

GS EDUCATION

**INTRODUCTION TO**

**ORGANIC CHEMISTRY**

**WORKBOOK**

FOR AQA A-LEVEL CHEMISTRY

# FORMULAE

Organic chemistry focuses on carbon-containing compounds. This is a huge area of chemistry and you'll learn about a wide range of compounds and their reactions as part of your A-Level studies. This workbook introduces some of the key concepts that you'll use in later sections, starting with the different types of formulae.

## TYPES OF FORMULAE

Organic compounds may be represented by various different formulae. You need to make sure you know what each term means and how to write or draw each type (there's a worksheet to help with this later in the workbook).

State the meaning of each of the following terms:

### Molecular formula

### Empirical formula

### Displayed formula

### Structural formula

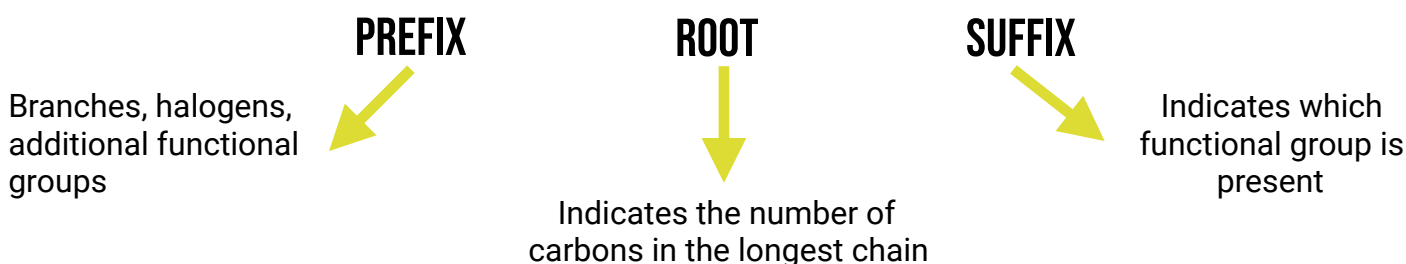
### Skeletal formula

# NOMENCLATURE

The names of organic compounds are based on the IUPAC system. Their name is determined by the number and arrangement of carbons, and the functional group(s).

## IUPAC NOMENCLATURE

IUPAC names have 3 components:



## THE ROOT

You should know the root for compounds that have between 1 and 8 carbons in their longest chain or ring. Fill in the boxes to show the root names for 1-8 carbons:

1	2	3	4
5	6	7	8

The vowel that follows the root name indicates whether the molecule is **saturated or unsaturated**.

For **saturated compounds** the root name is followed by an **a** (e.g. ethane) For **unsaturated compounds** the root name is followed by an **e** (e.g. ethene).

**What is meant by the term 'saturated'?**

**What is meant by the term 'unsaturated'?**

## THE SUFFIX

The suffix name makes up the end of the name and indicates which functional group is present. The functional group is the reactive part of the molecule, so compounds that have the same functional group do the same reactions and are said to belong to the same **homologous series**.

If the functional group can have more than one possible position the suffix may be preceded by a number to indicate its position on the carbon chain. This is only necessary if the functional group has more than one possible position (e.g. alcohols, alkenes).

Fill in the boxes to show the the **suffix name** for each homologous series:

**Alkanes**  
**Alcohols**  
**Aldehydes**  
**Amines**


**Alkenes**  
**Ketones**  
**Nitriles**  
**Carboxylic acids**


When you write a structural formula, it's important that you represent the functional groups according to the convention. If you write the atoms in the incorrect order you could end up suggesting that the molecule contains a different functional group

Fill in the boxes to show the correct way to write the following **functional groups** in structural formulae.

**Alkanes**  
**Alcohols**  
**Aldehydes**  
**Amines**


**Alkenes**  
**Ketones**  
**Nitriles**  
**Carboxylic acids**


NOTE: these are not the only homologous series you will meet in the full 2 years of A-level Chemistry, but these are the ones you will come across in year 1/AS Chemistry.

## THE PREFIX

Prefixes are used before the root name to indicate the following:

- The presence of any carbon side-chains
- The presence of halogens
- Any functional groups in addition that that which makes up the suffix.

Give the prefixes used for the following groups:

Fluorine		Chlorine	
Bromine		Iodine	
Hydroxyl (OH)		Amine (NH <sub>2</sub> )	
CH <sub>3</sub>		C <sub>2</sub> H <sub>5</sub>	
C <sub>3</sub> H <sub>7</sub>		C <sub>4</sub> H <sub>9</sub>	

The prefix '**cyclo**' may also be used to indicate that that the compound has a cyclic (ring) structure. If a prefix has more than one possible position on the carbon chain it should be numbered. The number is placed before the prefix itself.

If more than one of the same groups is present, **di**, **tri**, **tetra** (etc.) can be used before the prefix (but after the number) to indicate this. Remember to number each group. (e.g. a compound with 2 methyl groups on carbon 2 would be 2,2-dimethyl).

**If the compound has more than one type of group or branch (e.g. a chlorine or methyl group) what order should these be placed in at the start of the name?**

NOTE: Alkenes may also be named with an E or Z prefix. This not covered here, but it is covered in the alkenes workbook.

## PUNCTUATION

The IUPAC system of nomenclature also has rules about the use of punctuation:

- Numbers should be separated from numbers by a **comma**
- Numbers should be separated from words by a **hyphen**

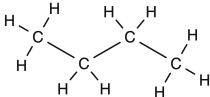
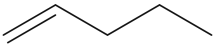

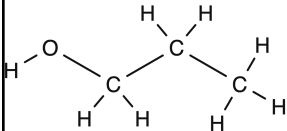
# NOMENCLATURE & FORMULAE

Time to put into practice what you've learnt! Complete the table below to show the different types of formulae for the compounds in column 1.

