Carboxylic Acids & Derivatives

Question Paper 2

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Carboxylic Acids & Derivatives
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 2

Time Allowed:	**71 minutes**
Score:	**/59**
Percentage:	**/100**

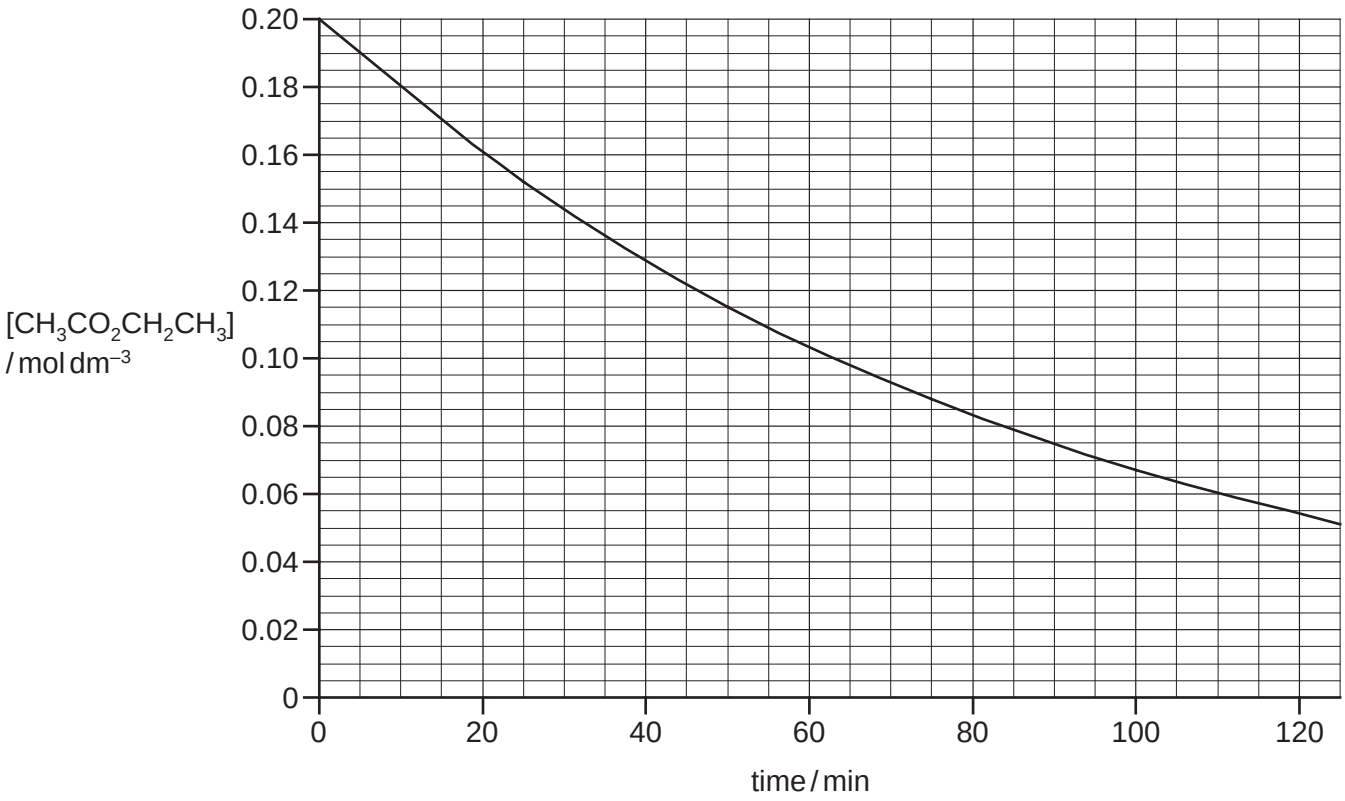
Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 Ethyl ethanoate is hydrolysed slowly by water in the following acid-catalysed reaction.

$$CH_3CO_2CH_2CH_3 + H_2O \xrightarrow{H^+} CH_3CO_2H + CH_3CH_2OH$$

The concentration of ethyl ethanoate was determined at regular time intervals as the reaction progressed.
Two separate experiments were carried out, with different HC*l* concentrations.
The following graph shows the results of an experiment using [HC*l*] = 0.1 mol dm^{-3}.



