

## Organic Molecules Functional groups

### Key Concepts

This lesson will focus on the following:

- Functional groups
- Ethers
- Alcohol
- Aldehydes
- Ketones
- Carboxylic acids
- Esters

### Terminology & definitions

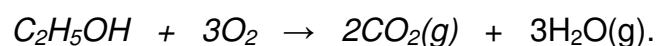
- Functional groups – are individual atoms or a group of atoms attached to carbon chains or rings, that give organic molecules their characteristic properties.

### X-planation of key concepts and terminologies

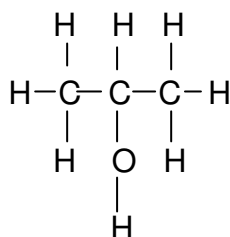
The functional group determines the properties of the particular group of compounds.

### Alcohols

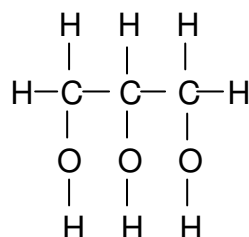
Alcohols are formed when one or more Hydrogen (H) atoms of an alkane molecule are replaced with an **–OH** group. Alcohols are miscible with water. Like other hydrocarbons, alcohols form carbon dioxide and water during combustion, e.g.,



The position of the **–OH** group is indicated by numbering the **C** atoms from the end closest to the **–OH** group and the writing, then writing the number of the **C**-atom it is attached to before the **–ol**. The presence of two **–OH** groups is indicated by **-diol** and three **–OH** groups indicated by **-triol**.



**2-propanol/propane-2-ol**



**1,2,3-propantriol**

Alcohols can be divided into primary, secondary and tertiary alcohols, referring to the number of carbon atoms attached to the **–OH** group. A primary alcohol has one or two carbon atoms attached to the **C –OH** group, a secondary alcohol has two carbon

atoms attached to the – **OH** group, and a tertiary alcohol has three carbon atoms attached to the – **OH** group.

## Ethers

Ethers are compounds that have an oxygen atom somewhere between two carbon atoms in the chain, and can be represented by the general formula of **R - O - R'**, where **R** and **R'** are alkyl groups. Ethers are named in general by giving the name of each of the alkyl group followed by the word 'ether'. The alkyl groups are named in alphabetic order.

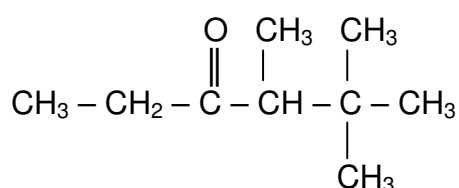
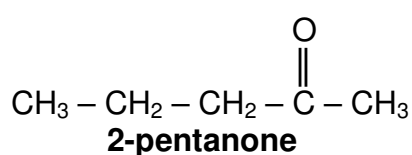
## Aldehydes

An aldehyde is a compound that contains a carbonyl group with at least one hydrogen atom attached to the same carbon atom. An aldehyde is a product of the oxidation of a primary alcohol. Aldehydes are named by identifying the longest carbon chain followed by the suffix **-al**. The carbon atoms are numbered from the carbon containing the **=O**, and any chains or atoms attached to the stem chain must be indicated in alphabetical order, including the number of the carbon atom to which it is attached.

## Ketones

Ketones differ from the aldehydes in the fact that the carbon of the carbonyl group is bonded to two other carbon atoms.

The first member of the ketones homologous series, is propanone. A ketone is the product of the oxidation of a secondary alcohol. Ketones are named by identifying the carbon chain containing the **C=O** group, followed by the suffix **-one**. Numbering begins at the end closest to the carbonyl group. Indicate the number of the carbon atom on which the carbonyl is attached as prefix of the root name. Number the carbon atoms in the longest chain and name any branches according to their positions. The branches are arranged alphabetically in the final name.

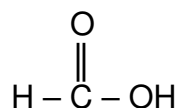


**4,5,5-trimethylhexan-3-one**

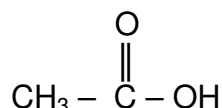
## Carboxylic acid

Carboxylic acids have the functional group **-COOH**. The names of carboxylic acids are the same as for the alkanes from which the acid is derived, with the ending 'oic acid'. Carboxylic acids are formed by the oxidation of a corresponding alcohol or aldehyde.

Carboxylic acid reacts with alcohol to produce esters.

