Additional Assessment Materials

Summer 2021

Pearson Edexcel GCE in Chemistry 9CH0

Resource Set 2 – Topic Group 5

Topics included:

Topic 6: Organic Chemistry I

Topic 7: Modern Analytical Techniques I

Topic 17: Organic Chemistry II

Topic 18: Organic Chemistry III

Topic 19: Modern Analytical Techniques II

(Public release version)

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Additional Assessment Materials, Summer 2021

General guidance to Additional Assessment Materials for use in 2021

Context

- Additional Assessment Materials are being produced for GCSE, AS and A levels (with the exception of Art and Design).
- The Additional Assessment Materials presented in this booklet are an **optional** part of the range of evidence teachers may use when deciding on a candidate's grade.
- 2021 Additional Assessment Materials have been drawn from previous examination materials, namely past papers.
- Additional Assessment Materials have come from past papers both published (those materials available publicly) and unpublished (those currently under padlock to our centres) presented in a different format to allow teachers to adapt them for use with candidate.

Purpose

- The purpose of this resource to provide qualification-specific sets/groups of questions covering the knowledge, skills and understanding relevant to this Pearson qualification.
- This document should be used in conjunction with the mapping guidance which will map content and/or skills covered within each set of questions.
- These materials are only intended to support the summer 2021 series.

2 This question is about lactic acid (2-hydroxypropanoic acid), $CH_3CH(OH)COOH$.
Lactic acid is used to make biodegradable polymers.

(a) Lactic acid can be made in a two-step synthesis starting from ethanal, CH_3CHO.

Devise a reaction scheme for a two-step synthesis.

Include in your answer all reagents and conditions, the type of reaction occurring at each step, and a balanced equation for each reaction.
State symbols are **not** required.

(7)

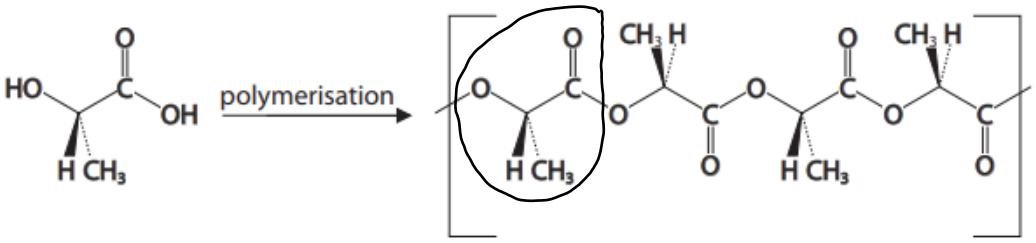
Step 1: $CH_3CHO + HCN \rightarrow CH_3C(OH)H-CN$

- HCN
- Nucleophilic addition

Step 2: $CH_3CH(OH)CN + 2H_2O + HCl \rightarrow CH_3CH(OH)COOH + NH_4Cl$ (any strong, dilute acid)

- water + heat under reflux
- Hydrolysis

(b) Polymerisation of lactic acid forms poly(lactic acid) as shown in the diagram.



(i) State the type of polymerisation occurring in this reaction.

(1)

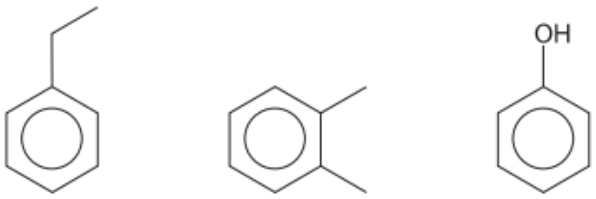
Condensation

(ii) **On the diagram**, draw a circle around the repeat unit of the polymer.

(1)

(Total for Question 2 = 9 marks)

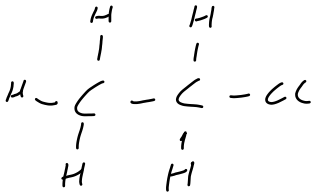
5 This question is about the arenes, ethylbenzene, xylene, and phenol, which can be identified in wine samples using gas chromatography.



