WJEC Chemistry A-level

2.8: Instrumental Analysis

Practice Questions

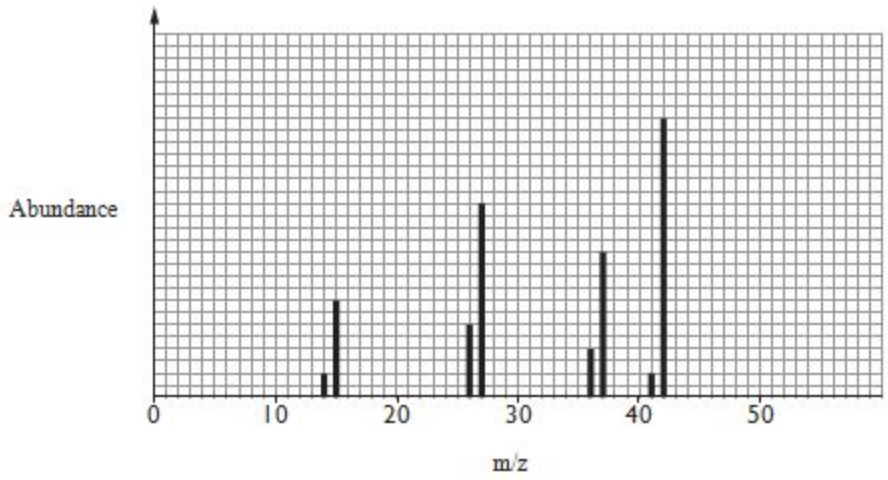
Wales Specification

1. (a) Compound **X** is a straight-chain hydrocarbon that consists of 85.7 % carbon by mass.

(i) Find the **empirical** formula of compound **X**

[3]

(ii) Some peaks from the mass spectrum of **X** are shown below.



Use the empirical formula and the mass spectrum to find the molecular formula of **X**. Show your workings

[2]

(iii) Suggest what information the presence of the peak at m/z 15 gives about the structure of **X**.

[1]

(b) Butene, C_4H_8, is an alkene. Draw **displayed** formulae for three **straight-chain** isomers of C_4H_8. [3]

(Total 9)

2. (a) Propene reacts with hydrogen bromide to give 2-bromopropane.

(i) Draw the mechanism for this reaction.

[3]

(ii) Explain why the product of this reaction is mainly 2-bromopropane rather than 1-bromopropane

[2]

(b) Compound **C** is a compound of carbon, hydrogen and bromine only. Bromine has two isotopes, ^{79}Br and ^{81}Br, in equal abundance. Use all the information below to deduce the structure of compound **C**, giving your reasoning. [6]

QWC [1]

- Compound **C** contains 29.8% carbon, 4.2% hydrogen and 66.0% bromine by mass.
- The mass spectrum of compound **C** contains peaks at m/z of 15, 41 and a pair of peaks at 120 and 122.
- The infrared spectrum of compound **C** has absorptions at 550 cm^{-1}, 1630 cm^{-1} and 3030 cm^{-1}.
- Compound **C** is a Z-isomer.

(Total 12)

3. *(a)* An acid **F** was known to be one of the following.

$CH_3CH_2HC{=}CHCO_2H$	Acid 1	$M_r = 100$
$HO_2CCH_2CH_2CO_2H$	Acid 2	$M_r = 118$

A sample of 1.20 g of acid **F** was burned in excess oxygen. 1.79 g of carbon dioxide was formed.

(i) Calculate the mass of carbon present in the sample of acid **F**. [1]

Mass of carbon = ... g

(ii) The mass of hydrogen in the sample is 0.061 g. Assuming that the rest of the sample is oxygen, calculate the mass of oxygen in the sample.

[1]

Mass of oxygen = ... g

(iii) Use your answers to parts (i) and (ii) to find the empirical formula of acid **F**.

[2]

Empirical formula . . . . . .

(iv) State the identity of acid **F**. Show clearly how you reached this conclusion.

