Spectroscopy (IR & Mass Spec)

Question Paper

Level	International A Level
Subject	Chemistry
Exam Board	Edexcel
Topic	Chemistry Lab Skills 1
Sub Topic	Spectroscopy (IR & Mass Spec)
Booklet	Question Paper

Time Allowed: **41 minutes**

Score: **/34**

Percentage: **/100**

Grade Boundaries:

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

1 **P**, **Q** and **R** are different halogenoalkanes with the general formula C_3H_7X.

(a) 2 cm^3 of ethanol is added to three test tubes in a water bath at 50 °C.

Three drops of **P** are added to the first test tube, three drops of **Q** to the second and three drops of **R** to the third.

2 cm^3 portions of aqueous silver nitrate solution are added to each test tube.

Explain why ethanol is added to each test tube.

(1)

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(b) Cream coloured precipitates form in the test tubes containing **P** and **Q**. These precipitates are **soluble** in concentrated ammonia solution.

A yellow coloured precipitate forms in the test tube which contains **R**. This precipitate is **insoluble** in concentrated ammonia solution.

Deduce the identity of the halogen present in each halogenoalkane.

(2)

P and **Q** .....

R .....

(c) The mass spectrum of **P** includes a peak at $m/e = 29$ but neither **Q** nor **R** has a peak at this value.

(i) Suggest the identity of the positive ion responsible for this peak at $m/e = 29$.

(1)

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(ii) Deduce the structural formulae of the three halogenoalkanes.

(3)

P

Q

R

(Total for Question 1 = 7 marks)

2 An organic compound, **Z**, has only one –OH group.

(a) State the test which confirms the presence of an –OH group and give the result of a positive test.

(2)

Test .....

Result .....

.....

(b) Name **two** series of organic compounds, with different general formulae, each of which has one –OH group.

(1)

..... and .....

(c) Neither red nor blue litmus paper changed colour when used to test an aqueous solution of **Z**. A different sample of **Z** was warmed with a mixture of aqueous potassium dichromate(VI) and sulfuric acid. No change was observed.

What can be deduced about the identity of the functional group in **Z** from each of these observations? Justify your answer.

(2)

Test with litmus paper

.....

.....

Warming with aqueous potassium dichromate(VI) and sulfuric acid

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(d) **Z** was investigated by measuring the volume of carbon dioxide formed on complete combustion.

A sample of 0.10 mol of **Z** produced 9.6 dm^3 of carbon dioxide.

Under the conditions of the experiment, the molar volume of a gas is 24 $dm^3\,mol^{-1}$.

Use this information to calculate the number of carbon atoms in one molecule of **Z**. Use the result of your calculation and your deduction in (c) to draw the displayed formula of **Z**. Show your working.

(3)

(e) **Z** has several isomers, only some of which contain an –OH group.

(i) Give **one** piece of evidence from their mass spectra which would show that two compounds could be isomers.

(1)

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.....

(ii) How could infrared spectroscopy be used to show that two isomers of **Z** both have an –OH group? You are not required to give wavenumber values.

(1)

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(Total for Question 2 = 10 marks)

3 This question concerns the analysis of an organic compound.

(a) (i) How can the relative molecular mass of a compound be found from its mass spectrum?

(1)

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.....

(ii) The general formula of an alcohol can be written ROH, where R is an alkyl group.

The relative molecular mass of an alcohol **Q** is 88. The formula of the alkyl group may be represented as C_xH_y.

State the values of x and y.

(1)

x ..... y .....

(b) When **Q** was warmed with a mixture of sulfuric acid and aqueous potassium dichromate(VI), there was no colour change.

Deduce the displayed formula of alcohol **Q**.

(1)

(c) When a sample of **Q** was reacted with phosphorus(V) chloride, PCl_5, steamy fumes were seen.

(i) Identify these steamy fumes by name or formula.

(1)

.....

(ii) The steamy fumes were tested by reacting them with ammonia gas. A white smoke was seen.

Write an equation, including state symbols, for the reaction in which the white smoke was formed.

(2)

(d) One of the isomers of the alcohol **Q** is an ether. Ethers contain two alkyl groups linked by an oxygen atom and can be represented as R-O-R.

Explain how the information in an **infrared** spectrum would be used to decide whether the spectrum is produced by an alcohol or an ether. Wavenumber data are not required.

(1)

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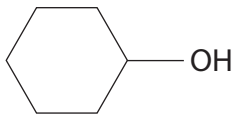
(Total for Question 3 = 7 marks)

4 The skeletal formulae of two compounds with molecular formula $C_6H_{12}O$ are shown below.



cyclohexanol

hex-5-en-1-ol

(a) Each of the compounds reacts when warmed with a mixture of potassium dichromate(VI) and sulfuric acid.

(i) What colour change is seen during this reaction?

(1)

From ..... to .....

