

Cambridge (CIE) IGCSE Co-ordinated Sciences (Double Award): Chemistry



Your notes

Formulae, Functional Groups & Terminology

Contents

- * Organic Formulae
- * Homologous Series
- * Saturated & Unsaturated Compounds
- * Naming Organic Compounds

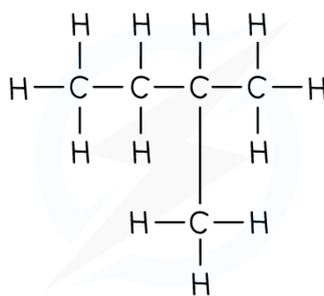


Displayed formulae

- Organic Chemistry is the scientific study of the structure, properties, and reactions of organic compounds.
- Organic compounds are those which contain carbon
- For conventional reasons metal carbonates, carbon dioxide and carbon monoxide are **not** included in organic compounds
- Many of the structures you will be drawing are hydrocarbons
- A **hydrocarbon** is a compound that contains **only** hydrogen and carbon atoms
- Organic compounds can be represented in a number of ways:
 - Displayed Formulae
 - General Formulae
 - Structural Formulae

The **displayed formula** shows the spatial arrangement of all the atoms and bonds in a molecule

- For example:



- This displayed formula tells us several things about the compound
 - It has 5 carbon atoms
 - It has 12 hydrogen atoms
 - It has only single bonds



Examiner Tips and Tricks

It's really important to show ALL the bonds between atoms in displayed formulae.

For example, in the -OH group for an alcohol, the bond between the oxygen and hydrogen atom must be shown.



Your notes



Homologous series

- A homologous series is a family of organic compounds that have similar features and chemical properties due to them having the same **functional group**
- The functional group is a group of atoms which are bonded in a specific arrangement that is responsible for the characteristic reactions of each member of a homologous series

Table of compounds & their functional groups

Family	Functional Group	Name ends in...
Alkane	C-C	-ane
Alkene	C=C	-ene
Alcohol	-OH	-ol



Examiner Tips and Tricks

Make sure you can identify the functional group for each homologous series.

General characteristic of homologous series

Extended tier only

- All members of a homologous series have:
 - The **same general formula**
 - **Same functional group**
 - The difference in the molecular formula between one member and the next is CH_2
- These characteristics are shown below for ethanol and propanol, which belong to homologous series, alcohols

Table of characteristics of ethanol and propanol

	Ethanol	Propanol

Molecular formula	CH ₃ CH ₂ OH	CH ₃ CH ₂ CH ₂ OH
General formula	C _n H _{2n+1} OH	C _n H _{2n+1} OH
Functional group	-OH	-OH
Boiling point (°C)	78	97



Your notes



Examiner Tips and Tricks

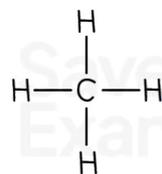
Make sure you learn the general formula for each homologous series.



Saturated & unsaturated Compounds

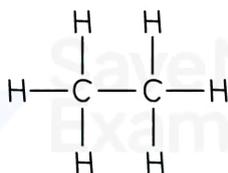
What are saturated compounds?

- **Saturated compounds** are molecules with only **single carbon-carbon bonds** (C-C)
 - Each carbon atom has 4 single bonds to other atoms
- **Alkanes** are examples of saturated compounds
- Alkanes have the general formula C_nH_{2n+2}
- The first three alkanes are:
 1. Methane, CH_4



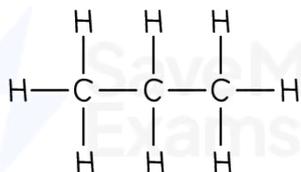
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2. Ethane, C_2H_6



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3. Propane, C_3H_8



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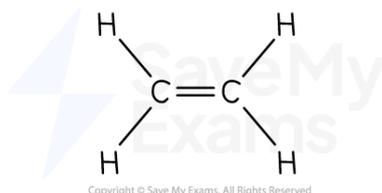
What are unsaturated compounds?

- **Unsaturated compounds** are molecules with one or more carbon-carbon **double bonds** (C=C)

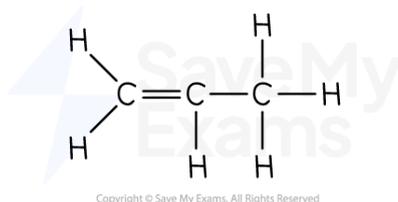


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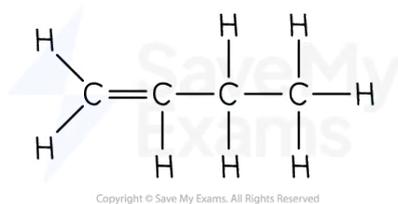
- Each carbon atom has 4 bonds to other atoms
- But, one bond is a double bond
- **Alkenes** are examples of unsaturated compounds
- Alkenes have the general formula C_nH_{2n}
- The first three alkenes are:
 1. Ethene, C_2H_4



2. Propene, C_3H_6



3. Butene, C_4H_8



Examiner Tips and Tricks

Remember:

Saturated compounds have **S**ingle bonds only.