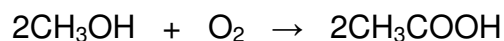


**Methanoic acid**



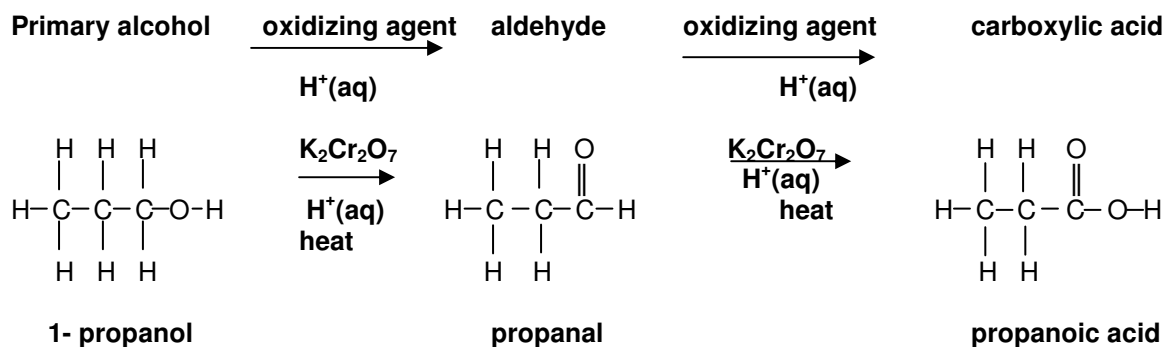
**Ethanoic acid**

Ethanoic acid is prepared by the oxidation of ethanol with oxygen in the presence of a catalyst.



Carboxylic acids donate  $\text{H}^+$  ions in solution, as do all the acids. Carboxylic acids are weak acids and thus ionise only to a small extent when in solution.

There are different ways in which carboxylic acid can be prepared. One way is by oxidation of an aldehyde. Since an aldehyde can be formed by the oxidation of an alcohol, it means that we can prepare a carboxylic acid by adding an excess amount of oxidising agent to a suitable alcohol. This is one of the reasons why wine turns to vinegar when exposed to air.



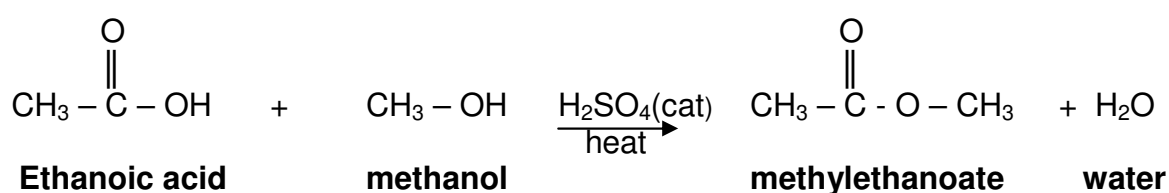
## Esters

Esters are derivatives of alcohol and carboxylic acids. Esters are characterised by a carbon chain interrupted by an oxygen atom, with =O attached to one of the carbon atoms next to the oxygen atom in the chain. The lighter esters have pleasant odours, used in perfumes. The heavier esters are oily, used in oil based medicine. Fats and oils are esters formed from alcohol and long chain carboxylic acids.

The ester produced from, e.g., ethanol + methanoic acid, is called ethyl methanoate. If you have to name an ester from a structural formula, divide the chain in two parts:

1. the part on the one side of the O in the chain containing no oxygen atom and
2. the other side with the =O, including the O in the chain.

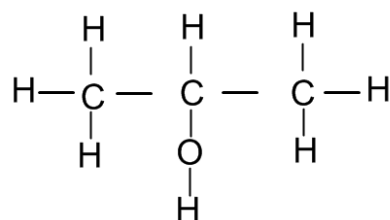
The name of the part without O atoms, is considered as an alkyl group and the part containing the O atoms are as methan-/ethan-/propanoate.



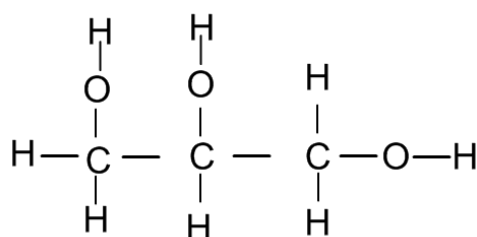
## X-ample Questions

1. Give the IUPAC name for the following structural formulae:

1.1



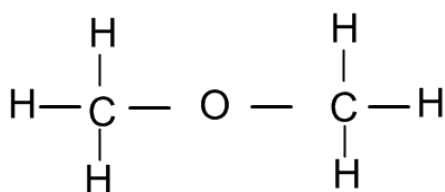
1.2



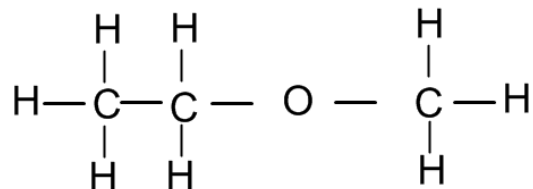
- 1.3 Write down a balanced chemical equation indicating how methanol burns in oxygen.

2. Give the IUPAC names for the following organic molecules

a)



b)



3. Write down structural formulae for the following organic molecules:

3.1 propanal

3.2 2,3-dimethylbutanal

4. Write down structural formulae of ...

4.1 4,5,5 trimethyl-3-hexanone

4.2 3-ethyl-2-pentanone

5. Carboxylic acids are organic acids and are found in some fruits.

5.1 Why are carboxylic acids considered weak acids?

5.2 Write down structural formulae for the following carboxylic acids:

5.2.1 ethanoic acid

5.2.2 butanoic acid

5.2.3 propanoic acid

6. For the following; write down the alcohol and the carboxylic acid needed to prepare ester and the chemical equation showing how the ester was formed.