(ii) One of the compounds forms a carboxylic acid when it is heated under reflux with a mixture of potassium dichromate(VI) and sulfuric acid.

Give the **structural** formula of this carboxylic acid.

(1)

(b) Under suitable conditions, each of the compounds reacts slowly with a small piece of sodium to form a sodium salt and one other product. Give **two** observations you would make when this reaction occurs.

(2)

Observation 1 .....

.....

Observation 2 .....

.....

(c) Hex-5-en-1-ol can be distinguished from cyclohexanol by its reaction with aqueous bromine.

(i) What colour change would be seen in this reaction when hex-5-en-1-ol is used?

(1)

From ..... to .....

(ii) Complete the skeletal formula below to show the product of this reaction.

(1)

(d) Hex-5-en-1-ol reacts with acidified potassium manganate(VII) at room temperature.

(i) What colour change would be seen in this reaction?

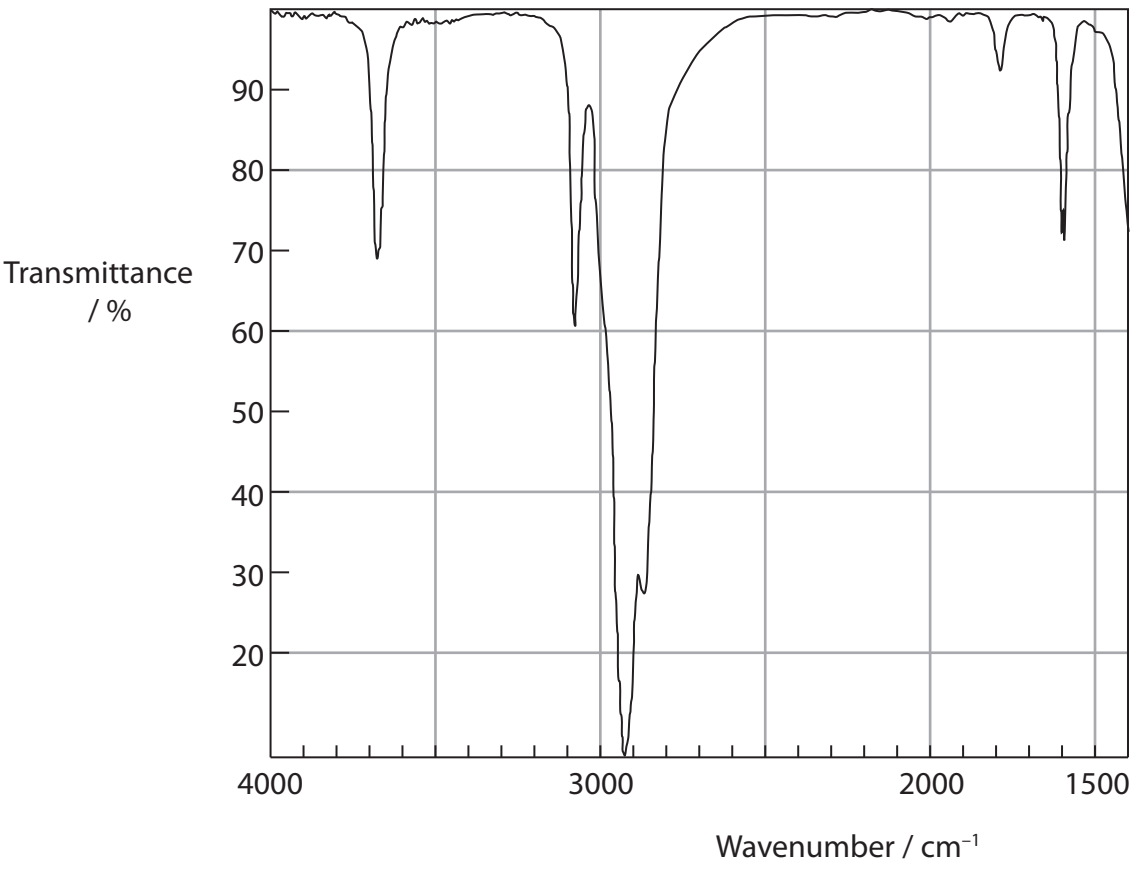
(1)

From ..... to .....

(ii) Complete the skeletal formula below to show the product of this reaction.

(1)

(e) The infrared spectrum below is for either cyclohexanol or hex-5-en-1-ol.



For which of the two compounds is this the infrared spectrum? Use **two** pieces of data from the table below to justify your answer.

Bond	Wavenumber / cm^{-1}
C—H stretch, alkane	2962–2853
C—H stretch, alkene	3100–3010
C=C stretch, alkene	1669–1600
O—H stretch, alcohols	3750–3200

(2)

Spectrum is for .....

Justification: .....

.....

.....

(Total for Question 4 = 10 marks)