Unsaturated compounds have do**U**ble bonds



Naming organic compounds

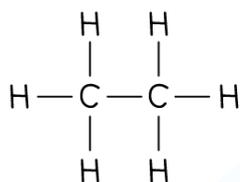
- The names of organic compounds have two main parts:
 - the stem (sometimes called the prefix)
 - end part (or suffix)
- The stem indicates the number of carbon atoms present in the longest continuous chain of the compound

Number of carbon atoms in the longest chain	Part of the chemical's name
1	meth
2	eth
3	prop
4	but
5	pent
6	hex

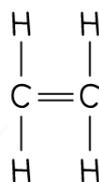
- The end part of the name tells you what **functional group** is in the compound

End part of the name	Functional group	Organic family
ane	none (contains only C-C bonds)	Alkane
ene	C=C bond	Alkene
anol	-OH	Alcohol
anoic acid	-COOH	Carboxylic acid
amine	-NH ₂	Amine
-yl -anoate	-COO-	Ester

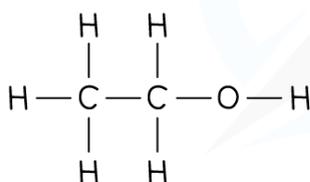
Structures of organic compounds



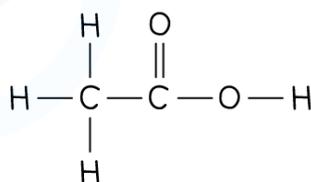
ETHANE



ETHENE



ETHANOL



ETHANOIC ACID

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Worked Example

Name the following organic compounds:

1	2	3
$ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}=\text{C}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array} $	$ \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} $	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{C}-\text{H} \\ \quad \quad \quad \quad \\ \text{H} \quad \text{O} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \\ \quad \text{H} \end{array} $

Answers:

1. Propene

- The longest carbon chain is 3 carbons, so the name contains **prop**
- The functional group is C=C, so the name contains **-ene**

2. Propanol

1. The longest chain is 3 carbons, so the name is **prop**
2. The functional group is OH, so the name contains **-anol**

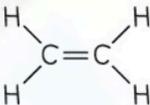
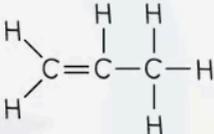
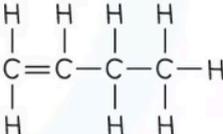
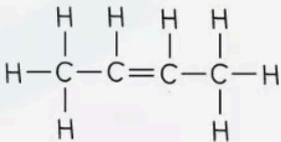
3. Pentanol

- The longest carbon chain is 5 carbons, so the name contains **pent**

- This indicates that those compounds contain only single carbon-carbon bonds, C-C

Alkenes

- As before, the number of carbon atoms gives the part of the compounds name
- Alkenes contain at least one **double carbon-carbon bond, C=C**, which means that their name ends with **-ene**
 - The first alkene is ethene because you must have two carbons to be able to form a double carbon-carbon bond, C=C
- After propene, you must state the number of the first carbon that is part of the double carbon-carbon bond, C=C
 - e.g. but-1-ene has a double carbon-carbon bond, C=C, on the first carbon in the chain
 - But-2-ene has a double carbon-carbon bond, C=C, on the second carbon in the chain

Alkene	Structural formula	Displayed formula
Ethene	$\text{CH}_2=\text{CH}_2$	
Propene	$\text{CH}_2=\text{CHCH}_3$	
But-1-ene	$\text{CH}_2=\text{CHCH}_2\text{CH}_3$	
But-2-ene	$\text{CH}_3\text{CH}=\text{CHCH}_3$	

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Alcohols

- As before, the number of carbon atoms gives the part of the compounds name
- Alcohols contain an **alcohol / hydroxyl group, -O-H**, which means that their name ends with **-anol**



- After ethanol, you must state the number of the carbon that has the alcohol / hydroxyl group, $-O-H$, attached
 - e.g. propan-1-ol has the alcohol / hydroxyl group, $-O-H$, on the first carbon in the chain
Propan-2-ol has the alcohol / hydroxyl group, $-O-H$, on the second carbon in the chain

