

GCSE Chemistry (9 – 1)

Organic 2 – Alcohols, Carboxylic acids and Esters

Name:

Group:



Instructions

- Read each question carefully before you begin to answer it.
- Use black ink or black ball-point pen for your answers.
- Fill in the boxes at the top of this page with your name and group.
- Attempt to answer every question in the booklet.
- Answer the questions in the spaces provided – there may be more space than you need in some answer spaces.
- Calculators may be used for this booklet.
- For any calculations, you **must** show all your working.
- Any and all drawings or graphs should be completed in pencil.

For markers use	
Question	Mark
1	/6
2	/7
3	/18
4	/12
5	/17
6	/9
Total	/69
%	
Grade	

Information

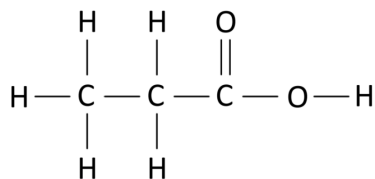
- The maximum mark for this paper is 69 marks.
- The marks for each question are shown in brackets.
- Please be aware that good English and clear presentation are required in your answers.



1. Alcohols, a family of compounds containing an -OH group, react with weak organic acids known as carboxylic acids to produce esters, which are often responsible for the sweet and fruity aromas in foods and perfumes.

Circle the letter of the correct answer for each of the following questions.

- a. What type of compound is shown below.



Ester

Alcohol

Alkane

Carboxylic acid

A

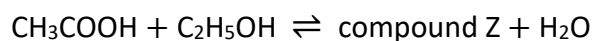
B

C

D

(1 mark)

- b. The equation shows the reaction between an alcohol and a carboxylic acid.



What is the name of the ester, compound Z?

Methyl methanoate

Ethyl ethanoate

Propyl ethanoate

Ethyl propanoate

A

B

C

D

(1 mark)

- c. The table shows four molecular structures.

Which row **correctly** identifies the homologous series for the structure shown?

	Molecular structure	Homologous series
A	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array} $	Alcohol
B	$ \begin{array}{c} \text{H} \quad \text{O} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{O}-\text{H} \\ \\ \text{H} \end{array} $	Carboxylic acid
C	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}=\text{C}-\text{C}-\text{H} \\ \quad \quad \\ \quad \quad \text{H} \end{array} $	Alkane
D	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{O}-\text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array} $	Alkene

(1 mark)

d. Which statements about the ester ethyl ethanoate are correct?

- 1 It is formed from ethanoic acid and ethanol.
- 2 It turns universal indicator orange.
- 3 It typically has a sweet, fruity smell.
- 4 Its functional group is -OH .

1 and 2 only

2 and 4

3 and 4 only

1 and 3 only

A

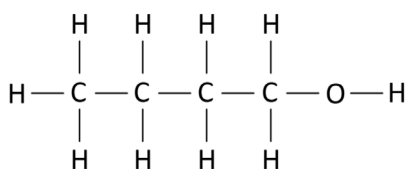
B

C

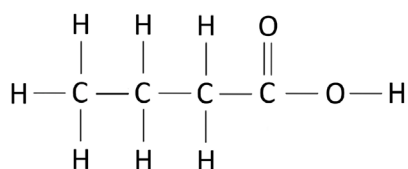
D

(1 mark)

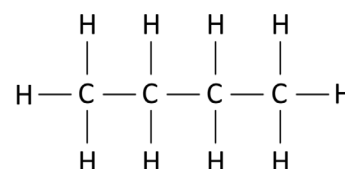
e. The figures below show different organic compounds. Which structure shows butanoic acid?



A



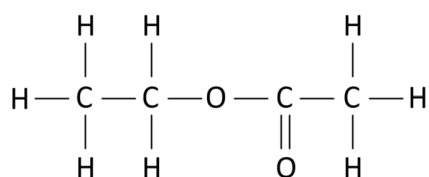
B



C

(1 mark)

f. The figure below shows the structure of an ester.



What are the names of the carboxylic acid and the alcohol that react together to form this ester?

