Aldehydes and Ketones

Question Paper 2

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Rates, Equilibria & Further Organic Chemistry
Sub Topic	Aldehydes and Ketones
Booklet	Question Paper 2

Time Allowed: **74 minutes**

Score: **/61**

Percentage: **/100**

Grade Boundaries:

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

1 Ethanoic acid, CH_3COOH, is a carboxylic acid with many uses, including as a food additive. It can be made by the reaction of butane with oxygen.

$$2CH_3CH_2CH_2CH_3(g) + 5O_2(g) \rightleftharpoons 4CH_3COOH(l) + 2H_2O(l)$$

(a) (i) Use the Data Booklet to complete the table below.

(3)

	$CH_3CH_2CH_2CH_3(g)$	$O_2(g)$	$CH_3COOH(l)$	$H_2O(l)$
$\Delta H_f^{\ominus}$ / kJ mol^{-1}		0		
$S^{\ominus}$ / J mol^{-1} K^{-1}		205		

(ii) Use data from your table to calculate the standard enthalpy change, in kJ mol^{-1}, for this reaction.

$$2CH_3CH_2CH_2CH_3(g) + 5O_2(g) \rightarrow 4CH_3COOH(l) + 2H_2O(l)$$

(2)

(iii) Use data from your table to calculate the standard entropy change of the system, in J mol^{-1} K^{-1}, for the same reaction.

$$2CH_3CH_2CH_2CH_3(g) + 5O_2(g) \rightarrow 4CH_3COOH(l) + 2H_2O(l)$$

(2)

(iv) Use your answer to (a)(ii) to calculate $\Delta S_{surroundings}$ and use this and your answer to (a)(iii) to calculate ΔS_{total} for the reaction at 298 K.

(3)

(v) It was suggested that **increasing** the temperature of the reaction to more than 298 K would produce a greater yield of ethanoic acid.

Explain, in terms of the effect on ΔS_{system}, $\Delta S_{surroundings}$ and hence ΔS_{total}, whether this would be the case.

(3)

(b) Infrared spectroscopy can be used to follow the progress of reactions.

Using information from the Data Booklet, suggest one way this technique could be used to follow the progress of the reaction in (a) to produce ethanoic acid.

(1)

(c) Ethanoic acid is the food additive E260. Suggest the role it may have when added to foodstuffs.

(1)

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(d) An organic compound, **Q**, is found to contain 52.5% carbon and 7.5% hydrogen by mass.

(i) Use these data to confirm its empirical formula is $C_7H_{12}O_4$.

(3)

(ii) Explain how the mass spectrum of **Q** could be used to confirm that its relative molecular mass is 160.

(1)

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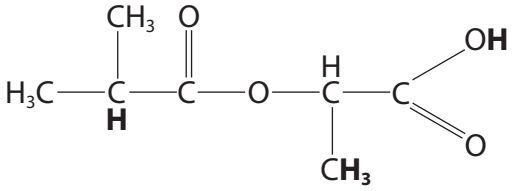
(iii) The table below summarises some information about parts of the nmr spectrum of compound **Q**.

Use the Data Booklet, and your knowledge of features in nmr spectra, to complete the table with respect to the features of compound **Q** shown in bold.

(4)



Feature of compound **Q**	Chemical shift / ppm for TMS	Splitting pattern	Relative area below peak
C**H**$_3$	0.1 – 1.9	doublet	
C**H**			1
COO**H**		singlet	1

(Total for Question 1 = 23 marks)

2 (a) Ethanoic acid and ethanol react together to form the ester ethyl ethanoate, $CH_3COOC_2H_5$, and water.

$$CH_3COOH(l) + CH_3CH_2OH(l) \rightleftharpoons CH_3COOCH_2CH_3(l) + H_2O(l) \qquad \Delta H = -3.5 \text{ kJ mol}^{-1}$$

(i) Give the expression for the equilibrium constant, K_c, for this reaction.

(1)

(ii) By considering the effect of temperature on the entropy change of the surroundings, suggest why changing the temperature has little effect on this equilibrium.

(3)

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*(iii) An experiment was carried out to determine the value of K_c for this reaction.

- 0.120 mol of ethanoic acid was added to 0.220 mol of ethanol.
- 5.00 cm^3 of 1.00 mol dm^{-3} hydrochloric acid was added as a catalyst. This contains 0.278 mol of water.
- The mixture was left to reach equilibrium.
- The mixture was titrated with 1.00 mol dm^{-3} sodium hydroxide, which reacted with **both** of the acids.
- The titre was 45.0 cm^3.

Use these data to determine the value for K_c.

(6)

(b) Ethanoic acid reacts with another alcohol, **Y**, to produce an ester **Z**.

(i) Alcohol **Y** has molar mass 74 g mol^{-1} and the following composition by mass:

carbon, C = 64.9%

hydrogen, H = 13.5%

oxygen, O = 21.6%.

Use all these data to confirm that the molecular formula for **Y** is $C_4H_{10}O$.
Show your working.

(2)

(ii) Draw the displayed formulae of the **four** possible structures of alcohol **Y**.

(2)

Alcohol 1	Alcohol 2
Alcohol 3	Alcohol 4

(iii) The mass spectrum of alcohol **Y** has a major peak at *m/e* = 45.
Suggest the structures of two species that could give this peak.

