Higher Chemistry: Unit 2 – Nature's Chemistry

Part C – Esters, Fats and Oils

Lesson 1 - Esters

Learning Outcomes

By the end of this lesson you should know:

1. How to name and draw esters using names, shortened and extended formula
2. How to describe a condensation reaction and hydrolysis reaction
3. Physical properties of esters
4. Uses of esters

Success Criteria

You will have been successful in this lesson if you:

1. Read and learn the notes given
2. Watch the links provided
3. Complete questions provided
4. EXTENSION: There is a further reading section to help you gain more depth of understanding for this section. There are also suggested questions for you to try from the blue book of revision questions.

If you have any questions about the content of this lesson, you should ask your class teacher either through your class MS team or via email. The teams will be monitored through the week and someone will get back to you as soon as they can.

Links to Prior Knowledge

You may wish to revise the following to help you understand this lesson:

- Higher chemistry – alcohols and carboxylic acids

You may wish to have a copy of the data booklet handy for this lesson. Download or print a copy of the Higher Chemistry Data Booklet from MS Teams or the SQA website - https://www.sqa.org.uk/sqa/files_ccc/ChemistryDataBooklet_NewH_AH-Sep2016.pdf

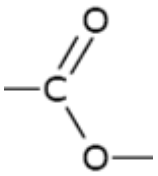
Notes - you should either copy, print or save the notes below.

A full copy of these notes are available on the Higher Chemistry Teams site and you will receive a paper copy when we return to school.

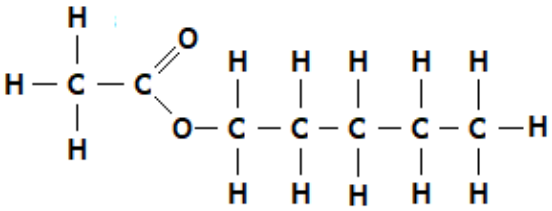
Esters

Click here for a 10 minute PowerPoint with voice recording from Ms Hastie for this lesson

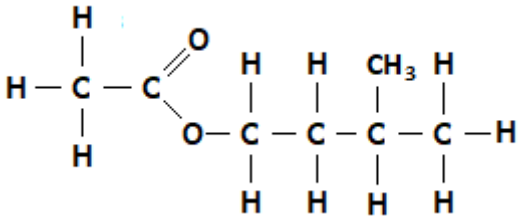
Esters are molecules that contain an ester link, -COO- .



Esters are sweet smelling molecules that exist in nature and can be synthesised by chemists to create fruity flavours and perfumes.



pentyl ethanoate (pear smell)



3-methylbutyl ethanoate (banana smell)

Uses of Esters

Esters are used as:

1. **Flavourings and Fragrances** - as many have pleasant, fruity smells.
2. **Solvents for non-polar compounds** that do not dissolve in water.

WATCH - (3 mins) https://www.twigscotland.com/film/esters-and-perfumes-1373/

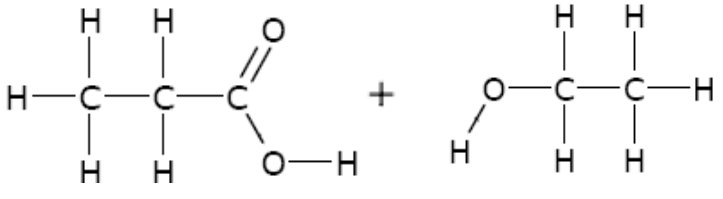
Formation of Esters

Esters are formed by the condensation reaction between a carboxylic acid and an alcohol:

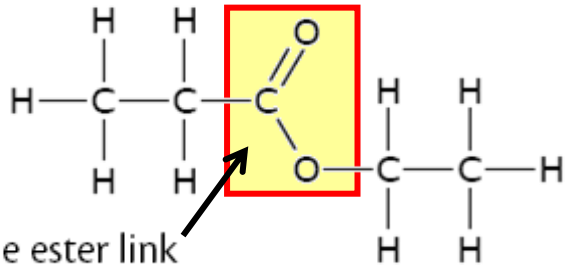
carboxylic acid + alcohol ⇌ ester + water

A condensation reaction is a reaction in which two small molecules join to make a larger molecule with the elimination of a small molecule (usually water).