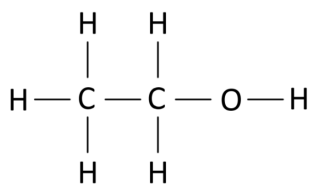
	Carboxylic acid	Alcohol
A	Propanoic acid	Ethanol
B	Ethanoic acid	Propanol
C	Ethanoic acid	Ethanol
D	Propanoic acid	Propanol

(1 mark)

(Total for Question 1 is 6 marks)

2. Ethanol, propanol, and butanol are alcohols with different chain lengths.

Look at the displayed formula of ethanol.



- a. Draw a **ring** around the functional group of ethanol. (1 mark)

- b. Ethanol can be produced by the hydration of ethene.

- i. State the conditions required for this reaction to occur industrially.

.....

.....

.....

.....

.....

(2 marks)

- ii. Explain why ethene is described as unsaturated.

.....

.....

.....

(1 mark)

- c. Alcohols have the general formula $\text{C}_n\text{H}_{2n+2}\text{O}$.

- i. A molecule of propanol contains 3 carbon atoms. State the molecular formula of propanol.

.....

(1 mark)

- ii. Draw the displayed formula of **butanol**, showing all the atoms and bonds.

(2 marks)

(Total for Question 2 is 7 marks)

3. Ethanol is an important alcohol with many industrial uses.

It is manufactured by reacting ethene with steam in a process called hydration.

a. Write a **balanced** chemical equation for the hydration of ethene to produce ethanol.

.....
(2 marks)

b. State the conditions used for this industrial process.

.....
.....
(2 marks)

c. A chemical plant uses 112 kg of ethene (C_2H_4) to produce ethanol (C_2H_5OH).

Calculate the maximum theoretical mass of ethanol that can be produced from 112 kg of ethene.

Relative atomic masses (A_r): H = 1, C = 12, O = 16.

Maximum theoretical mass = ... kg
(4 marks)

d. In the reaction, the actual mass of pure ethanol produced was 174.8 kg.

i. Calculate the percentage yield of ethanol.
(Use your answer from part (c) in this calculation.)

Percentage yield = ... %
(2 marks)

ii. Suggest **two** reasons why the actual yield is less than the theoretical maximum.

.....
.....
.....
.....
.....
(2 marks)

The table compares two industrial processes for making ethanol.

	Hydration	Fermentation
Raw materials	ethene from crude oil	sugar from plants
Type of process	continuous	batch
Rate of reaction	fast	slow
Conditions used	High temperature, 300°C, high pressure (60 atmospheres), and a catalyst.	Low temperature, 40°C, atmospheric pressure and an enzyme in yeast acts as a catalyst.
Purity of product	pure	impure
Atom economy	100%	51%

- e. Evaluate the two methods for the industrial production of ethanol.

Your answer should use the information in the table to compare the two processes and conclude which method is better for large-scale manufacturing in the UK, giving reasons for your choice.

[illegible]

(6 marks)

(Total for Question 3 is 18 marks)

4. Ethanoic acid can be made by the oxidation of ethanol. It is a member of the carboxylic acid homologous series.

a. State the functional group of a carboxylic acid.

.....

(1 mark)

b. Draw the displayed formula of the carboxylic acid containing four carbon atoms.
Show all of the atoms and all of the bonds.

(2 marks)

c. Carboxylic acids react with alcohols in the presence of an acid catalyst to produce esters and water.
Ethanoic acid reacts with ethanol.

i. Name the ester produced in this reaction.

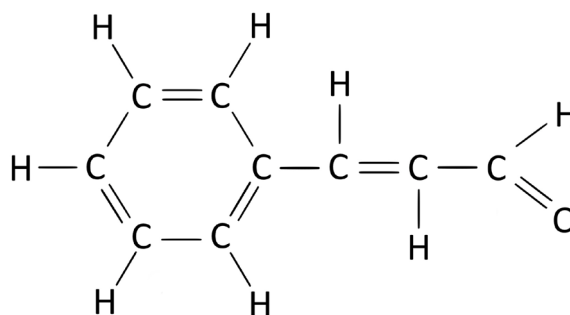
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(1 mark)

(ii) Draw the displayed formula of the ester formed when ethanoic acid reacts with ethanol.

