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**

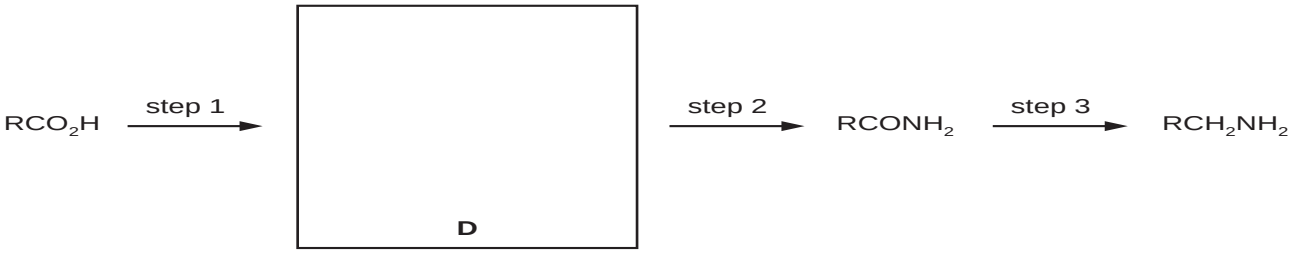
Score: **/59**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	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 HC*l*(aq)?

..... [1]

(ii) Which of these functional groups react readily with cold NaOH(aq)?

..... [1]

The molecular formula of the four isomers, **E**, **F**, **G** and **H**, is $C_8H_9NO_2$. All four compounds are insoluble in water. **Table 1** shows their solubilities in acid or alkali.

compound	solubility in HC*l*(aq)	solubility in NaOH(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.

E

F

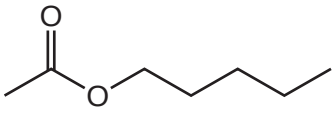
G

H

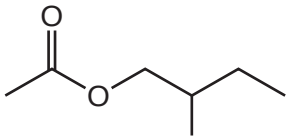
[4]

[Total: 13]

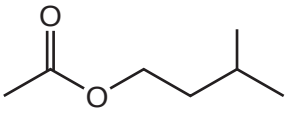
2 The following four isomeric esters with the molecular formula $C_7H_{14}O_2$ are used as artificial flavours in drinks and sweets to give a pear, banana or plum taste to foodstuffs.



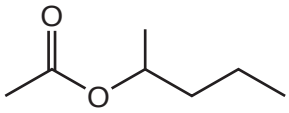
A



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 1.75×10^{-5} mol dm^{-3}.

(i) Explain why this value of K_a is

- much larger than that of ethanol, CH_3CH_2OH,

.....

.....

- smaller than that of chloroethanoic acid, $Cl CH_2CO_2H$.

.....

.....

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

[4]

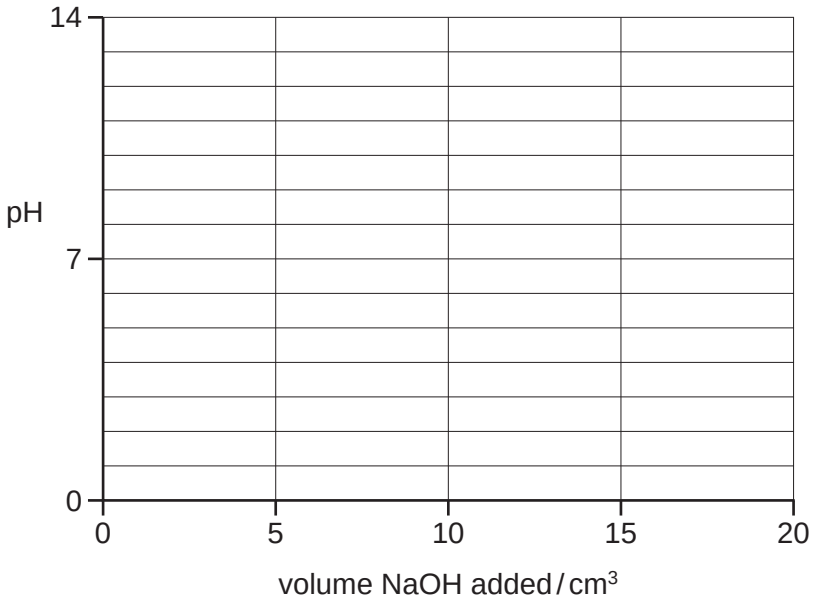
(d) 20.0 cm^3 of 0.100 mol dm^{-3} NaOH were slowly added to a 10.0 cm^3 sample of 0.100 mol dm^{-3} ethanoic acid, and the pH was measured throughout the addition.

