Q1. 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 $(CH_3)_2CHOH$ with $(CH_3CO)_2O$

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

Equation

.....

IUPAC name of the ester .....

(2)

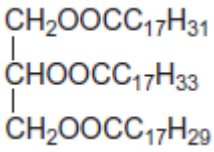
(ii) The same ester was prepared using method **2** by reacting $(CH_3)_2CHOH$ with CH_3COCl

Outline a mechanism for this reaction.

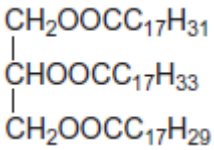
(4)

(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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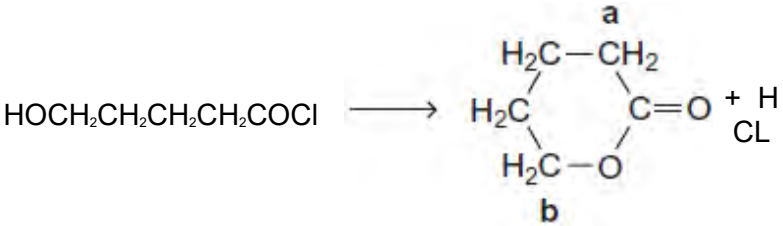
(1)

(Total 9 marks)

Q2. This question is about some isomers of $C_5H_8O_2$

(a) Compound **H** is a cyclic ester that can be prepared as shown.

On the structure of **H**, two of the carbon atoms are labelled.



H

(i) Name and outline a mechanism for this reaction.

Use **Table C** on the Data Sheet to give the ^{13}C n.m.r. δ value for the carbon atom labelled **a** and the δ value for the carbon atom labelled **b**.

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(7)

(ii) $HOCH_2CH_2CH_2CH_2COCl$ can also react to form a polyester in a mechanism similar to that in part (i).

Draw the repeating unit of the polyester and name the type of polymerisation involved.

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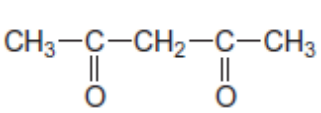
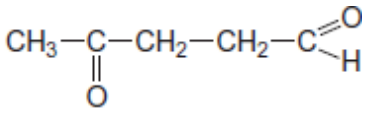
(2)

(b) State how you could distinguish between compounds **J** and **K** by a simple test-tube reaction.

State how you could distinguish between **J** and **K** by giving the number of peaks in the ^{1}H n.m.r. spectrum of each compound.



J



K

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(5)

(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.

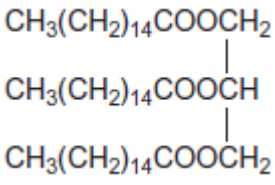
P is an optically active carboxylic acid.

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

(5)
(Total 19 marks)

Q3. 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.



$+ \ 3H_2O \rightarrow 3$ ..... $+$ .....

(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 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)

Q4. Salicylic acid, $C_6H_4(OH)COOH$, reacts with magnesium to produce magnesium salicylate and hydrogen.

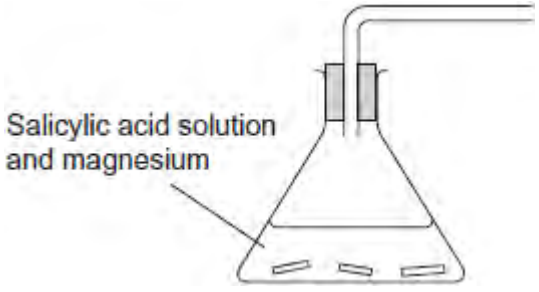
(a) Complete the equation for this reaction.

$C_6H_4(OH)COOH$

(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)

Q5. 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 $C_{17}H_{35}COOCH_3$.

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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.

A **DEM**

(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 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)