(a) When the experiment was carried out using [HC*l*] = 0.2 mol dm^{-3}, the following results were obtained.

time / min	$[CH_3CO_2CH_2CH_3]$ / mol dm^{-3}
0	0.200
10	0.160
25	0.115
50	0.067
75	0.038
100	0.022
125	0.013

(i) Plot these data on the axes above, and draw a line of best fit.

(ii) Use one of the graphs to show that the reaction is first order with respect to $CH_3CO_2CH_2CH_3$.

Show all your working, and show clearly any construction lines you draw on the graphs.

(iii) Use the graphs to calculate the order of reaction with respect to HC*l*.

Show all your working, and show clearly any construction lines you draw on the graphs.

(iv) Write the rate equation for this reaction, and calculate the value of the rate constant.

rate =

[7]

(b) **(i)** Why is it **not** possible to determine the order of reaction with respect to water in this experiment?

.....

.....

(ii) Although [$CH_3CO_2CH_2CH_3$] decreases during each experiment, [HC*l*] remains the same as its initial value.

Why is this?

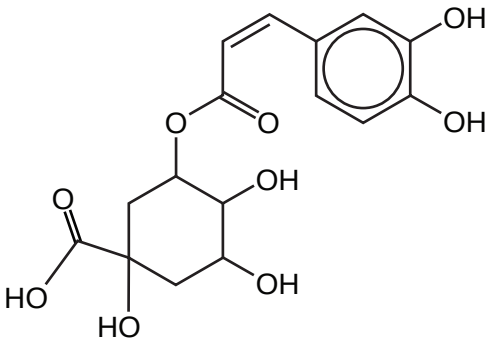
.....

.....

[2]

[Total: 9]

2 Coffee beans contain chlorogenic acid.



chlorogenic acid

(a) Draw circles around any chiral centres in the above structure.

(ii) Write down the molecular formula of chlorogenic acid.

.....

(iii) How many moles of $H_2(g)$ will be evolved when 1 mol of chlorogenic acid reacts with an excess of sodium metal?

.....

