Carboxylic Acids and Derivatives

Question Paper

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Rates, Equilibria & Further Organic Chemistry
Sub Topic	Carboxylic Acids and Derivatives
Booklet	Question Paper

Time Allowed: **47 minutes**

Score: **/39**

Percentage: **/100**

Grade Boundaries:

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

1 Which type of radiation is used in nmr spectroscopy?

☒ **A** Infrared

☒ **B** Microwaves

☒ **C** Radio waves

☒ **D** Ultraviolet

(Total for Question 1 = 1 mark)

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2 This question is about low resolution proton nuclear magnetic resonance spectroscopy, NMR.

(a) NMR involves the interaction of hydrogen nuclei, ^{1}H, in the presence of a powerful magnetic field with

(1)

☒ **A** microwaves.

☒ **B** radio waves.

☒ **C** ultraviolet radiation.

☒ **D** X-rays.

(b) Which of the following has **two** peaks in its low resolution NMR spectrum?

(1)

☒ **A** Dichloromethane, CH_2Cl_2

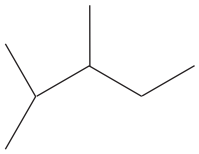
☒ **B** Ethane, CH_3CH_3

☒ **C** Methanal, HCHO

☒ **D** Methanol, CH_3OH

(c) NMR spectra depend on the number of different hydrogen environments in a molecule.

How many different hydrogen environments are there in a molecule of 2,3-dimethylpentane, the skeletal formula of which is shown below?



(1)

☒ **A** Seven

☒ **B** Six

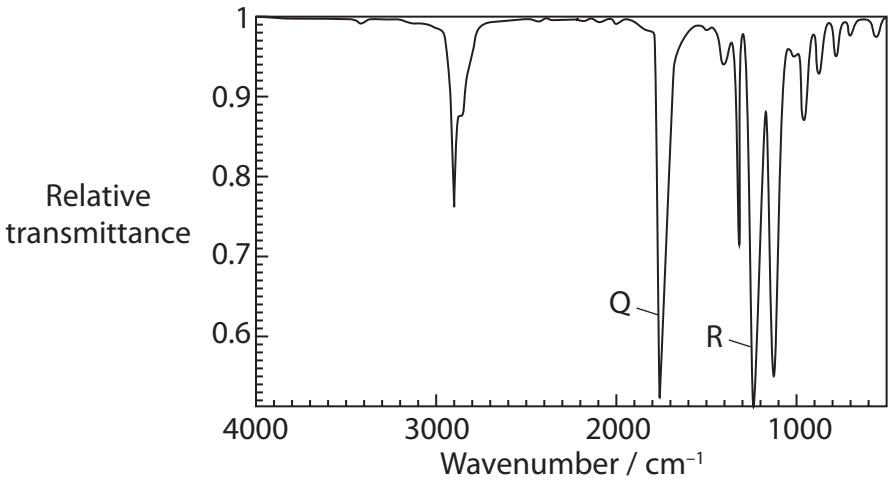
☒ **C** Five

☒ **D** Four

(Total for Question 2 = 3 marks)

3 An organic compound, **X**, has the molecular formula $C_6H_{12}O_2$ and contains **one** functional group.

(a) The infrared spectrum of **X** is shown below.



Identify the **bonds** responsible for the peaks labelled Q and R in the spectrum by referring to your Data Booklet. Hence deduce the functional group present in **X**.

(2)

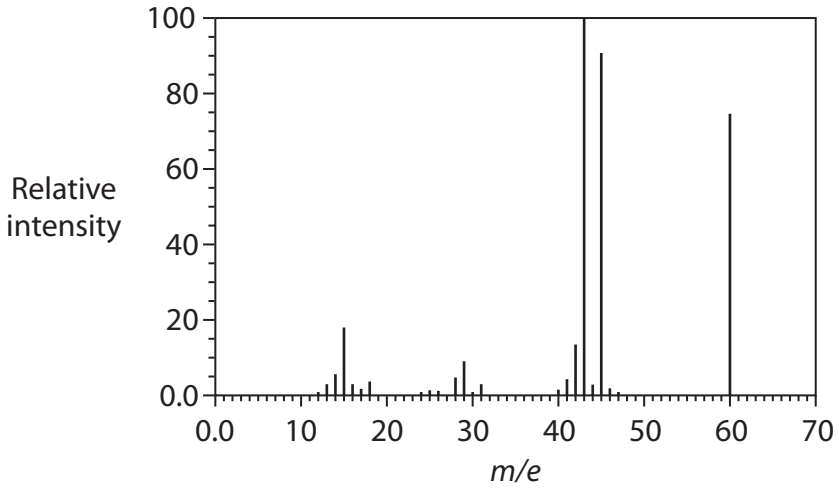
Q .....

R .....

Functional Group .....

(b) When **X** is heated under reflux with dilute sulfuric acid, two organic products, **Y** and **Z**, are formed.

The mass spectrum of **Y** is shown below.



(i) **Y** reacts with sodium carbonate solution producing carbon dioxide.
Use this information, together with the mass spectrum, to identify **Y**.

Explain your reasoning.

(3)

(ii) **Z** has molecular formula $C_4H_{10}O$. **Z** reacts with sodium, producing a gas. When **Z** is warmed with a mixture of potassium dichromate(VI) and sulfuric acid, no reaction occurs.

Deduce the structural formula of **Z**. Explain your reasoning and give the equation for the reaction with sodium producing a gas.

(3)

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Equation for reaction of **Z** with sodium:

(iii) Use your answers to part (a), part (b)(i) and (b)(ii) to deduce the **displayed** formula of **X**.

(1)

(iv) Evidence for the structure of **X** comes from its proton nmr spectra.

Use the formula you have deduced in (b)(iii) to predict the number of peaks and their relative areas in the **low** resolution nmr spectrum of **X**.

State the splitting pattern of each peak in the **high** resolution nmr spectrum.

Justify your answers.

(3)

(Total for Question 3 = 12 marks)

4 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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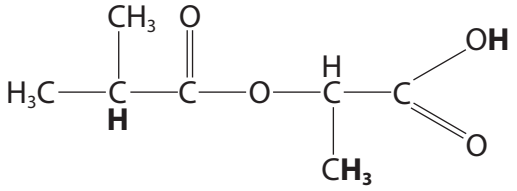
.....

(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 4 = 23 marks)