

Carboxylic Acids & Derivatives

Question Paper 1

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Carboxylic Acids & Derivatives
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 1

Time Allowed: 71 minutes

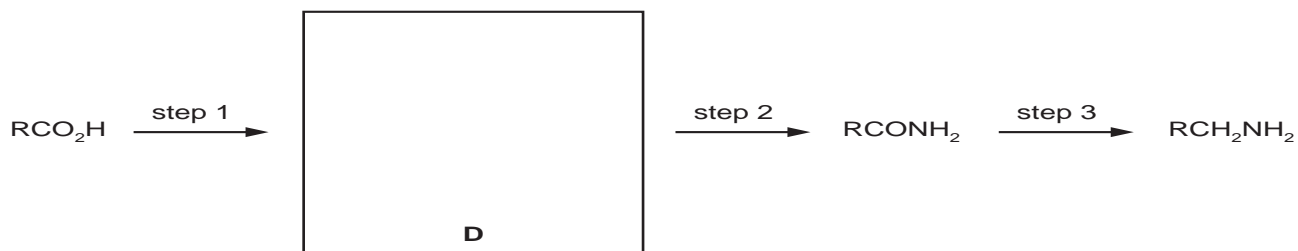
Score: /59

Percentage: /100

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

1 (a) Carboxylic acids can be converted into primary amines by the following sequence of reactions.



(i) Suggest the identity of intermediate **D** and write its structure in the box above. [1]

(ii) Suggest the reagents for

step 1

step 2

step 3

[2]

(b) Four compounds, **E**, **F**, **G** and **H**, are isomers of each other.

Each compound contains an aromatic ring and **two** functional groups from the following list.

- alcohol
- amide
- amine
- carboxylic acid
- ester
- phenol

(c) Which of these functional groups react readily with cold $\text{HCl}(\text{aq})$?

..... [1]

(ii) Which of these functional groups react readily with cold $\text{NaOH}(\text{aq})$?

..... [1]

The molecular formula of the four isomers, **E**, **F**, **G** and **H**, is $\text{C}_8\text{H}_9\text{NO}_2$. All four compounds are insoluble in water. **Table 1** shows their solubilities in acid or alkali.

compound	solubility in $\text{HCl}(\text{aq})$	solubility in $\text{NaOH}(\text{aq})$
E	insoluble	insoluble
F	soluble	soluble
G	soluble	insoluble
H	insoluble	soluble

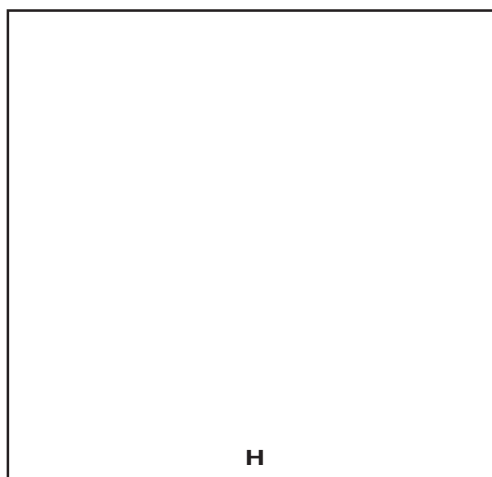
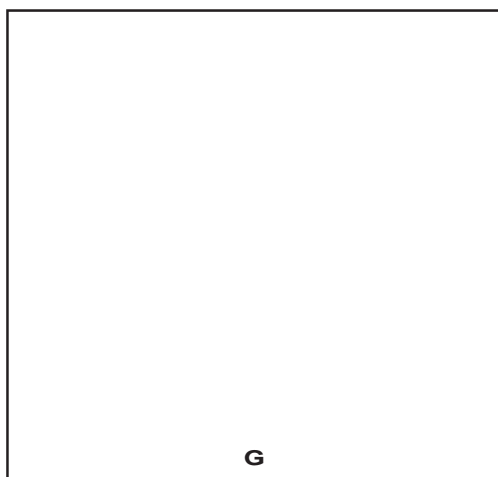
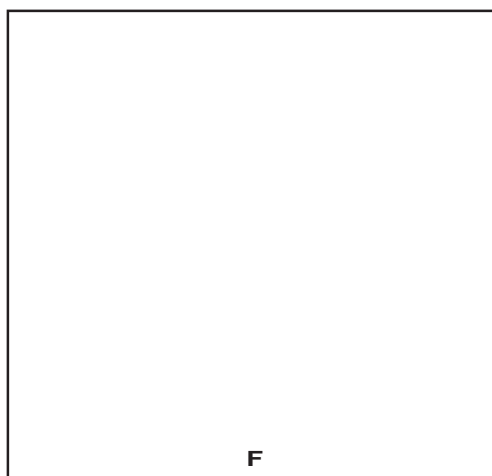
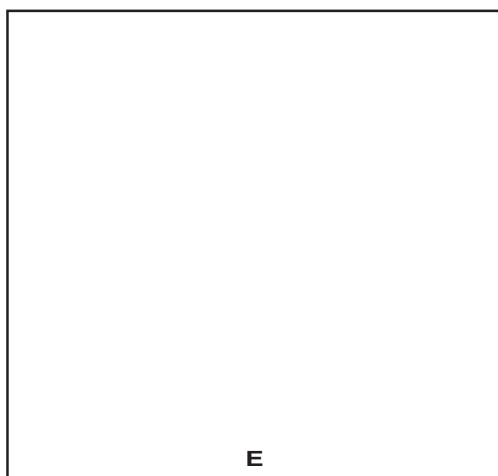
Table 1

