Edexcel International AS Chemistry

Your notes

Introductory Organic Chemistry

Contents

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Hazards & Risks

- The hazard of a chemical substance relates to the inherent properties of the substance
- The risk is more to do with how you plan to use it and the chance of it causing harm
- For example, water generally has no hazards however a beaker of water being boiled on a tripod and gauze has several risks associated with it
  - The steam coming from the water and the boiling water could both cause damage if they came into contact with your skin
- Another example would be hydrochloric acid, a substance most people generally consider hazardous
- You will have been told to use eye protection when using the acid as it can potentially cause harm to your eyes
  - This is due to hydrochloric acid being corrosive
- This risk, however, depends on how likely it is the acid will get in your eyes
  - Using eye protection does not affect the hazard, but does decrease the risk

Hazard warning symbols

Table showing the most common hazard symbols

Hazard symbol	Meaning	Description
	Health hazard	includes warning on skin rashes, eye damage and ingestion
	Corrosive	can cause skin burns and permanent eye damage

	Flammable	can catch fire if heated or comes into contact with a flame
	Acute toxicity	can cause life-threatening effects, even in small quantities
	Oxidising	can supply oxygen to fuel fires or cause explosions
	Dangerous to the environment	can cause lasting harm to aquatic life and ecosystems
	Health hazard	can indicate carcinogenic, mutagenic or reproductive hazards

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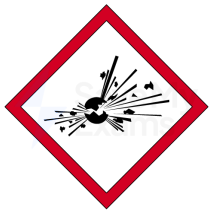
	Gas under pressure	can explode if heated or release gas rapidly if the container is damaged
	Explosive	can explode through shock, friction or exposure to heat

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Risk assessments

- Risk assessments can be used to help reduce the risk of certain hazards in a laboratory
- This is carried out by looking at the hazards of the chemical substances being used
- The way the substances will be used is considered to assess the risk associated
- Control measures or guidelines are then written in order to inform other people using the lab how to operate to reduce the risks associated with the chemicals
- Such guidelines will consider lots of different factors including:
  - The amount used
  - The age and experience of the person using it
  - Whether it will be heated
  - Whether ventilation or a fume cupboard should be used
- The control measures may include
  - The type of eye protection that needs to be worn
  - The need to wear gloves
  - Keeping a cap on a bottle after removing some of the substance
  - Keeping the substance away from a source of heat
  - What to do if some of the substance is spilt on the floor or gets on the skin

Examiner Tips and Tricks

When an exam question asks you to suggest a precaution when tackling a practical assignment you cannot just say 'wear a lab coat and goggles'.

This is standard practice in any practice. Therefore you need to comment on the particular procedure in the practical e.g.

'HCl gas is produced, so this step needs to be carried out in a fume cupboard'

Your notes

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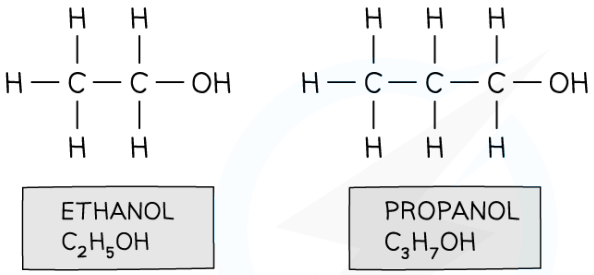
Functional Groups & Homologous Series

Homologous series

- A homologous series is a group of organic compounds that have the same functional group, but each successive member differs by CH_2



- BOTH HAVE AN ALCOHOL FUNCTIONAL GROUP (–OH)
- BOTH HAVE THE SAME GENERAL FORMULA ($C_nH_{2n+1}OH$)
- BOTH HAVE SIMILAR CHEMICAL REACTIVITY

Ethanol and propanol belong to the same homologous series

Homologous Series of Alkanes

Name of alkane	Number of carbons	Chemical formula	Boiling point in °C	State at room temperature	Melting point in °C
Methane	1	CH_4	−162	gas	−182
Ethane	2	C_2H_6	−89	gas	−183
Propane	3	C_3H_8	−42	gas	−188
Butane	4	C_4H_{10}	−1	gas	−138
Pentane	5	C_5H_{12}	36	liquid	−130

