# Structural Analysis (combined techniques) AS & A Level

## Question Paper 3

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|---|---|
| Level | A Level |
| Subject | Chemistry |
| Exam Board | OCR |
| Module | |
| Topic | Structural Analysis ( combined techniques) |
| Paper | AS & A Level |
| Booklet | Question Paper 3 |

**Time allowed:** **63 minutes**

**Score:** **/47**

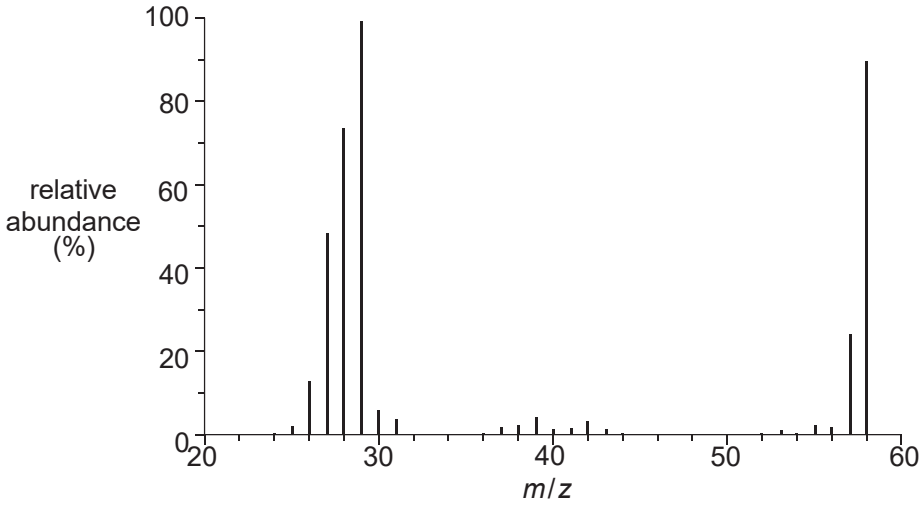
**Percentage:** **/100**

**Grade Boundaries:**

| A* | A | B | C | D | E |
|---|---|---|---|---|---|
| >85% | 73% | 60% | 47% | 34% | 21% |

Mass spectrometry and infrared spectroscopy are used in analysis.

(a) The mass spectrum of compound **Z** is shown below.




Compound **Z** has the molecular formula $C_3H_6O_x$.

(i) Using the mass spectrum, deduce the value of $x$ in $C_3H_6O_x$.

Explain your answer. [2]

(ii) Suggest a possible structure for **Z**. [1]

(iii) Suggest the formula of an ion that gives rise to the peak at $m/z$ = 29 in this spectrum. [1]

(b) A space probe has detected the presence of the element iron on the surface of the planet Mars.

Outline how a mass spectrum would show the presence of iron. [1]

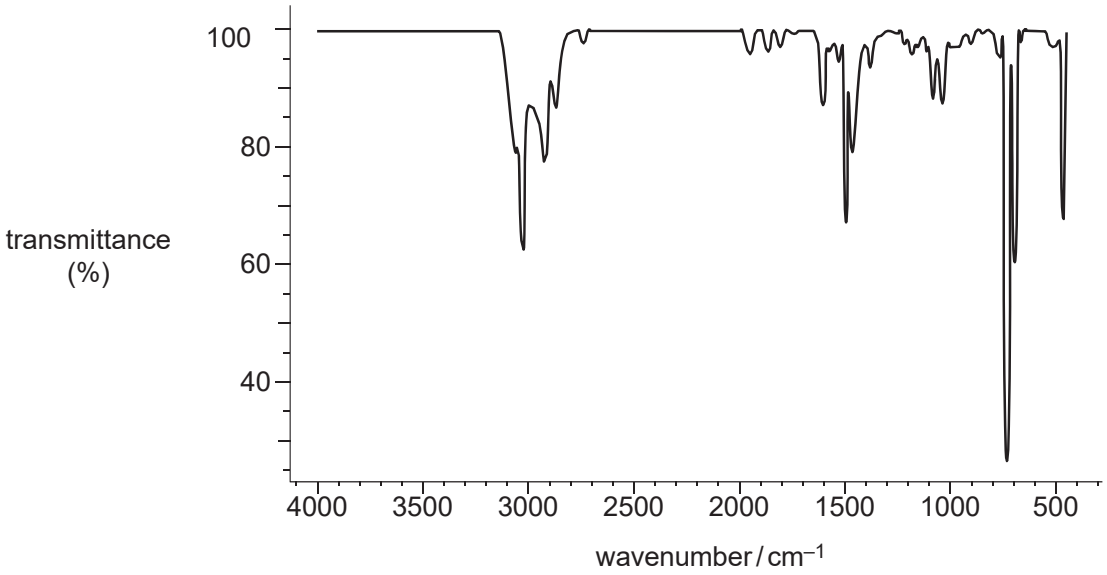
(c) The space probe also detected different isotopes of sulfur on Mars.