- (iii) Use this information to suggest the **two** functional groups, taken from the list on page 10, that each compound contains.

compound	first functional group	second functional group
E		
F		
G		
H		

[4]

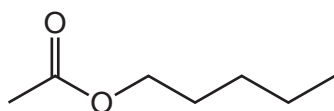
- (iv) Suggest a structure for each compound.



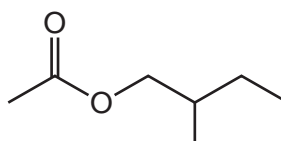
[4]

[Total: 13]

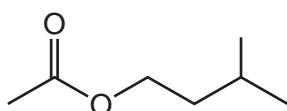
- 2 The following four isomeric esters with the molecular formula $C_7H_{14}O_2$ are used as artificial flavours in drinks and sweets to give a pear, banana or plum taste to foodstuffs.



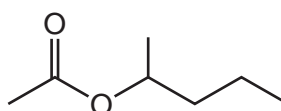
A



B



C



D

- (a) In each of the spaces below, write one or more of the letters **A-D**, as appropriate.

- (i) Which of these compounds can exist as optical isomers?

.....

- (ii) On hydrolysis, which of these compounds produce(s) a secondary alcohol?

.....

[3]

- (b) The hydrolysis of all these compounds produces ethanoic acid, CH_3CO_2H , as one of the products.

State the reagents and conditions needed for this hydrolysis.

..... [1]

(c) The acid dissociation constant, K_a , of ethanoic acid is $1.75 \times 10^{-5} \text{ mol dm}^{-3}$.

(i) Explain why this value of K_a is

- much larger than that of ethanol, $\text{CH}_3\text{CH}_2\text{OH}$,

.....
.....

- smaller than that of chloroethanoic acid, $\text{ClCH}_2\text{CO}_2\text{H}$.

.....
.....

(ii) Calculate the pH of a $0.100 \text{ mol dm}^{-3}$ solution of ethanoic acid.

[4]