- Things we can say about a **homologous series:**
  - Each member has the same **functional group**
  - Each member has the same **general formula**
  - Each member has **similar** chemical properties

- Each successive member differs by $-CH_2-$
- Members have gradually changing physical properties, for example, boiling point, melting point and density

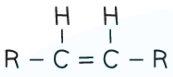
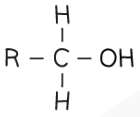
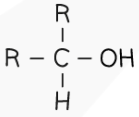
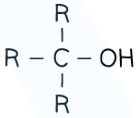
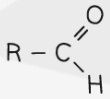
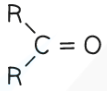
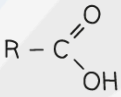
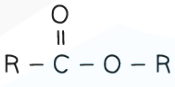
- As a homologous series is ascended, the size of the molecule increases
- This has an effect on the physical properties, such as boiling point and density

Your notes

Functional Groups

- Functional groups determine the physical and chemical properties of molecules
- The table below shows a summary of common functional groups found in compounds
- R is any other atom or group of atoms (except for hydrogen)

Functional Groups Found in Compounds Table

Family	Functional Group
Alkene	
Halogenoalkane	R – X Where X = F, Cl Br and I
Alcohol	 Primary alcohol  Secondary alcohol  Tertiary alcohol
Aldehydes	
Ketone	
Carboxylic Acid	
Ester	
Primary Amine	$R-NH_2$
Nitrile	$R-C\equiv N$

Your notes

IUPAC Nomenclature

- **Systematic nomenclature** can be used to name organic compounds and therefore make it easier to refer to them
- The **alkanes** provide the basis of the naming system and the **stem** of each name indicates how many carbon atoms are in the **longest chain** in one molecule of the compound

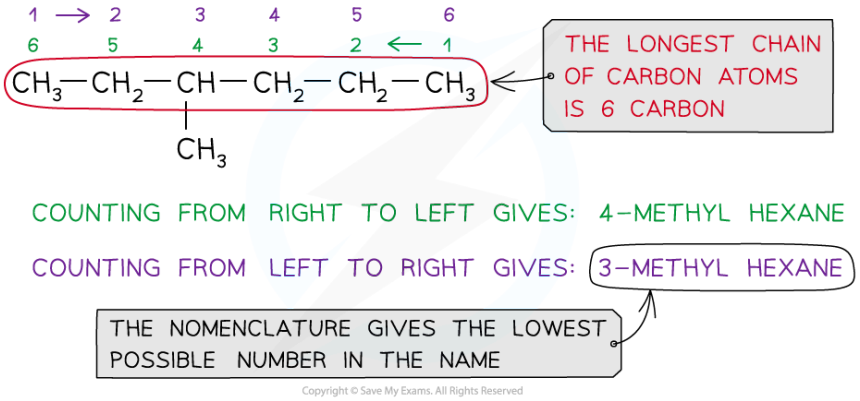
Nomenclature of Organic Compounds Table

Number of C atoms	Molecular formula of straight-chain alkane	Name of alkane	Stem used in naming
1	CH_4	methane	meth-
2	C_2H_6	ethane	eth-
3	C_3H_8	propane	prop-
4	C_4H_{10}	butane	but-
5	C_5H_{12}	pentane	pent-
6	C_6H_{14}	hexane	hex-
7	C_7H_{16}	heptane	hept-
8	C_8H_{18}	octane	oct-
9	C_9H_{20}	nonane	non-
10	$C_{10}H_{22}$	decane	dec-

- If there are any side-chains or functional groups present, then the position of these groups is indicated by numbering the carbon atoms in the longest chain starting at the end that gives the lowest possible numbers in the name
- The hydrocarbon **side-chain** is shown in **brackets** in the structural formula