Alcohol	Structural formula	Displayed formula
Methanol	CH_3OH	$\begin{array}{c} H \\ \\ H-C-O-H \\ \\ H \end{array}$
Ethanol	CH_3CH_2OH	$\begin{array}{c} H \quad H \\ \quad \\ H-C-C-O-H \\ \quad \\ H \quad H \end{array}$
Propan-1-ol	$CH_3CH_2CH_2OH$	$\begin{array}{c} H \quad H \quad H \\ \quad \quad \\ H-C-C-C-O-H \\ \quad \quad \\ H \quad H \quad H \end{array}$
Propan-2-ol	$CH_3CHOHCH_3$	$\begin{array}{c} H \quad H \quad H \\ \quad \quad \\ H-C-C-C-H \\ \quad \quad \\ H \quad O \quad H \\ \\ H \end{array}$
Butan-1-ol	$CH_3CH_2CH_2CH_2OH$	$\begin{array}{c} H \quad H \quad H \quad H \\ \quad \quad \quad \\ H-C-C-C-C-O-H \\ \quad \quad \quad \\ H \quad H \quad H \quad H \end{array}$
Butan-2-ol	$CH_3CH_2CHOHCH_3$	$\begin{array}{c} H \quad H \quad H \quad H \\ \quad \quad \quad \\ H-C-C-C-C-H \\ \quad \quad \quad \\ H \quad O \quad H \quad H \\ \\ H \end{array}$

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Carboxylic acids

- As before, the number of carbon atoms gives the part of the compounds name



Your notes

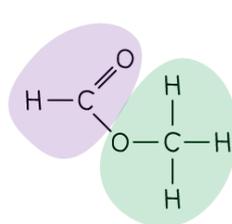
- Carboxylic acids contain a **carboxylic acid group**, $-\text{COOH}$, which means that their name ends with **-anoic acid**
- There is no need to number carboxylic acids because the carbon that is part of the carboxylic acid group is automatically the first carbon of the chain

Carboxylic acid	Structural formula	Displayed formula
Methanoic acid	HCOOH	$\begin{array}{c} \text{O} \\ \parallel \\ \text{H}-\text{C}-\text{O}-\text{H} \end{array}$
Ethanoic acid	CH_3COOH	$\begin{array}{c} \text{H} \quad \text{O} \\ \quad \parallel \\ \text{H}-\text{C}-\text{C}-\text{O}-\text{H} \\ \\ \text{H} \end{array}$
Propanoic acid	$\text{CH}_3\text{CH}_2\text{COOH}$	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{O} \\ \quad \quad \parallel \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{O}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array}$
Butanoic acid	$\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$	$\begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{O} \\ \quad \quad \quad \parallel \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{O}-\text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array}$

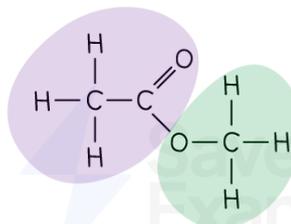
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Esters

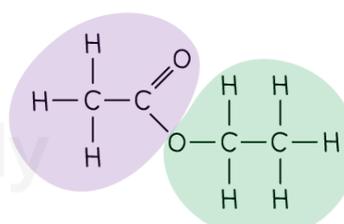
- Esters are one of the more challenging compounds to name
- Their name is based on the original alcohol and carboxylic acid that they were prepared from



METHYL
METHANOATE



METHYL
ETHANOATE



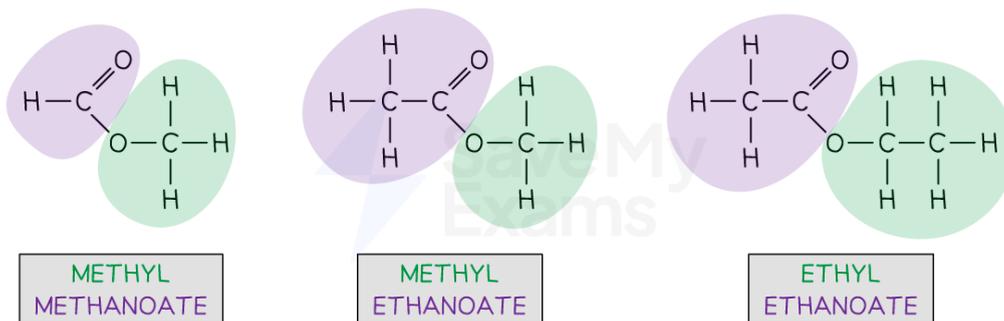
ETHYL
ETHANOATE

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Your notes

- Ester names are confusing because the name is written backwards from the way the structure is drawn



- Methyl methanoate
 - The alcohol portion of the molecule contains the C–O single bond and is coloured green
 - There is one carbon, so this gives the methyl part of the name
 - The carboxylic acid portion contains the C=O double bond and is coloured purple
 - There is one carbon, so this gives the methanoate part of the name
- Methyl ethanoate
 - The alcohol portion of the molecule contains the C–O single bond and is coloured green
 - There is one carbon, so this gives the methyl part of the name
 - The carboxylic acid portion contains the C=O double bond and is coloured purple
 - There are two carbons, so this gives the ethanoate part of the name
- Ethyl ethanoate
 - The alcohol portion of the molecule contains the C–O single bond and is coloured green
 - There are two carbons, so this gives the ethyl part of the name
 - The carboxylic acid portion contains the C=O double bond and is coloured purple
 - There are two carbons, so this gives the ethanoate part of the name



Examiner Tips and Tricks

Extended tier students should be able to draw the structural and displayed formulae for all of the compounds written above.