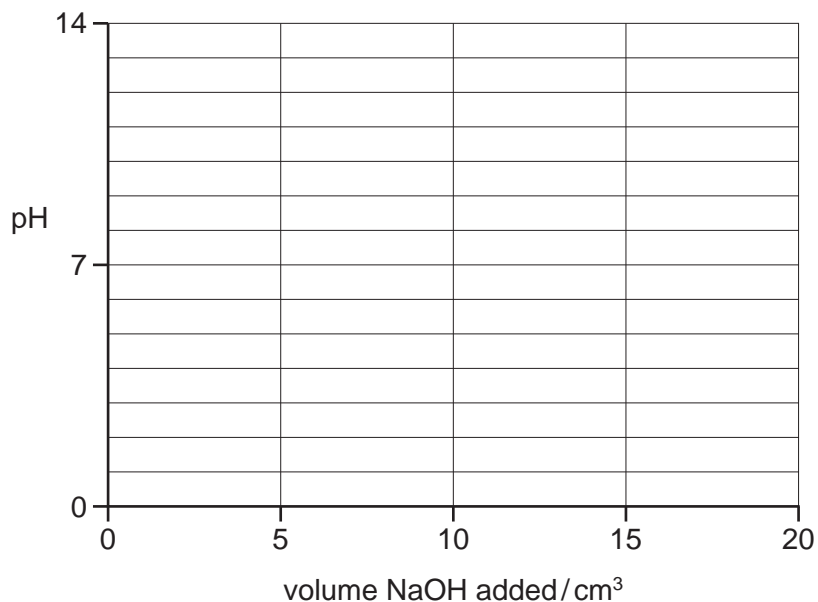
(d) 20.0 cm^3 of $0.100 \text{ mol dm}^{-3}$ NaOH were slowly added to a 10.0 cm^3 sample of $0.100 \text{ mol dm}^{-3}$ ethanoic acid, and the pH was measured throughout the addition.

(i) Calculate the number of moles of NaOH remaining at the end of the addition.

(ii) Calculate the $[\text{OH}^-]$ at the end of the addition.

(iii) Using the expression $K_w = [\text{H}^+][\text{OH}^-]$ and your value in (ii), calculate $[\text{H}^+]$ and the pH of the solution at the end of the addition.

- (iv) On the following axes, sketch how the pH will change during the addition of a total of 20.0 cm^3 of $0.100 \text{ mol dm}^{-3}$ NaOH. Mark clearly where the end point occurs.



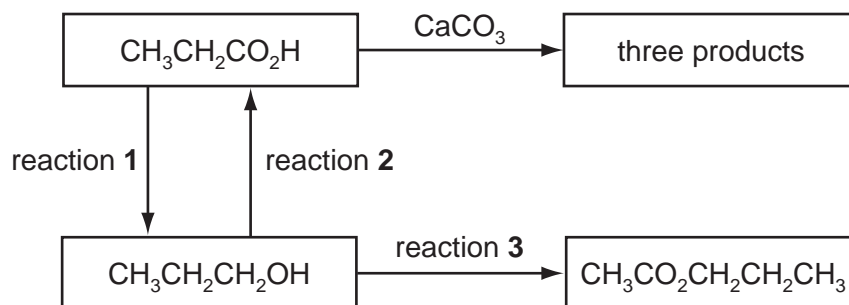
- (v) From the following list of indicators, put a tick in the box by the side of the indicator you consider most suitable for this titration.

indicator	pH at which colour changes	place one tick only in this column
malachite green	0 - 1	
thymol blue	1 - 2	
bromophenol blue	3 - 4	
thymolphthalein	9 - 10	

[7]

[Total: 15]

3 A series of reactions based on propanoic acid is shown.



(a) Write an equation for reaction 1, using [H] to represent the reducing agent.

..... [2]

(b) What type of reaction is reaction 2?

..... [1]

(ii) Suggest a suitable reagent and conditions for reaction 2.

..... [2]

(c) Write an equation for the reaction of propanoic acid with calcium carbonate, CaCO₃.

..... [2]

(d) (i) Suggest a suitable reagent and conditions for reaction 3.

.....
 [2]

(ii) Identify the **other** product of reaction 3.

..... [1]

[Total: 10]

- 4 A student reacted together an alcohol and a carboxylic acid under appropriate conditions to produce an ester.

A sweet smelling organic liquid, **Q**, with the empirical formula C_2H_4O was produced.

The M_r of **Q** was found by experiment to be 87.5.

- (a) What is the molecular formula of **Q**?

..... [1]

- (b) In the boxes below, draw the structural formulae of **four** isomers with this formula that are esters.

W	X
Y	Z

[4]

A sample of **Q** was hydrolysed by heating with aqueous sulfuric acid.
The resulting mixture was heated under reflux with acidified potassium dichromate(VI) to give a **single** organic product, **R**.
The product, **R**, was collected and subjected to the following tests.