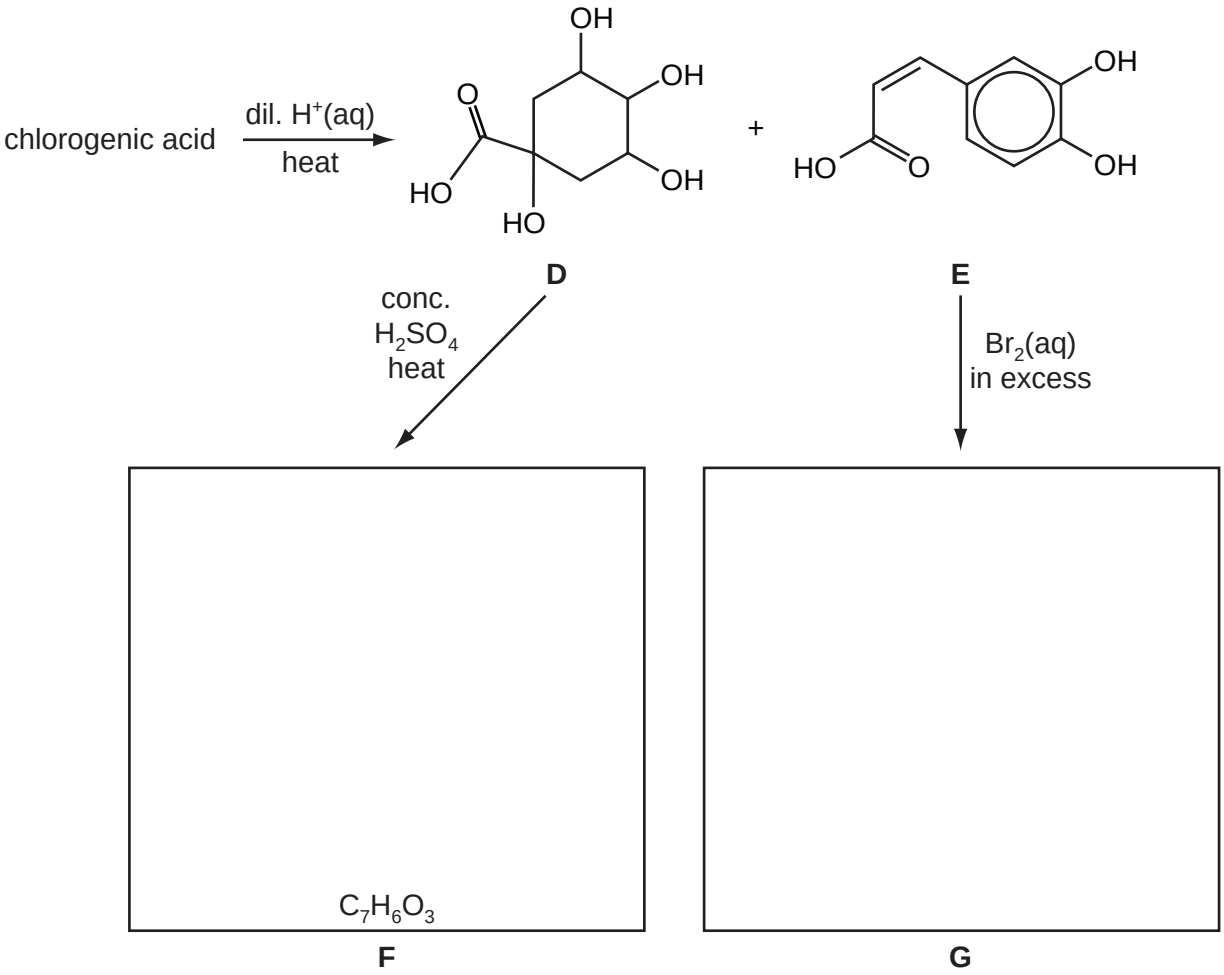
(iv) How many moles of NaOH(aq) will react with 1 mol of chlorogenic acid under each of the following conditions?

in the cold .....

on heating .....

[6]

(b) On heating with dilute aqueous acid, chlorogenic acid produces two compounds, **D** and **E**.



(i) What *type of reaction* is chlorogenic acid undergoing when **D** and **E** are formed?

.....

When compound **D** is heated with concentrated H_2SO_4, compound **F**, $C_7H_6O_3$, is formed.

Compound **F** evolves $CO_2(g)$ when treated with $Na_2CO_3(aq)$, and decolourises $Br_2(aq)$, giving a white precipitate. It does not, however, decolourise cold dilute acidified $KMnO_4$.

When compound **E** is treated with an excess of $Br_2(aq)$, compound **G** is produced.

(ii) If the test with cold dilute acidified $KMnO_4$ had been positive, which functional group would this have shown to be present in **F**?

.....

(iii) **Name** the functional groups in compound **F** that would react with the following.

$Na_2CO_3(aq)$ ..... $Br_2(aq)$ .....

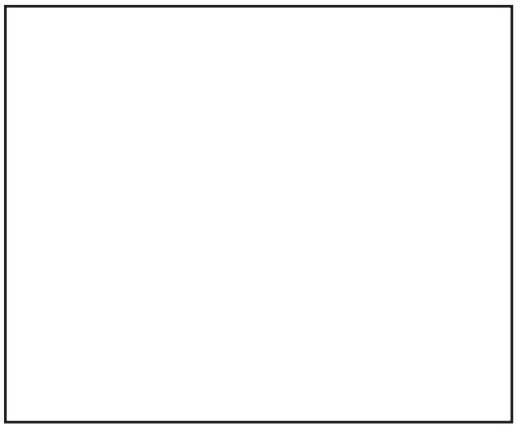
(iv) Suggest structures for compounds **F** and **G** and draw them in the relevant boxes above.

(v) Compound **E** is one of a pair of stereoisomers.

What type of stereoisomerism is shown by compound **E**?

.....

(vi) Draw the structure of the other stereoisomer in the box below.