[1]

(v) Describe a chemical test that would distinguish between Acid 1 and Acid 2.You should include the expected results

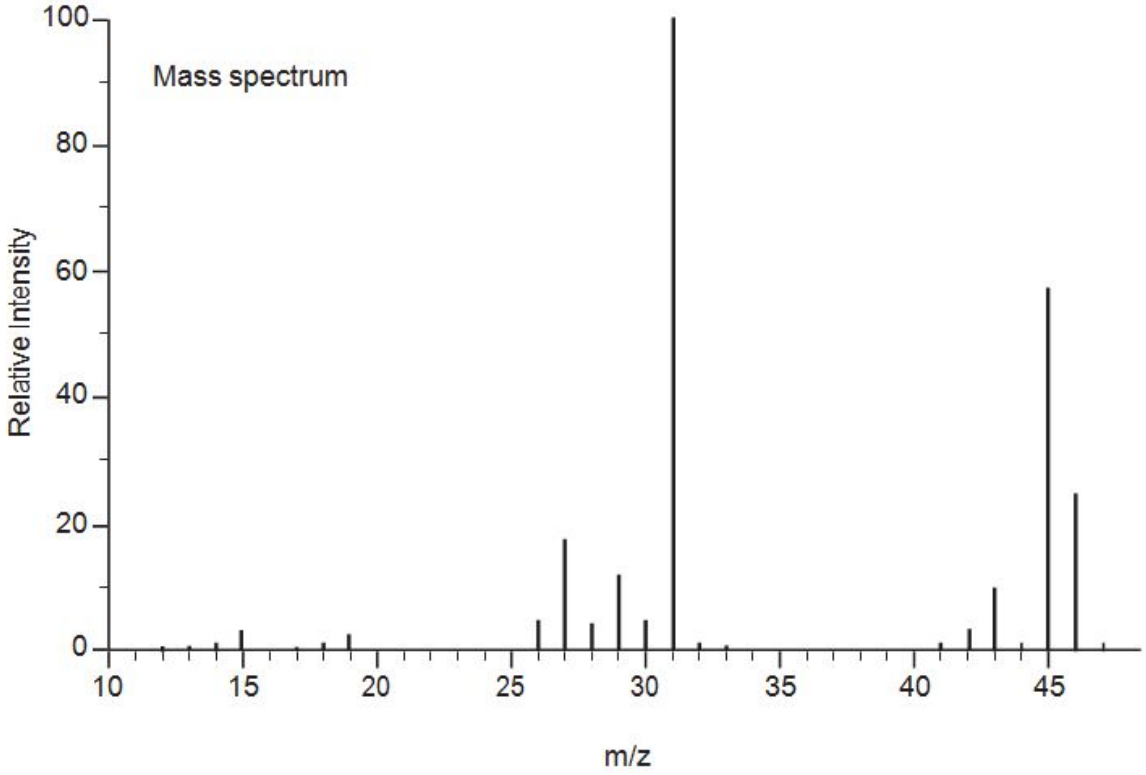
[1]