A sample of **R** gave no reaction with Tollens' reagent.

A second sample of **R** gave no reaction with 2,4-dinitrophenylhydrazine reagent.

A third sample of **R** gave an effervescence with sodium carbonate.

(c) (i) What does the result of the test with Tollens' reagent show about **R**?

.....

(ii) What does the result of the test with 2,4-dinitrophenylhydrazine reagent show about **R**?

.....

(iii) What functional group does the result of the test with sodium carbonate show to be present in **R**?

.....

[3]

(d) (i) What is the identity of the single organic compound, **R**?

.....

(ii) Which of your structures, **W**, **X**, **Y** or **Z**, represents the ester, **Q**?

.....

[2]

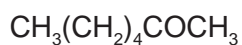
(e) Which, if any, of your esters, **W**, **X**, **Y** or **Z**, is chiral?

.....

..... [1]

[Total: 11]

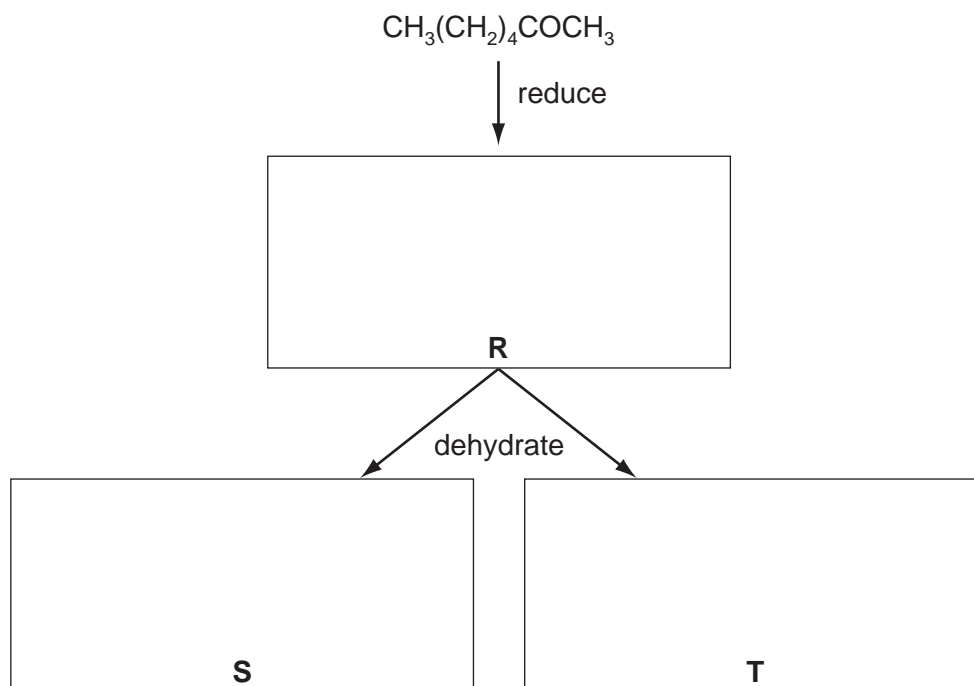
- 5 Compound **Q**, heptan-2-one, is found in some blue cheeses.



compound **Q**

- (a) Compound **Q** may be reduced to **R**.
Compound **R** may be dehydrated to give two different products, **S** and **T**.

- (i) In the boxes below, draw the **structural formulae** of **R**, **S**, and **T**.



- (ii) State the reagents that would be used for **each** of these reactions in a school or college laboratory.

reduction

dehydration

[5]

- (b) In the boxes below, write the **structural formula** of the organic compound formed when **Q** is reacted separately with each reagent under suitable conditions. If you think no reaction occurs, write 'NO REACTION' in the box.

Tollens' reagent	
HCN	
$K_2Cr_2O_7/H^+$	

[3]

- (c) The first stage of cheese making is to produce 2-hydroxypropanoic acid (lactic acid) from milk.



lactic acid

Other than the use of a pH indicator, what reagent could you use to confirm the presence of some lactic acid in a sample of heptan-2-one?
State what observation you would make.

reagent

observation [2]

[Total: 10]