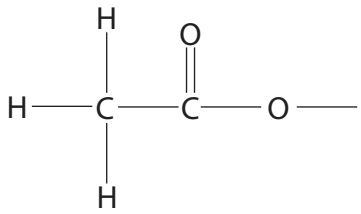
(2)

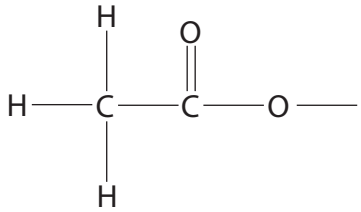
(iv) Use your answers to (b)(ii) and (b)(iii) to identify which two of the alcohols you have drawn in (b)(ii) could be alcohol **Y**.

(1)

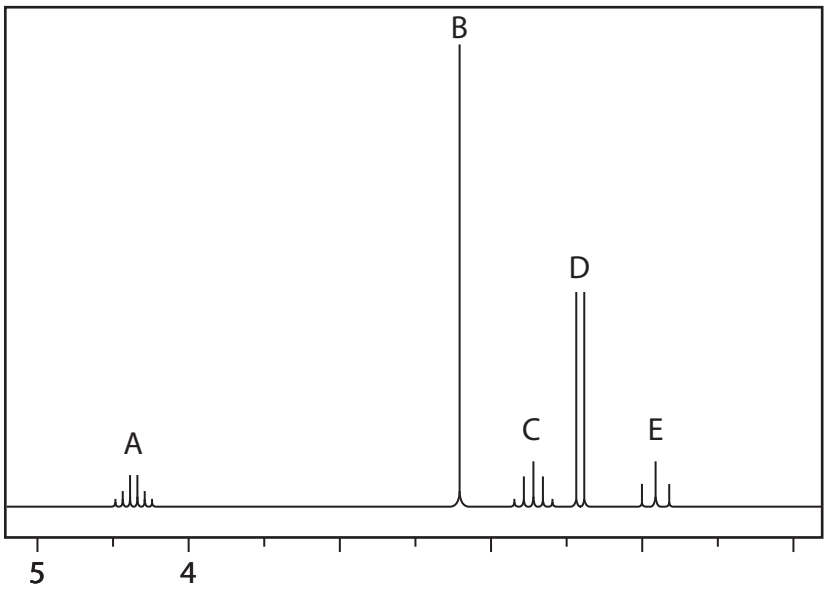
(v) Complete the displayed formulae for the two possible esters that could be **Z**.

(1)





*(vi) The high resolution proton nmr spectrum of ester **Z** is shown below.



The relative number of protons causing the peaks shown are:
A = 1, B = 3, C = 2, D = 3 and E = 3.

Use the nmr spectrum to determine the structural formula for ester **Z** that is consistent with this data.

Draw your formula below and on it label the protons responsible for the peaks A to E.

Explain the splitting patterns of the spectrum.

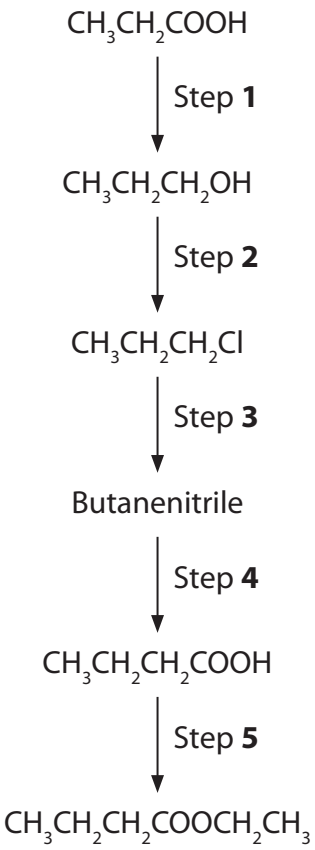
(5)

Structure

Explanation of splitting patterns

(Total for Question 2 = 23 marks)

3 This question is about the reaction scheme below which may be used to convert propanoic acid to ethyl butanoate in five steps.



(a) Give the structural formula for butanenitrile, showing any multiple bonds.

(1)

(b) Give the formula of the reagent needed for each of the Steps **1**, **2**, **4** and **5**. The reagent for Step **3** has been given.

Conditions and solvents are not required.

(4)

Step **1** .....

Step **2** .....

Step **3** KCN .....

Step **4** .....

Step **5** .....

(c) Write the equation for the neutralization of sodium carbonate by butanoic acid. State symbols are not required.

(2)

(d) State **two** differences between the **low** resolution proton nuclear magnetic resonance spectra of butan-1-ol and butanoic acid.

(2)

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(e) Give **two** differences between the infrared spectra of butan-1-ol and butanoic acid, mentioning any bonds involved with their wavenumber ranges.

(2)

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(f) Give the skeletal formula of ethyl butanoate, $CH_3CH_2CH_2COOCH_2CH_3$.

(1)

(g) Suggest the reagents required for a different, two-step method which could be used instead of the single step method you have given for Step **5** in part (b), to obtain ethyl butanoate from butanoic acid.

What is the advantage of using this alternative method?

(3)

Reagent for first step .....

Reagent for second step .....

Advantage .....

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(Total for Question 3 = 15 marks)