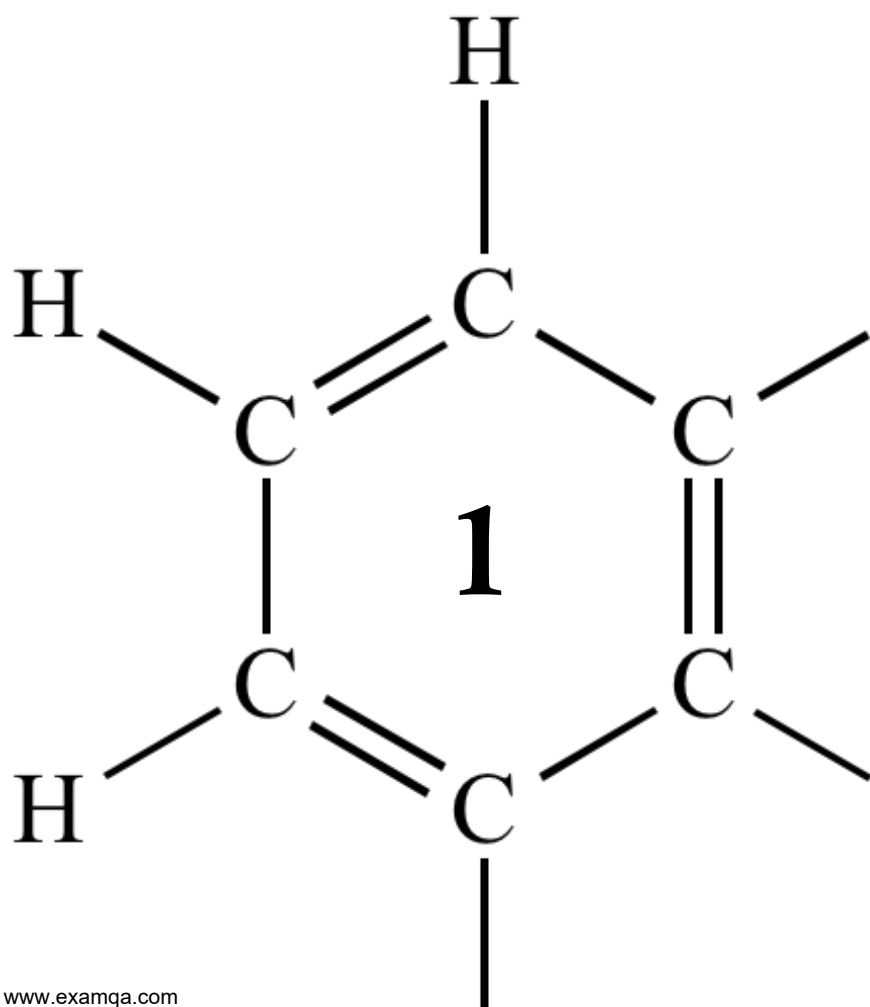


AQA A2 CHEMISTRY

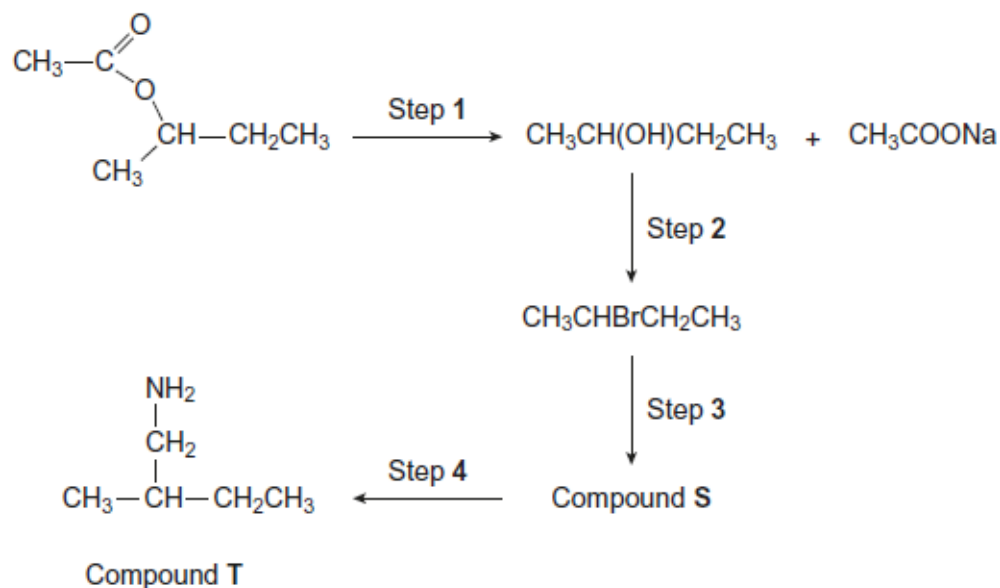
ISOMERISM ~ CARBONYLS

CARBOXYLIC ACIDS + ESTERS



1

A four-step synthesis of compound **T** is shown.



- (a) Give the reagent and conditions for Step 1.
State how you could obtain a sample of the alcohol from the reaction mixture formed in Step 1.