***Example 1**. Formation of ethyl propanoate*

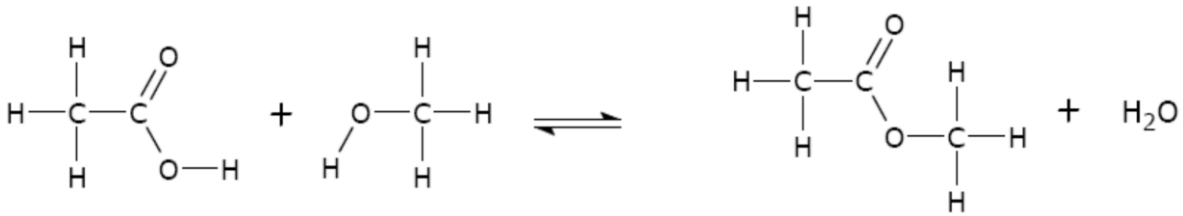


propanoic acid + *ethanol* ⇌



ethyl propanoate + H_2O

***Example 2**. Formation of methyl ethanoate*



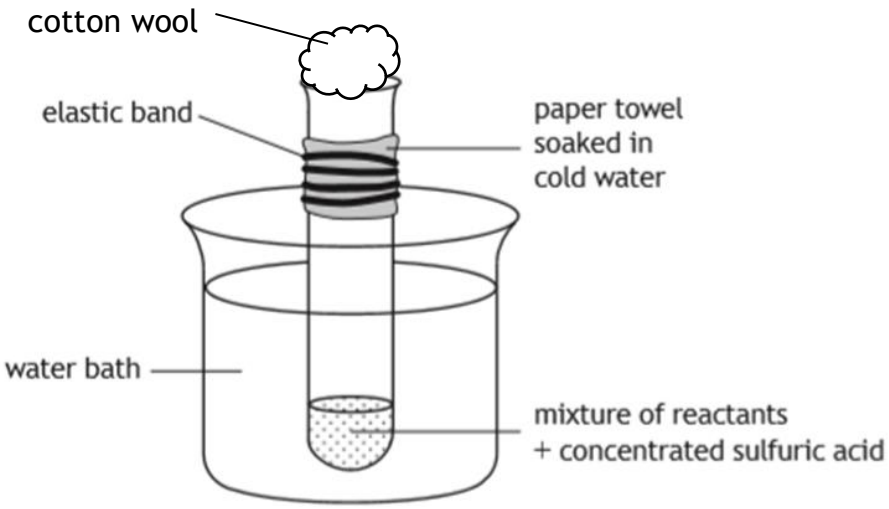
ethanoic acid + methanol ⇌ methyl ethanoate + water

CH_3COOH + CH_3OH ⇌ CH_3COOCH_3 + H_2O

WATCH – (2 mins) https://www.bbc.co.uk/bitesize/guides/zp8wwmn/video

Making Esters

Esters can be made in the laboratory using the following apparatus:



The formation of esters is a slow reaction. The reaction rate is increased by:

1. Adding a catalyst– concentrated sulfuric acid, H_2SO_4.
2. Placing the test tube in a beaker of hot water.

However, the heat from the water bath can often cause the volatile reactants to vaporise and rise up the test tube. A wet paper towel is wrapped around the top of the test tube to act as a condenser. A condenser is a piece of equipment that cools gases down into a liquid state. In this set up, condenser stops the vapours from escaping. A piece of cotton wool is often place at the mouth of the test tube to stop the reactants from bubbling out of the tube.

After around 20 minutes, 2 separate layers will appear in the test tube. The ester will be the sweet-smelling oily layer and will appear on top of the aqueous layer.