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

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

(iii) Using the expression $K_w = [H^+][OH^-]$ and your value in **(ii)**, calculate $[H^+]$ 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 mol dm^{-3} NaOH. Mark clearly where the end point occurs.



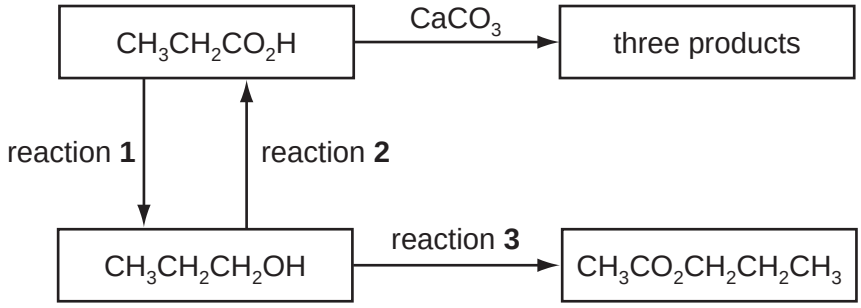
(v) From the following list of indicators, put a tick in the box by the side of the indicator you consider most suitable for this titration.

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, $CaCO_3$.

..... [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]

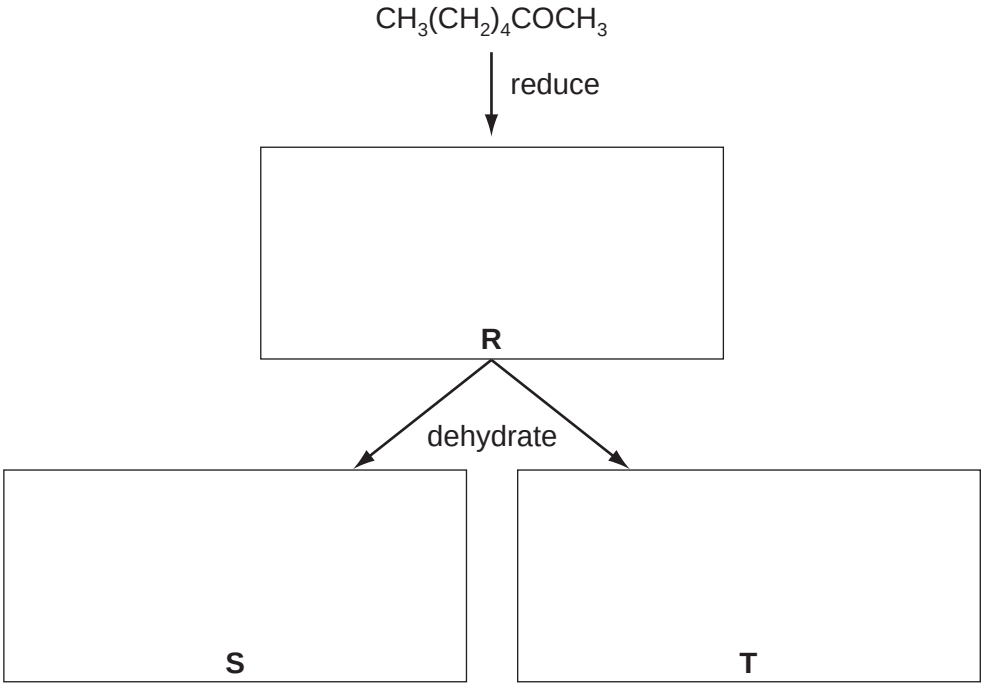
5 Compound **Q**, heptan-2-one, is found in some blue cheeses.

$CH_3(CH_2)_4COCH_3$

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.

$CH_3CH(OH)CO_2H$

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]