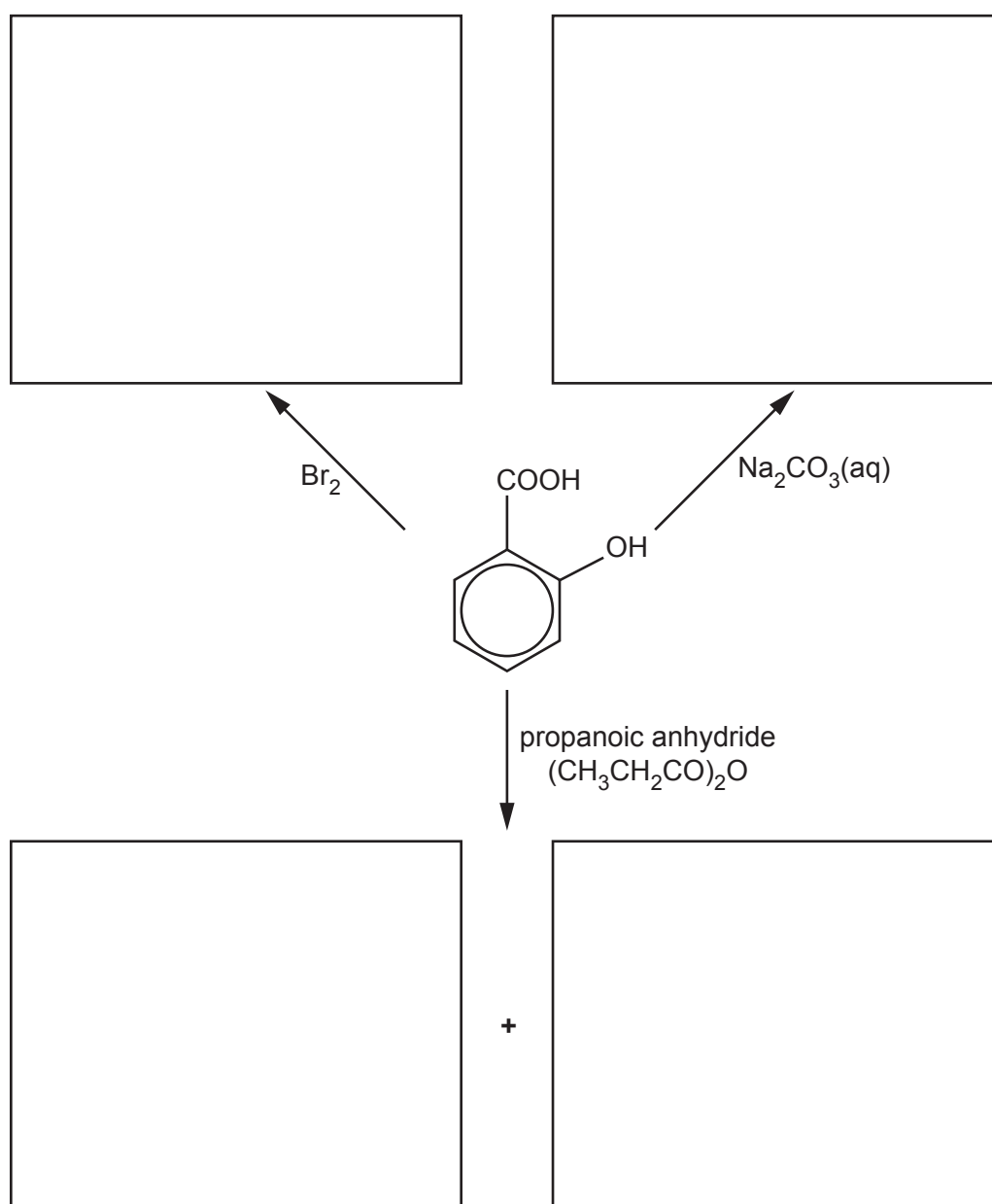
30 This question is about aromatic compounds containing the -COOH and -OH functional groups.