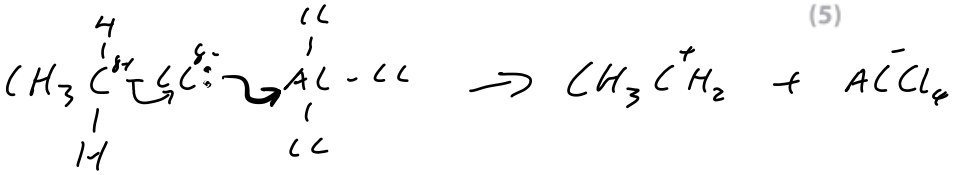
ethylbenzene xylene phenol

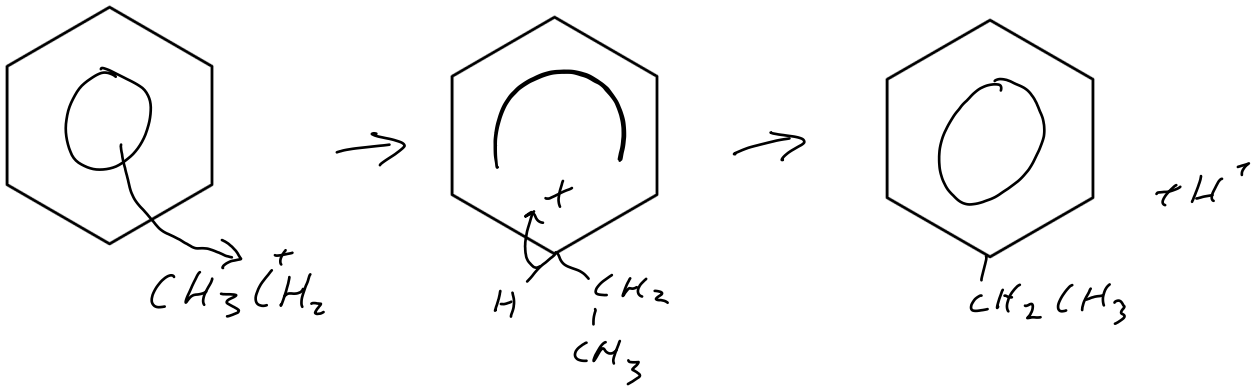
(a) Ethylbenzene can be formed by the reaction of a chloroalkane with benzene, catalysed by aluminium chloride, $AlCl_3$.

(i) Draw the **displayed** formula of the chloroalkane required for this reaction. **(1)**



(ii) Draw the mechanism for this reaction.
Include equations showing the role of the catalyst and how it is regenerated. **(5)**





(iii) Explain whether phenol is likely to be less or more reactive than benzene with the chloroalkane from (a)(i).

(3)

The oxygen on the benzene ring of phenol donates its lone pair to the benzene ring delocalised system, increasing its electron density as compared to benzene. This means the positive chloroalkane ion will be more attracted to the phenol than to benzene. So phenol would be more reactive.

(b) A student carried out an experiment to determine the molar mass of xylene.

The student's sample of xylene vapour had a mass of 0.271 g.

At a temperature of 165 °C and a pressure of 118 kPa, this sample had a volume of 70.5 cm^3.

Use the Ideal Gas Equation to calculate the molar mass, in g mol^{-1}, of this sample.

Give your answer to an appropriate number of significant figures.

You **must** show your working.

(4)

$$n = \frac{PV}{RT} = \frac{118 \times 10^3 \times 70.5 \times 10^{-6}}{8.31 \times (165 + 273)} = 2.29 \times 10^{-3}$$

$$mr = \frac{m}{n} = \frac{0.271}{2.29 \times 10^{-3}} = 118 \text{ g mol}^{-1}$$

(c) The time taken for a compound to pass through the column in gas chromatography is called the retention time.

Explain why different compounds will have different retention times in the same column, under the same conditions.

(2)

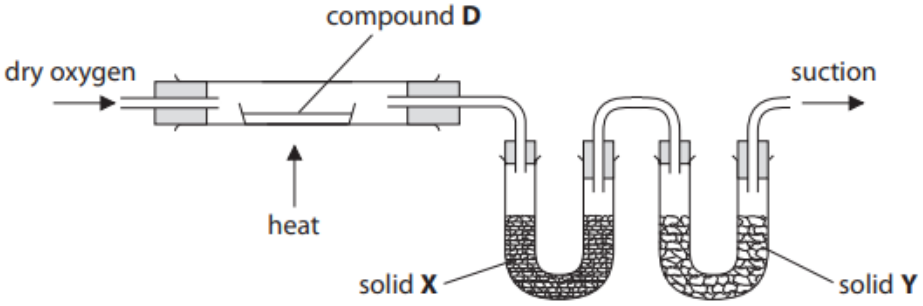
Boiling point → different compounds have different boiling points. A compound which boils at a higher temperature will spend more time condensed as a liquid, leading to a higher retention time.

Solubility in the liquid phase → different compounds have different solubilities in the liquid phase. And one solubility means the compound will spend more time dissolved in the liquid → higher retention time.

(Total for Question 5 = 15 marks)

10 Organic compound **D** contains the elements carbon, hydrogen, oxygen and nitrogen only.

(a) A sample of **D** was burned completely in the apparatus shown.
Solid **X** absorbed the water formed in the combustion.
Solid **Y** absorbed the carbon dioxide.



(i) The masses of solids **X** and **Y** increased during the experiment.

Explain the effect, if any, on the changes in mass of **X** and **Y** if the oxygen gas was not dry.

(3)

Increase in mass of solid X would increase, as there would be more water for it to absorb.

Increase in mass of solid Y would not change, as the quantity of CO_2 produced would not change.

(ii) On combustion in dry oxygen, 3.36 g of **D** produced 0.72 g of water and 5.28 g of carbon dioxide.
This sample of **D** also contained 0.56 g of nitrogen.

Use these data to calculate the empirical formula of compound **D**.

You **must** show your working.