Naming Esters

The name of the ester comes from the alcohol and the carboxylic acid used:

Alcohol	Carboxylic acid	Ester Name
methanol	ethanoic acid	methyl ethanoate

butan-1-ol	pentanoic acid	butyl pentanoate
ethanol	propanoic acid	ethyl propanoate

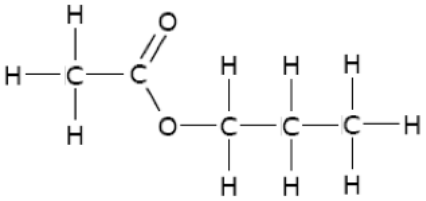
Hydrolysis of Esters

The formation of esters is a reversible reaction. The reverse of a condensation reaction is a hydrolysis reaction:

ester + water ⇌ carboxylic acid + alcohol

A hydrolysis reaction is the breaking down of a larger molecule into smaller molecules using water

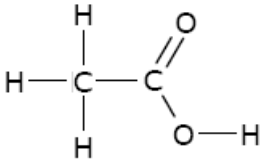
***Example 3**. Hydrolysis of propyl ethanoate.*



+ H_2O

propyl ethanoate $CH_3COOCH_2CH_2CH_3$

⇅



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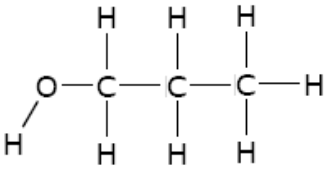


ethanoic acid CH_3COOH *propan-1-ol* $CH_3CH_2CH_2OH$

SUMMARY

Esters:

- contain the ester link -COO-
- are sweet smelling non-polar molecules
- are used as fragrances, flavourings and solvents for non-polar compounds

- are formed in condensation reactions between carboxylic acids and alcohols
- broken down in hydrolysis reactions by the reaction with water

Learning Outcomes

You should now know:

1. How to name and draw esters using names, shortened and extended formula
2. How to describe a condensation reaction and hydrolysis reaction
3. Some physical properties of esters
4. Uses of esters

Further Reading

To learn more about esters, try the following online resources:

BBC Bitesize: https://www.bbc.co.uk/bitesize/guides/zp8wwmn/revision/1

Read page 1-3 and watch the video clip

Scholar: Log in through GLOW

Higher Chemistry → Nature's chemistry → 4. Esters

Read through the exercises and try the end of topic test

Evans2 chem web: https://www.evans2chemweb.co.uk/login/index.php#

Username: snhs password: giffnock

Select any teacher → revision material → CfE Higher → Unit 2: Nature's Chemistry → Esters, fats and oils

Check your understanding – Answers the questions below in you class jotter

2.8 Esters (i)

1. Esters are the products of a condensation reaction.

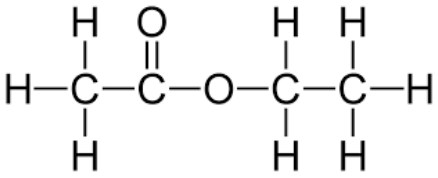
a) Define a condensation reaction.
b) Which two functional groups react to form an ester link?

2. For each of the reactants below, name and draw the full structural formula of the ester produced:

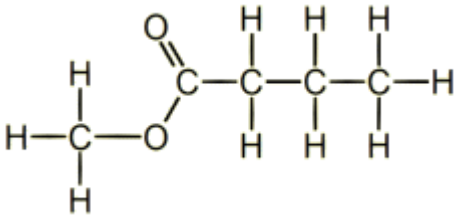
a) Propanol and ethanoic acid
b) Methanol and propanoic acid
c) Butanoic acid and ethanol
d) Methanoic acid and pentanol

3. Name and write the shortened structural formula for the esters shown below:

a)



b)



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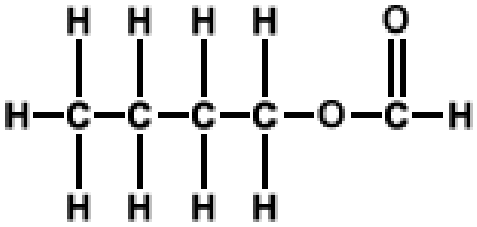

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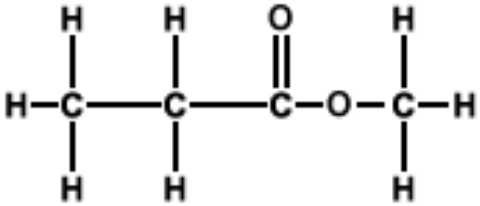