(a) Salicylic acid, shown below, is used in the manufacture of some important medicines.



Salicylic acid

Complete the flowchart for reactions of salicylic acid, by adding the organic products in each box.



[4]

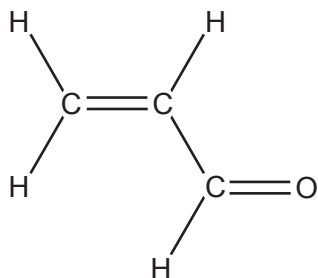
31 This question is about reactions of acrolein, $\text{H}_2\text{C}=\text{CHCHO}$.

(a) Acrolein reacts with sodium cyanide in acidic conditions, $\text{NaCN(aq)}/\text{H}^+(\text{aq})$.

(i) Outline the reaction mechanism for this reaction, showing the intermediate and the organic product.

The structure of acrolein has been provided.

Include curly arrows and relevant dipoles.



[4]

(ii) Name this type of mechanism.

..... [1]

32 Esterification reaction of $(\text{CH}_3)_3\text{COH}$

Reagent(s) and/or catalyst

.....

.....

organic product

[2]

33 Alkenes and carbonyl compounds take part in addition reactions.

Describe **one** addition reaction of an alkene and **one** addition reaction of a carbonyl compound.
Include reagents and reaction mechanisms. **[6]**

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Extra answer space if required.

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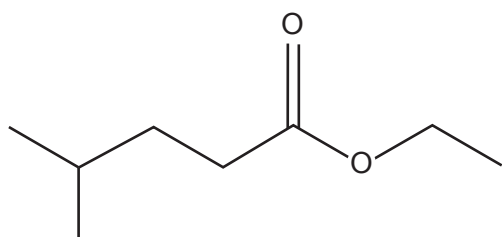
34 This question is about carboxylic acids and esters.

(a) Short-chain carboxylic acids, such as methanoic acid, HCOOH , are soluble in water.

Explain, with a labelled diagram, how HCOOH interacts with water when it dissolves.

.....
.....
..... [2]

(b) Ester **F** has the structure shown below.



Ester F

(i) What is the systematic name for this ester?

..... [1]

(ii) Ester **F** can be prepared from a carboxylic acid in two steps.

Step 1 The carboxylic acid is converted into an acyl chloride.

Step 2 The acyl chloride is converted into ester **F**.

Write equations for **Step 1** and **Step 2**.

Show organic compounds as structures.

Step 1

Step 2

[4]

- 35 0.200 mol of $\text{HOOCCH}_2\text{CH}_2\text{COOH}$ is reacted with 0.300 mol NaOH .

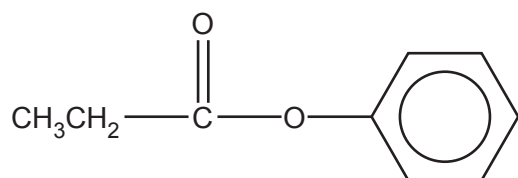
How many water molecules are formed?

- A** 1.204×10^{23}
B 1.806×10^{23}
C 2.408×10^{23}
D 3.612×10^{23}

Your answer

[1]

36 Which reagents could a student use to prepare the ester shown?



A	$\text{CH}_3\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH} \quad + \quad \text{HO}-\text{C}_6\text{H}_5$
B	$\text{CH}_3\text{CH}_2-\text{OH} \quad + \quad \text{HOOC}-\text{C}_6\text{H}_5$
C	$\text{CH}_3\text{CH}_2\text{CH}_2-\text{OH} \quad + \quad \text{HOOC}-\text{C}_6\text{H}_5$
D	$\text{CH}_3\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{Cl} \quad + \quad \text{HO}-\text{C}_6\text{H}_5$

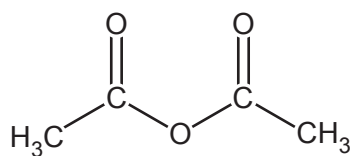
Your answer

[1]

37 3-Hydroxybutanoic acid reacts with ethanoic anhydride, $(\text{CH}_3\text{CO})_2\text{O}$.