(i) Outline how the mass spectrum would show how many different isotopes of sulfur were present on Mars. [1]

(ii) The relative atomic mass of the sulfur found by the space probe was different from the relative atomic mass of sulfur on Earth.

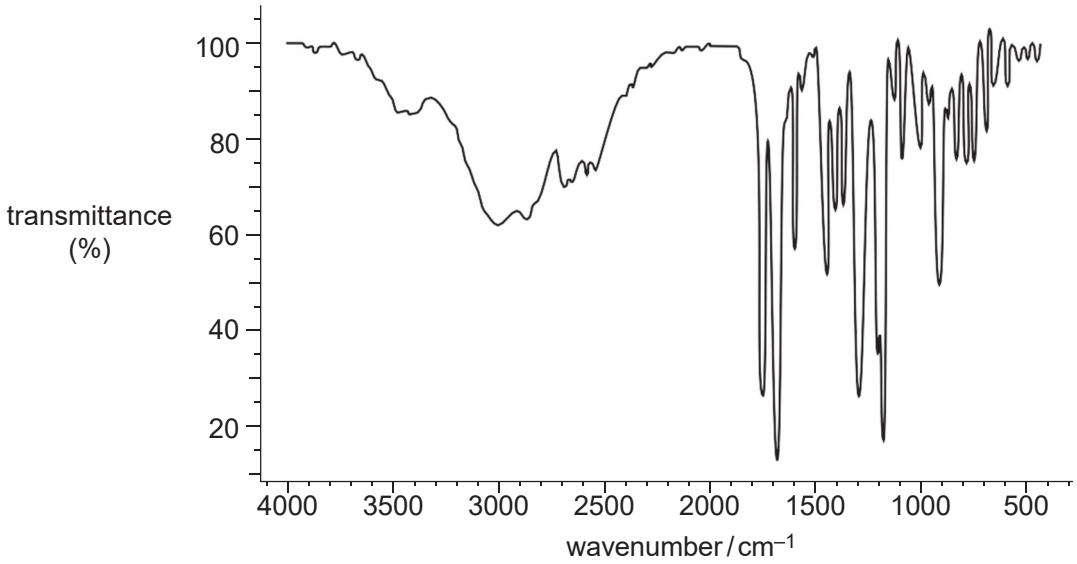
Suggest why. [1]

(d) An environmental chemist used infrared spectroscopy to monitor air pollution outside a petrol station. The infrared spectrum below was obtained from one of these pollutants.




What evidence is there in the spectrum that the pollutant may be a hydrocarbon rather than an alcohol or a carbonyl compound? [1]

(e) The infrared spectrum of a drug is shown below.




Suggest, with reasons, possible functional group(s) present in the drug. [2]

**[Total: 10 Marks]**

An industrial chemist discovered five bottles of different chemicals (three esters and two carboxylic acids) that were all labelled $C_5H_{10}O_2$.

The different chemicals had the structural formulae below.

$CH_3CH_2COOCH_2CH_3$ $(CH_3)_3CCOOH$ $CH_3COOCH(CH_3)_2$

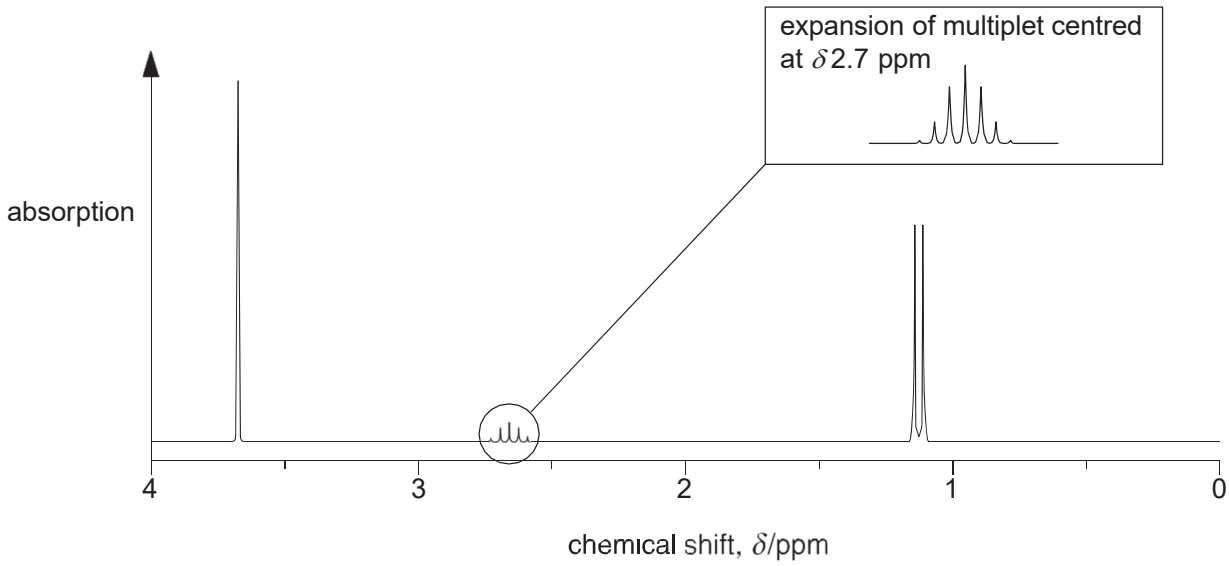
$(CH_3)_2CHCH_2COOH$ $(CH_3)_2CHCOOCH_3$