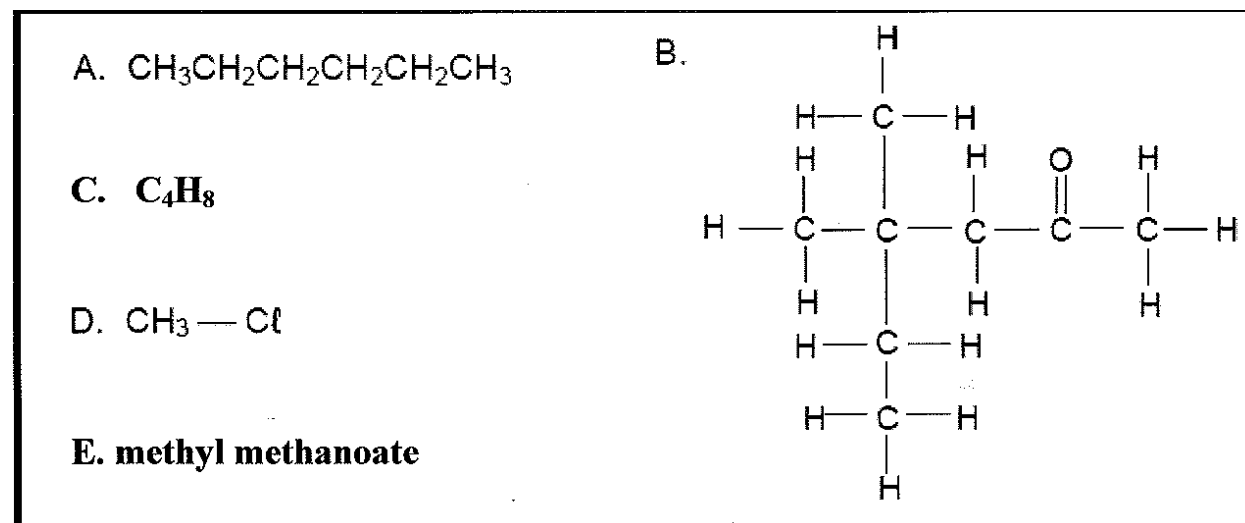
6.1 methyl ethanoate

6.2 ethyl propanoate

6.3 methyl butanoate

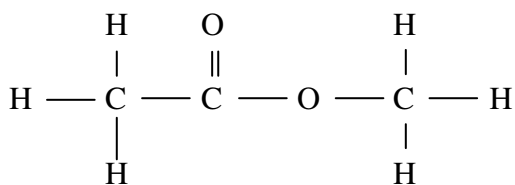
## X-ercise

1. Consider the organic compounds A – E.



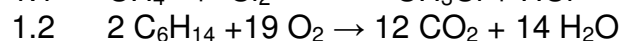
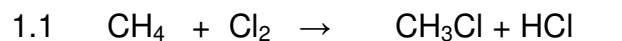
- 1.1 Write a **balanced chemical equation** for the preparation of compound D using an alkane as one of the reactants.
- 1.2 Write a balanced chemical equation for the combustion of compound A in oxygen.
- 1.3 Give the functional group for compound B.
- 1.4 Write down the IUPAC name for compound B?
- 1.5 Write down the structural formula of an isomer of compound A that has only FOUR carbon atoms in the longest chain.
- 1.6 Write down the IUPAC name for compound that you have drawn in 5?
- 1.7 Write down the structural formula for compound C.
- 1.8 Name the homologous series to which compound E belongs?
- 1.9 Using structural formulae, give the equation of the reaction in which methyl methanoate is formed?

2. Consider the following organic compound:



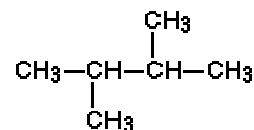
- 2.1 Write down the IUPAC name of this compound.
- 2.2 Write down the names of the two organic compounds that were used to prepare this compound.
- 2.3 Write down the structural formula and IUPAC name of one isomer of this compound.

### Answers



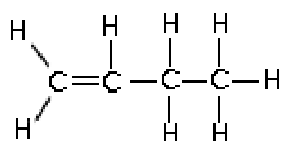
1.4 4,4- dimethyl-2- hexanone or 4,4-dimethylhexan-2-one

1.5

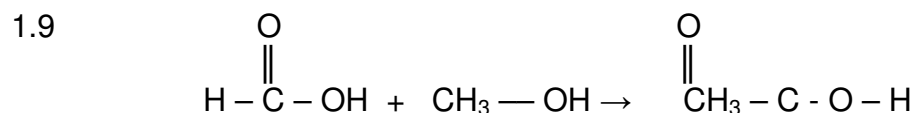


1.6 2,3-dimethylbutane

1.7



1.8 Esters.



2.1 Methyl ethanoate

2.2 Methanol and ethanoic acid

### 2.3 Propanoic acid