(5)

mass of carbon present : $\frac{12}{12+32} \times 5.28 = 1.44\,g$

mass of hydrogen present : $\frac{2\times 1}{2+16} \times 0.72 = 0.08\,g$

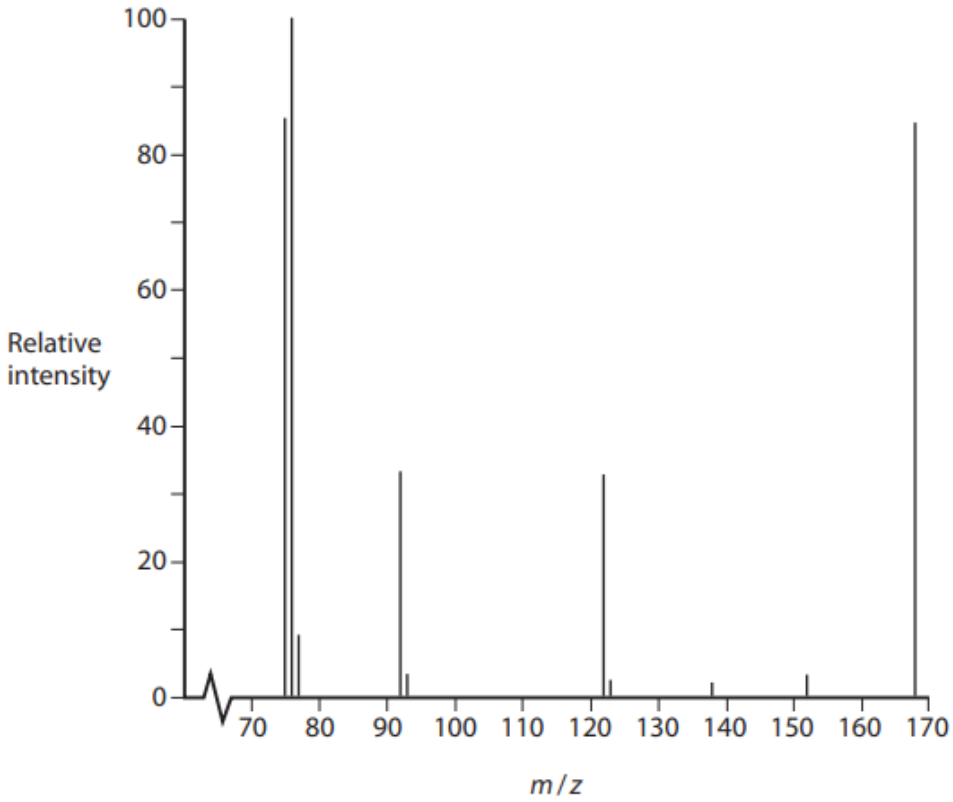
$\Rightarrow$ mass of oxygen $= 3.36 - (1.44 + 0.08 + 0.56)$

$= 1.28\,g$

empirical :	C	H	O	N
	1.44	0.08	1.28	0.56
	12	1	16	14
	0.12	0.08	0.08	0.04
	3	2	2	1

$C_3H_2O_2N$

(b) Part of the mass spectrum of **D** is shown.



Deduce the molecular formula of **D**. Justify your answer.

(2)

mr = 168 ÷2

mr of empirical = 84

molecular formula = empirical ×2 = $C_6H_4O_4N_2$

(c) Compound **D** contains a benzene ring.

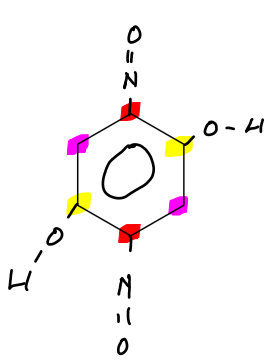
(i) Give the molecular formula of the species that causes the peak at $m/z = 76$ in the mass spectrum of **D**.

(1)

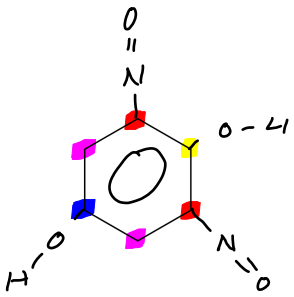
C_6H_4

(ii) Draw the structures of the **three** possible isomers of **D** containing a benzene ring.

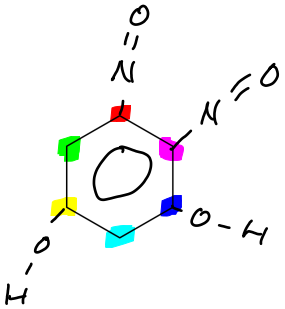
(2)



3 unique environments



4 unique environments

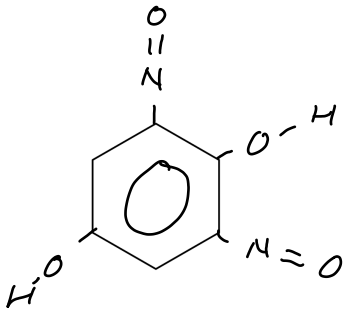


5 unique environments

(iii) The ^{13}C NMR spectrum of compound **D** has four peaks.

Identify the structure of **D**. Justify your answer by labelling the different carbon environments in **all** the structures drawn in (c)(ii).

(3)



(Total for Question 10 = 16 marks)

Total for Test = 40 marks