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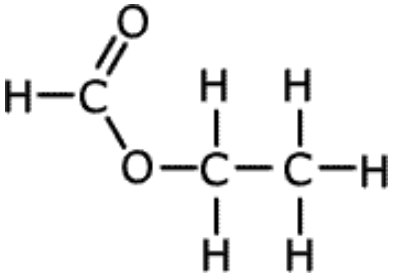

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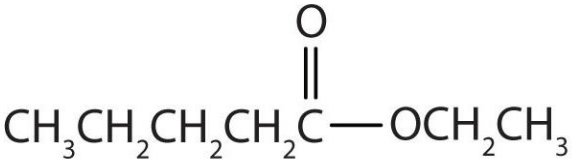

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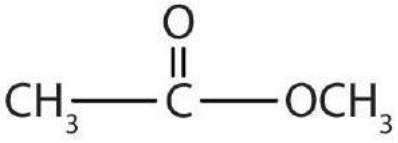
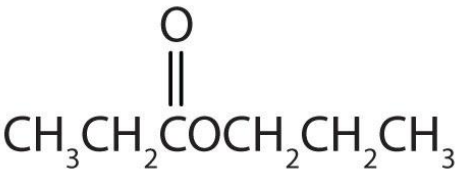


h)



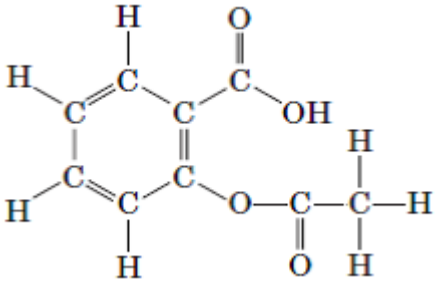
2.9 Esters (ii)

1. The shortened structural formulae of some esters are given below.
For each one,
i. Draw the full structural formula
ii. Name the alcohol and carboxylic acid that reacted to produce them.

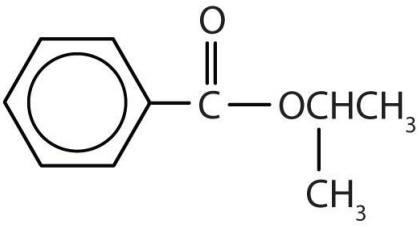
a) $CH_3COOCH_2CH_2CH_3$ b) $CH_3CH_2CH_2CH_2CH_2OOCH$
c) $CH_3OOCCH_2CH_3$ d) $CH_3CH(CH_3)CH_2COOCH_2CH_3$

2.

A



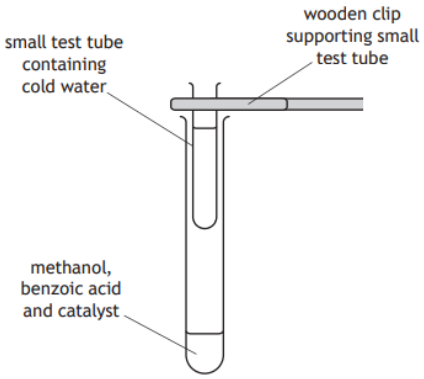
B



The above esters can be hydrolysed to produce the starting alcohols and carboxylic acids.

a) What is a hydrolysis reaction?
b) Name the carboxylic acid produced when **Ester A** is hydrolysed.
c) Draw the full structural formula and name the alcohol produced when **Ester B** is hydrolysed

3. The diagram below shows how methyl benzoate can be produced in the lab:



a) What catalyst is present with the reactants?
b) Suggest a reason for the small test tube with cold water.
c) Suggest and explain the best way to heat the reaction mixture.
d) What evidence will there be that methyl benzoate has been produced?

4. Natural and synthetic esters have a variety of uses.
Give **two** examples of the uses of esters.

ANSWERS TO EXERCISES WILL BE POSTED ON WEDNESDAY FOR YOU TO CHECK YOUR WORK

EXTENSION WORK

For more practise questions for esters, use your Revision Questions for Higher Chemistry "Blue book"

Esters (i) page 41 Q1-7

Esters (ii) page 42 Q1-5