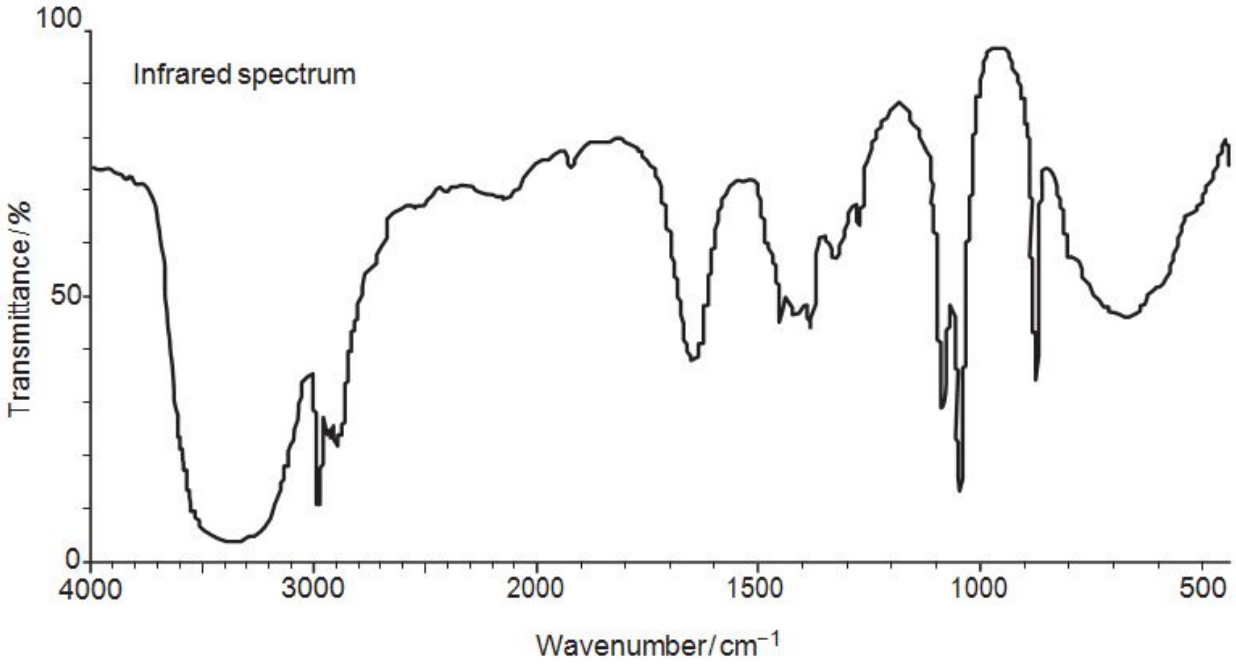
(vi) Draw the structural formula of the alcohol that can be oxidised to form Acid 2.

[1]

(b) Spectra give much information about the structure of organic compounds.

The mass spectrum and infrared spectrum of ethanol, C_2H_5OH, are shown.





(i) What can be deduced by the presence of the peak at m/z 46 in the mass spectrum?

[1]

(ii) What can be deduced by the presence of the peak at m/z 15 in the mass spectrum?

[1]

(iii) What can be deduced by the presence of an absorption peak at 3100 to 3500 cm−1 in the infrared spectrum?

[1]

(c) Ethene can be converted into ethanol and ethanol can be converted into ethene.

For each conversion, state the reagent(s) used and the conditions needed.

[4]

ethene to ethanol

ethanol to ethene

(Total 14)

4. This question concerns isomers with molecular formula $C_5H_{10}O_2$.

(a) Isomers **P**, **Q**, **R** and **S** all react with aqueous sodium carbonate to produce carbon dioxide.

Isomer **P** is a straight-chain compound.

Isomer **Q** contains a chiral carbon centre.

Isomer **R** has only two peaks in its NMR spectrum, both of which are singlets.

Draw the displayed formulae for all **four** isomers. [4]

(b) Isomer **T** is a neutral, sweet-smelling compound and is formed by the reaction between compounds **X** and **Y** in the presence of concentrated sulfuric acid.

Compound **X** has an absorption in its infrared spectrum at 1750 cm^{-1} and a broad absorption around 3000 cm^{-1}.

Compound **Y** can be formed directly from ethanal.

(i)Use **all** the information given to name compounds **X** and **Y**, giving your reasoning. Draw the displayed formula for isomer **T**.

[4] QWC [2]

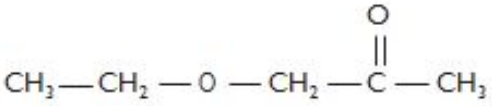
(ii) I. State the reagent needed to form compound **Y** from ethanal

[1]

II. State the role of sulfuric acid in the formation of **T**

[1]

(c) Isomer **U** has the structural formula shown below.



List the peaks which would be found in the NMR spectrum of isomer **U**. Identify which protons are responsible for each peak, giving the approximate chemical shift (ppm) and the splitting of the peak. [4]

(d) Explain which one of isomers **P**, **T** and **U** would have the highest boiling temperature.

[3] QWC [1]

(Total 20)