[8]

(c) Calculate the volume of 0.1 mol dm^{-3} NaOH that is needed to react completely with 0.1 g of compound **E**.

volume = ... cm^3

[3]

[Total: 17]

3 Compound **R** is a weak diprotic (dibasic) acid which is very soluble in water.

(a) A solution of **R** was prepared which contained 1.25 g of **R** in 250 cm^3 of solution. When 25.0 cm^3 of this solution was titrated with 0.100 mol dm^{-3} NaOH, 21.6 cm^3 of the alkali were needed for complete reaction.

(i) Using the formula H_2X to represent **R**, construct a balanced equation for the reaction between H_2X and NaOH.

.....

(ii) Use the data above to calculate the amount, in moles, of OH^- ions used in the titration.

(iii) Use your answers to **(i)** and **(ii)** to calculate the amount, in moles, of **R** present in 25.0 cm^3 of solution.

(iv) Calculate the amount, in moles, of **R** present in 250 cm^3 of solution.

(v) Calculate M_r of **R**.

[5]

(b) Three possible structures for **R** are shown below.

S	**T**	**U**
$HO_2CCH{=}CHCO_2H$	$HO_2CCH(OH)CH_2CO_2H$	$HO_2CCH(OH)CH(OH)CO_2H$

(i) Calculate the M_r of each of these acids.

M_r of **S** = ... M_r of **T** = ... M_r of **U** = ...

(ii) Deduce which of the structures, **S**, **T** or **U**, correctly represents the structure of the acid, **R**.

R is represented by .....

[2]

It is possible to convert **S**, **T**, or **U** into one another.

(c) State the reagent(s) and essential conditions that would be used for the following conversions.

S into **T**

.....

S into **U**

.....

T into **S**

..... [5]

(d) Give the structural formula of the organic product formed in **each** of the following reactions.

T reacting with an excess of Na

U reacting with an excess of Na_2CO_3

[2]

(e) The acid **S** shows stereoisomerism. Draw structures to show this isomerism.
Label each isomer.

[2]

(f) When one of the isomers of **S** is heated at 110 °C in the absence of air, a cyclic compound **V**, with molecular formula $C_4H_2O_3$, is formed.
The other isomer of **S** does not react at this temperature.

Suggest the displayed formula of **V**.

[2]

[Total: 18]

4 Compound **Q** is a viscous liquid which is very soluble in water.
The M_r of **Q** is 90.0.

Three possible structures for **Q** are shown below.

R	**S**	**T**
$HOCH_2CH_2CO_2H$	$HOCH_2CO_2CH_3$	$HCO_2CH_2CH_2OH$

(a) (i) What type of isomerism do **R**, **S** and **T** show?

.....

(ii) What oxygen-containing functional groups are present in **R**, **S** and **T**?
Give their **full names**.

R ..... and .....

S ..... and .....

T ..... and .....

(iii) Which functional group(s) in **(ii)** will react with sodium carbonate?

.....

(iv) Which functional group(s) in **(ii)** will react with sodium metal?

.....

[6]

(b) When 0.002 mol of **Q** is reacted with an excess of solid sodium carbonate, Na_2CO_3, 24 cm^3 of carbon dioxide, measured at room temperature and pressure, is produced.

(i) Calculate the amount, in moles, of carbon dioxide produced in this reaction.

(ii) Hence calculate the amount, in moles, of carbon dioxide produced by 1 mol of **Q**.

[2]

When 0.002 mol of **Q** is reacted with an excess of metallic sodium, 48 cm^3 of hydrogen, measured at room temperature and pressure, is produced.

(c) (i) Calculate the amount, in moles, of hydrogen molecules produced in this reaction.

(ii) Hence calculate the amount, in moles, of hydrogen molecules produced by 1 mol of **Q**.

[2]

(d) Use your answers to **(b)** and **(c)** to deduce which structure, **R**, **S** or **T**, corresponds to the structure of **Q** and write balanced equations for the reactions that occurred.

identity of **Q** is .....

equation for reaction with sodium carbonate

.....

equation for reaction with sodium metal

..... [5]

[Total: 15]