(2 marks)

Toothpaste contains cinnamal. Cinnamal is the organic compound that gives cinnamon its characteristic warm, spicy, and slightly sweet aroma and flavour. It is widely used as a flavouring agent in a vast range of products. The structure of cinnamal is shown.



Cinnamal can be oxidised to form a carboxylic acid.

- d. Draw the displayed formula of the **carboxylic acid functional group**. Show all atoms and all bonds.

(2 marks)

- e. A student adds sodium carbonate powder to a solution of ethanoic acid. A chemical reaction occurs.
- i. Describe **one** thing the student would observe.

.....

(1 mark)

- ii. State the **three** products formed in this reaction.

.....

.....

.....

(3 marks)

(Total for Question 4 is 12 marks)

5. Methanoic acid is the first member of the homologous series of carboxylic acids.

a. Give **three** characteristics of a homologous series.

.....

.....

.....

.....

.....

.....

.....

(3 marks)

b. Methanoic acid is the simplest carboxylic acid. It is often used in household products to remove limescale.

Methanoic acid (HCOOH) is the first member of the carboxylic acid homologous series.

i. The fourth member of this series is butanoic acid. State its molecular formula.

.....

(1 mark)

ii. Determine the empirical formula of butanoic acid.

.....

(1 mark)

c. A kettle is coated with 5.0 g of limescale, which is calcium carbonate (CaCO_3).

Methanoic acid is added to remove it.

i. Write a balanced chemical equation for the reaction between methanoic acid and calcium carbonate.

.....

(2 marks)

ii. Calculate the minimum mass of methanoic acid required to completely remove 5.0 g of calcium carbonate from the kettle.

Relative atomic masses (A_r): H = 1; C = 12; O = 16; Ca = 40.

Mass of methanoic acid = ... g
(2 marks)

d. Carboxylic acids react with metals.

i. Name the two products formed when zinc reacts with methanoic acid.

Product 1:

Product 2:

(2 marks)

ii. Aluminium is more reactive than zinc.

Suggest why methanoic acid can be used **safely** in an aluminium kettle without the kettle dissolving.

.....
.....
.....

(1 mark)

iii. Draw the structural formula of methanoic acid, showing all the bonds.

(2 marks)

e. An ester is produced by warming propanol with methanoic acid in the presence of an acid catalyst.

i. Name the ester formed in this reaction.

.....

(1 mark)

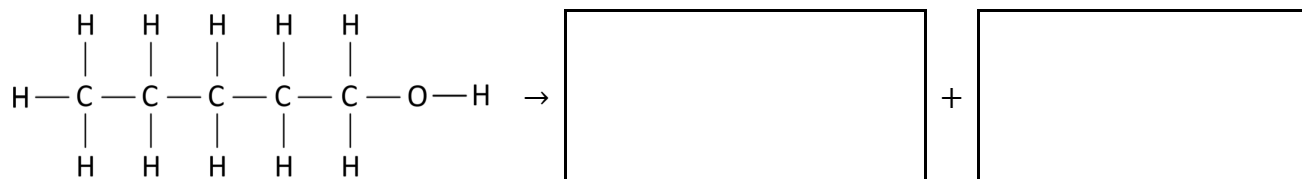
ii. Complete the word equation for this reversible reaction.

methanoic acid + propanol $\rightleftharpoons$ + ...

(2 marks)

(Total for Question 5 is 17 marks)

6. Alcohols can be dehydrated to produce useful products.
- a. Complete the balanced equation for the dehydration of pentan-1-ol by drawing the **structures** of the two products in the boxes provided.



(2 marks)

- b. Name the **two** products formed from the dehydration of pentan-1-ol.

.....

.....

(2 marks)

- c. In an experiment, a student dehydrates 13.2 g of pentan-1-ol.
- i. Calculate the maximum theoretical mass of pentene (C_5H_{10}) that can be produced.
(Relative atomic masses: $\text{H} = 1$, $\text{C} = 12$, $\text{O} = 16$)

Maximum theoretical mass = ... g

(3 marks)

- ii. The student collected 8.4 g of pure pentene.
Calculate the percentage yield for this experiment.

Percentage yield = ... %

(2 marks)

(Total for Question 6 is 9 marks)