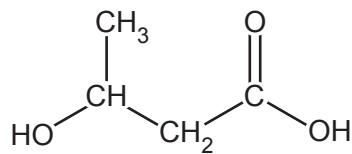
Complete the equation for this reaction.

Show the structures of the organic compounds.



Ethanoic anhydride

+



3-Hydroxybutanoic acid



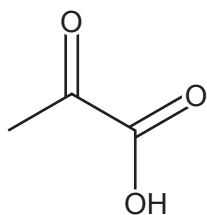
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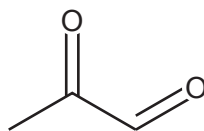
[2]

38 This question is about carbonyl compounds.

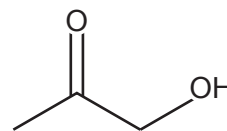
The three compounds below each contain a ketone and one other functional group.



Pyruvic acid



Methylglyoxal



Acetol

(a) What is a **functional group**?

.....
 [1]

(b) A chemical test is carried out which gives a positive result for **all three** compounds.

Suggest the reagent and observation of this chemical test.

Reagent

Observation [2]

(c) A student is provided with three unlabelled sample tubes, containing either pyruvic acid, methylglyoxal or acetol.

The student carries out three chemical tests on each sample.

Complete the table with the expected observations, including 'no change' where appropriate.

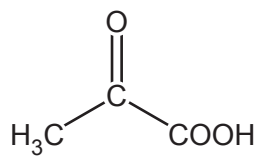
Chemical test	Expected observations		
	Pyruvic acid	Methylglyoxal	Acetol
Tollens' reagent			
$\text{Na}_2\text{CO}_3(\text{aq})$			
$\text{Cr}_2\text{O}_7^{2-}(\text{aq})/\text{H}^+(\text{aq})$			

[3]

(d) Pyruvic acid reacts with NaBH_4 .

Outline the mechanism for the reaction of pyruvic acid with NaBH_4 .

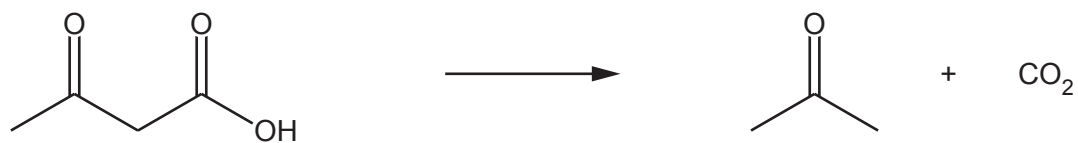
Include curly arrows and relevant dipoles.



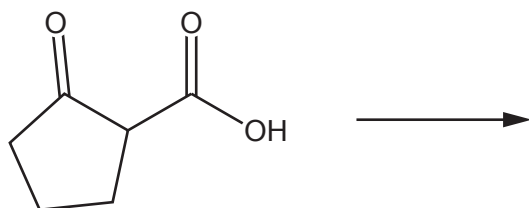
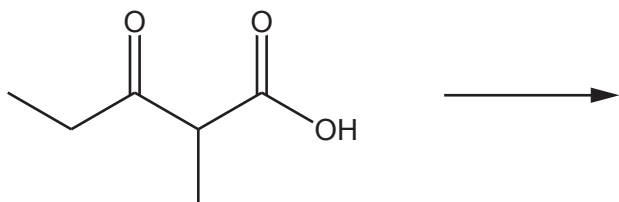
[4]

39 This part is about compounds called β -keto acids.

The equation shows the decomposition of a β -keto acid.



(i) Draw the structures of the organic products you would expect from the decomposition of the **two** other β -keto acids below.



[2]