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(3)

- (b) Draw the structure of compound **S**.
For each of Steps 3 and 4, give a reagent and one condition, other than heat.

(5)

(Total 8 marks)

2

Esters are used as raw materials in the production of soaps and biodiesel.

(a) A student prepared an ester by two different methods.

Method 1 alcohol + acid anhydride

Method 2 alcohol + acyl chloride

(i) An ester was prepared using method 1, by reacting $(\text{CH}_3)_2\text{CHOH}$ with $(\text{CH}_3\text{CO})_2\text{O}$

Write an equation for this reaction and give the IUPAC name of the ester formed.

Equation

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IUPAC name of the ester

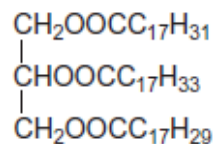
(2)

(ii) The same ester was prepared using method 2 by reacting $(\text{CH}_3)_2\text{CHOH}$ with CH_3COCl

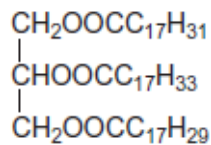
Outline a mechanism for this reaction.

(4)

- (b) The ester shown occurs in vegetable oils.
It can be hydrolysed to make soap and can also be used to produce biodiesel.



- (i) Write an equation for the reaction of this ester with sodium hydroxide to form soap.



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(2)

- (ii) Give the formula of the biodiesel molecule with the highest M_r that can be produced by reaction of this ester with methanol.

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(1)

(Total 9 marks)

- (c) Draw the structure of each of the following isomers of $C_5H_8O_2$
Label each structure you draw with the correct letter **L**, **M**, **N**, **P** or **Q**.

L is methyl 2-methylpropenoate.

M is an ester that shows E-Z stereoisomerism.

N is a carboxylic acid with a branched carbon chain and does **not** show stereoisomerism.

P is an optically active carboxylic acid.

Q is a cyclic compound that contains a ketone group and has only two peaks in its 1H n.m.r. spectrum.

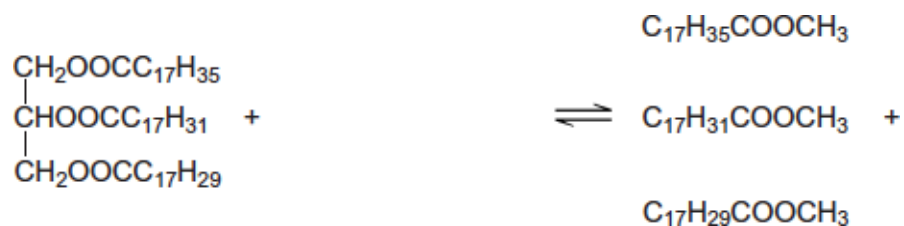
(5)
(Total 19 marks)

4

Esters are produced by the reaction of alcohols with other esters and by the reaction of alcohols with carboxylic acids.

- (a) The esters which make up biodiesel are produced industrially from the esters in vegetable oils.

- (i) Complete the equation for this formation of biodiesel.

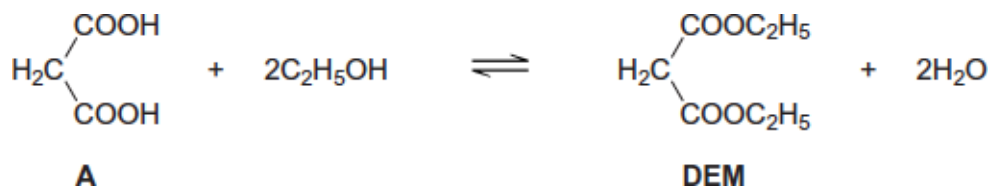


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(2)

- (ii) Write an equation for the complete combustion of $\text{C}_{17}\text{H}_{35}\text{COOCH}_3$.

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(2)

- (b) The ester commonly known as diethyl malonate (**DEM**) occurs in strawberries and grapes. It can be prepared from acid **A** according to the following equilibrium.



- (i) A mixture of 2.50 mol of **A** and 10.0 mol of ethanol was left to reach equilibrium in an inert solvent in the presence of a small amount of concentrated sulfuric acid. The equilibrium mixture formed contained 1.80 mol of **DEM** in a total volume, $V \text{ dm}^3$, of solution.

Calculate the amount (in moles) of **A**, of ethanol and of water in this equilibrium mixture.

Moles of **A**

Moles of ethanol

Moles of water.....

(3)

- (ii) The total volume of the mixture in part (b)(i) was doubled by the addition of more of the inert solvent.

State and explain the effect of this addition on the equilibrium yield of **DEM**.

Effect

Explanation

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(2)

- (iii) Using **A** to represent the acid and **DEM** to represent the ester, write an expression for the equilibrium constant K_c for the reaction.

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(1)

- (iv) In a second experiment, the equilibrium mixture was found to contain 0.85 mol of **A**, 7.2 mol of ethanol, 2.1 mol of **DEM** and 3.4 mol of water.

Calculate a value of K_c for the reaction and deduce its units.