NAME	MOLECULAR FORMULA	DISPLAYED FORMULA	STRUCTURAL FORMULA	SKELETAL FORMULA
Ethane				
Propene				
2-chlorobutane				
Propan-1-ol				
3-methylpentane				

# NOMENCLATURE & FORMULAE

Time to put into practice what you've learnt! Complete the table below to show the names and other formulae for the compounds shown in the table.

NAME	MOLECULAR FORMULA	DISPLAYED FORMULA	STRUCTURAL FORMULA	SKELETAL FORMULA
				
				
			(CH <sub>3</sub> ) <sub>3</sub> CCH <sub>2</sub> CH <sub>3</sub>	
				
				

# NOMENCLATURE & FORMULAE

These compounds may be a little less familiar to you, depending on where you are in your studies, so you may want to leave this worksheet until later in your studies.

NAME	MOLECULAR FORMULA	DISPLAYED FORMULA	STRUCTURAL FORMULA	SKELETAL FORMULA
ethylamine	$C_2H_3N$			
Propanal	$C_3H_6O$			
Butanamide	$C_4H_7ON$			
Pentan-3-one	$C_5H_{10}O$			
Propanoic acid	$C_3H_6O_2$			



# NOMENCLATURE & FORMULAE

Time to put into practice what you've learnt! Complete the table below to show the different types of formulae for the compounds in column 1. These are more challenging than the ones on the previous pages, so don't be concerned if you struggle a little.

NAME	MOLECULAR FORMULA	DISPLAYED FORMULA	STRUCTURAL FORMULA	SKELETAL FORMULA
3-ethylpentane	$C_7H_{16}$			
Cyclohexane	$C_6H_{12}$			
2,2-dibromo-1-chloropropane	$C_3H_5Br_2Cl$			
4,4-dimethylpentan-1-ol	$C_7H_{16}O$			
Propane-1,2-diol	$C_3H_8O_2$			

# HOMOLOGOUS SERIES

What is meant by the term 'homologous series'?

What characteristics do members of a homologous series have in common?

How do members of a homologous series differ from each other?

Describe and explain the trend in melting and boiling point in a homologous series

Why do branched chain members of a homologous series have lower melting and boiling points than straight-chain compounds with the same molecular mass?

# ISOMERISM

Many of the organic chemistry questions require you to be able to draw or recognise isomers. To do this successfully, you need to be aware of all the different types of isomers.

## TYPES OF ISOMERS

What are 'structural isomers'?

What are 'stereoisomers'?

Complete the table below to show the different types of isomers and add an explanation for each.

	TYPE OF ISOMER	EXPLANATION
STRUCTURAL ISOMERS		
STEREISOMERS	Optical	(you'll learn about this in year 2)

## PRACTICE DRAWING ISOMERS

In the space below draw all of the chain isomers with the molecular formula  $C_7H_{16}$

You should also name all of the isomers you draw and give their structural formula. (hint: you should find 9. It's a good idea to name them as you draw them to help you notice where you've drawn the same isomer more than once).


## PRACTICE DRAWING ISOMERS

There are 4 straight-chain alcohol positional isomers with the formula  $C_7H_{16}O$ .  
In the space below **draw** these isomers, **name** them and write their **structural formulae**.


Draw and name 2 positional and 2 chain isomers of 2-chloro-2-methylpentane.


## FUNCTIONAL GROUP ISOMERS

You need to know which homologous series' are isomeric with each other. You may not be able to answer the question about carboxylic acids until year 2.

**Which homologous series is isomeric with the alkenes?**

**Draw 2 functional group isomers with the formula  $C_4H_8$**

**Which homologous series is isomeric with the alcohols? (hint: this isn't in the text book)**

**Draw 2 functional group isomers with the formula  $C_4H_{10}O$**

**Which homologous series is isomeric with the aldehydes?**

**Draw 2 functional group isomers with the formula  $C_6H_{12}O$**

**Which homologous series is isomeric with the carboxylic acids?**

**Draw 2 functional group isomers with the formula  $C_6H_{12}O_2$**

# REACTIONS

In organic chemistry, we're not just interested in the overall reaction. We also need to know how the reactions take place i.e. the reaction mechanism.

Reaction mechanisms use 'curly arrows' to show the movement of electrons.

## CURLY ARROWS

Curly arrows show the movement of electrons when covalent bonds are broken or formed. The arrows **start from where the electrons are** and end where the electrons are going.

This means that the arrows will either start from the middle of a bond or a lone pair, and end at either the atom that is accepting the electrons or between 2 atoms that will be sharing the pair of electrons to form a double bond.

## BOND FISSION

Organic reactions involve the breaking of covalent bonds. Bonds can either break by homolytic fission or heterolytic fission.

**Describe what happens when a bond breaks by homolytic fission. Write an equation to show the reaction that takes place when one of the C-H bonds in methane breaks by homolytic fission.**

**Describe what happens when a bond breaks by heterolytic fission. Write an equation to show the reaction that takes place when one of the C-H bonds in methane breaks by heterolytic fission.**

# EXAM TECHNIQUE

As you work through the past papers, do the following 4 things and use the next few pages to make your notes:

- Use the mark schemes to help you understand what the examiner is looking for. Make notes on how to structure your answers and what to include in your explanations.
- Check that your definitions match what the mark scheme says and if not make sure you amend your notes.
- Make a note of any extra examples or details you see in the questions that you hadn't picked up on before.
- Write down the methods for any calculations you come across that you haven't seen before.



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## EXAM TECHNIQUE NOTES CONTINUED