(a) The chemist used both infrared and $^{13}C$ NMR spectroscopy to identify the two carboxylic acids and to distinguish between them.

How do both types of spectra allow the carboxylic acids to be identified and distinguished?

[3]

(b) The chemist analysed one of the esters by $^1H$ NMR spectroscopy. The spectrum is shown below.



Analyse the splitting patterns and the chemical shift values to identify the ester.

Give your reasoning.

*In your answer, you should use appropriate technical terms, spelt correctly.* [6]

[Total 9 Marks]

The relative molecular masses and boiling points of some fuels are shown in **Table 22.1**.

| Fuel | Relative molecular mass | Boiling point / °C |
|---|---|---|
| hexane | 86 | 69 |
| pentan-1-ol | 88 | 138 |
| heptane | 100 | 98 |

**Table 22.1**

(a) Write an equation for the incomplete combustion of heptane. **[1]**

(b) Explain the difference in the boiling points of the fuels in **Table 22.1**. **[4]**

(c) Fuel additives are often used to improve the combustion of a fuel.

(i) Compound **N** is a fuel additive containing carbon, hydrogen and oxygen only.

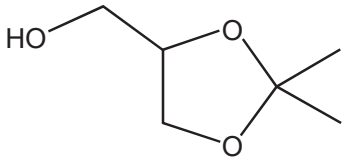
Complete combustion of 1.71 g of compound **N** produces 2.97 g of $CO_2$ and 1.62 g of $H_2O$. The relative molecular mass of compound **N** is 76.0.

Calculate the molecular formula of **N** and suggest a possible structure for the compound.

**compound N**

**[5]**

**(ii)** Solketal has been investigated as a potential fuel additive.




**solketal**

Solketal is synthesised from propane-1,2,3-triol and a carbonyl compound.

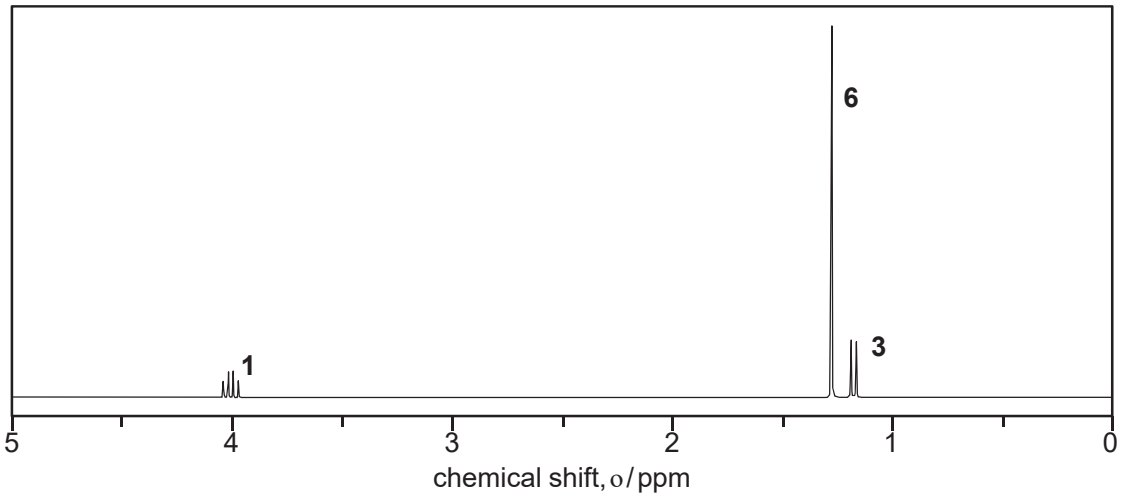
Construct a balanced equation for this synthesis.
Show structures for the organic compounds in your equation. **[2]**

**(d)*** A scientist is researching compounds that might be suitable as fuel additives.
One of the compounds gives the analytical results below.