Calculation.....

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Units.....

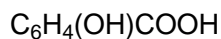
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(3)
(Total 13 marks)

5

Salicylic acid, $C_6H_4(OH)COOH$, reacts with magnesium to produce magnesium salicylate and hydrogen.

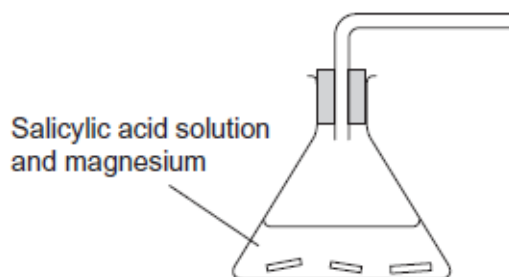
- (a) Complete the equation for this reaction.



(1)

- (b) In an alternative method for determining percentage purity, a student reacted a solution of salicylic acid with an excess of magnesium and collected the hydrogen gas that was released.

Complete the diagram below to show an apparatus that could be used to collect and measure the volume of hydrogen gas produced.



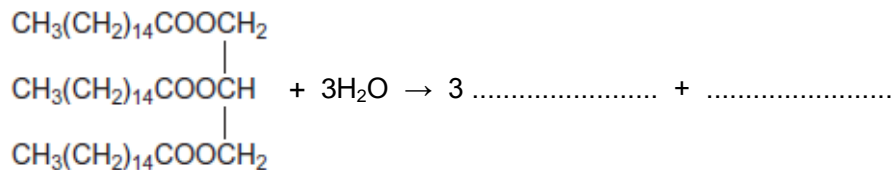
(1)
(Total 2 marks)

6

The slowing down of chemical processes is important in food storage. Over time, fats may become rancid. This involves the formation of compounds that have unpleasant odours and flavours within the food.

Hydrolysis of fats is one way in which rancid flavours are formed. Fats break down to long-chain carboxylic (fatty) acids and glycerol.

- (a) Complete the right-hand side of the equation below to show how hydrolysis affects the molecule of fat shown.



(2)

- (b) Other than by cooling, suggest **one** method that would decrease the rate of hydrolysis of fats.

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(1)

- (c) Food can also acquire unpleasant flavours when the fatty acids, produced by hydrolysis of fats, are oxidised by air. This oxidation occurs by a free-radical mechanism. Chemicals called anti-oxidants can be added to food to slow down the oxidation. Suggest why anti-oxidants are **not** regarded as catalysts.

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(2)

- (d) A student investigated the extent of hydrolysis in an old sample of the fat in part (a). The carboxylic acid extracted from a 2.78 g sample of this fat ($M_r = 806.0$) reacted with 24.5 cm^3 of a $0.150 \text{ mol dm}^{-3}$ solution of NaOH. Calculate the percentage of the fat that had hydrolysed. Show your working.

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(4)
(Total 9 marks)

7

The reactions of molecules containing the chlorine atom are often affected by other functional groups in the molecule.

Consider the reaction of $\text{CH}_3\text{CH}_2\text{COCl}$ and of $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$ with ammonia.

- (a) For the reaction of $\text{CH}_3\text{CH}_2\text{COCl}$ with ammonia, name and outline the mechanism and name the organic product.

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(Extra space)
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(6)

- (b) For the reaction of $\text{CH}_3\text{CH}_2\text{CH}_2\text{Cl}$ with an **excess** of ammonia, name and outline the mechanism and name the organic product.

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(6)

- (c) Suggest **one** reason why chlorobenzene (C_6H_5Cl) does **not** react with ammonia under normal conditions.

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(Extra space)

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(1)

(Total 13 marks)

8

- (a) Propanoic acid can be made from propan-1-ol by oxidation using acidified potassium dichromate(VI). Propanal is formed as an intermediate during this oxidation.

- (i) State the colour of the chromium species after the potassium dichromate(VI) has reacted.

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(1)

- (ii) Describe the experimental conditions and the practical method used to ensure that the acid is obtained in a high yield. Draw a diagram of the assembled apparatus you would use.

Conditions

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Apparatus

(4)

- (iii) Describe the different experimental conditions necessary to produce propanal in high yield rather than propanoic acid.

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(2)

- (b) Propan-1-ol is a volatile, flammable liquid.
Give **one** safety precaution that should be used during the reaction to minimise this hazard.

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(1)

- (c) A student followed the progress of the oxidation of propan-1-ol to propanoic acid by extracting the organic compounds from one sample of reaction mixture.

- (i) Give a chemical reagent which would enable the student to confirm the presence of propanal in the extracted compounds.
State what you would observe when propanal reacts with this reagent.

Reagent

Observation

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(2)

- (ii) Give a chemical reagent that would enable the student to confirm the presence of propanoic acid in the extracted compounds.
State what you would observe when propanoic acid reacts with this reagent.

Reagent

Observation

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(2)

- (d) Predict which **one** of the compounds, propan-1-ol, propanal and propanoic acid will have the highest boiling point. Explain your answer.

Prediction

Explanation

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(3)

(Total 15 marks)