**Elemental analysis by mass:**
C: 54.54%; H: 9.10%; O: 36.36%

**Mass spectrum:**
Molecular ion peak at $m/z$ = 132.0

**$^1$H NMR spectrum in $D_2O$**




The numbers by the peaks are the relative peak areas.

When the spectrum is run without $D_2O$, there are **two** additional peaks with the same relative peak areas at 11.0 ppm and 3.6 ppm.

Use the information provided to suggest a structure for the compound.

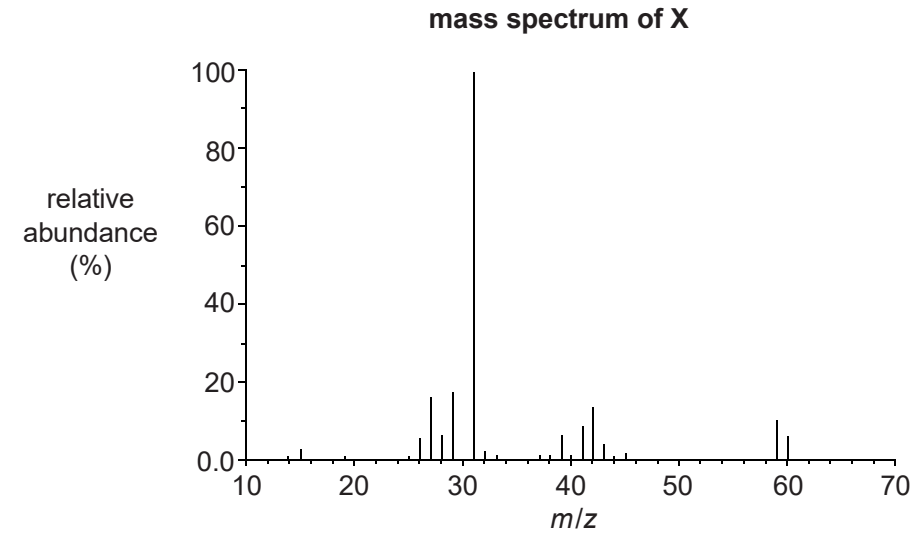
Show **all** your reasoning. **[6]**

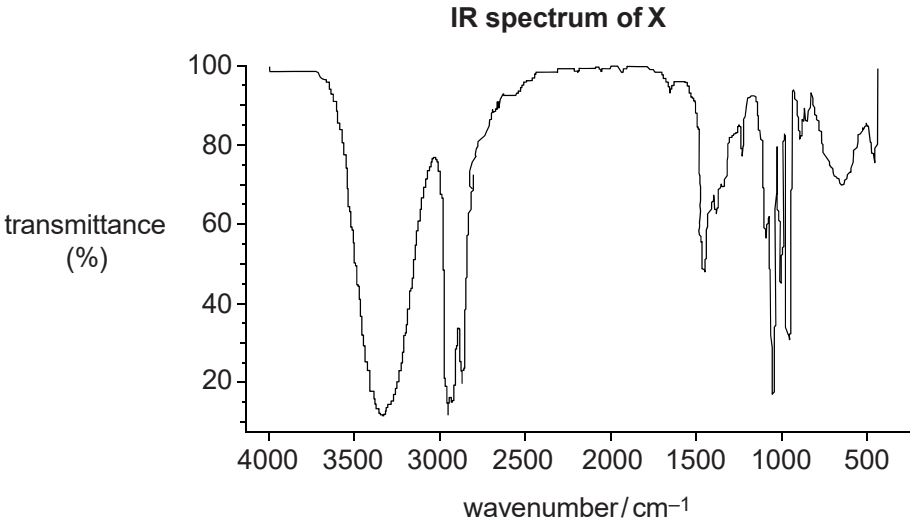
**(Total 18 marks)**

Compound **X** is a saturated compound that contains carbon, hydrogen and oxygen only.

A scientist analyses a 1.00 g sample of compound **X** and finds it contains 0.133 g of hydrogen and 0.600 g of carbon.

The scientist also analyses compound **X** using mass spectrometry and infrared spectroscopy.



The scientist finds that compound **X** reacts with ethanoic acid in the presence of a concentrated sulfuric acid catalyst to make compound **Y**.

Compound **Y** has the molecular formula $C_5H_{10}O_2$.

Using all the information, show the structures of compounds **X** and **Y**.
Include an equation for the reaction of compound **X** with ethanoic acid to make compound **Y**.

*In your answer you should link the evidence with your explanation.* [10]

[Total 10 Marks]