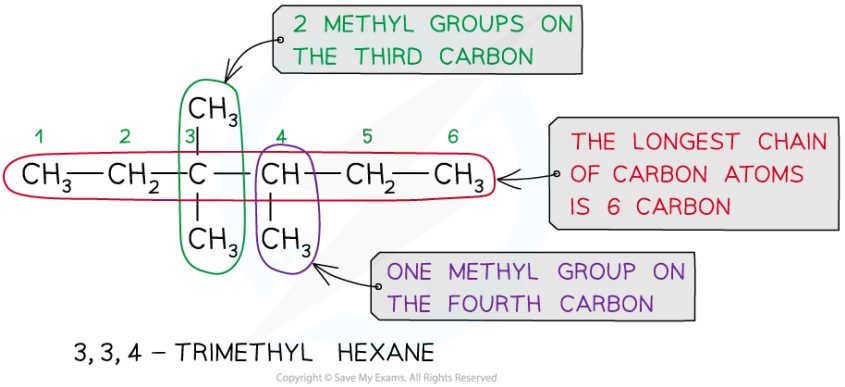
$$CH_3CH\mathbf{(CH_3)}CH_2CH_3$$

- The side-chain is named by adding '-yl' to the normal alkane **stem**
- This type of group is called an **alkyl** group



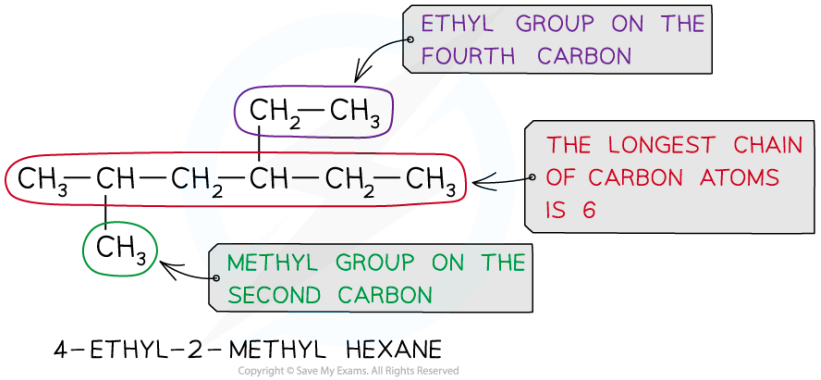
Naming Side Chains

- If there are more than one of the same alkyl side-chain or functional groups, **di-** (for two), **tri-** (for three) or **tetra-** (for four) is added in front of its name
- The adjacent **numbers** have a comma between them
- **Numbers** are separated from **words** by a hyphen



Naming Multiple Side Chains

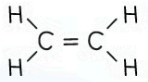
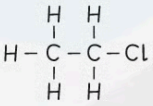
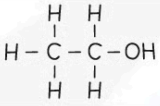
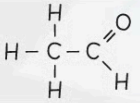
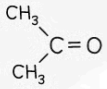
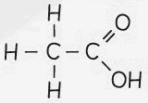
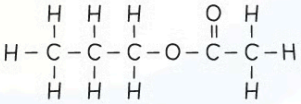
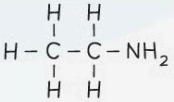
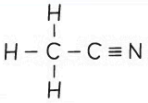
- If there is more than one type of alkyl side-chain, they are listed in alphabetic order



Your notes

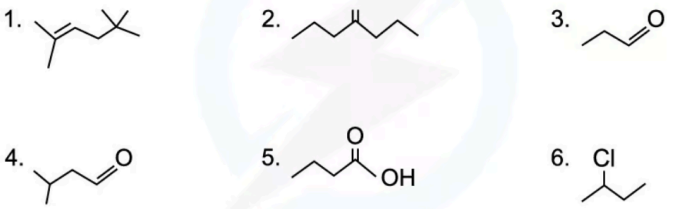
Functional Groups & their Nomenclature Table

Your notes

Functional Group	Nomenclature	Example	Name
Alkenes	– ene		Ethene
Halogenoalkane	chloro– fluoro– iodo– bromo–		Chloroethane
Alcohol	–ol		Ethanol
Aldehyde	–al		Ethanal
Ketone	–one		Propanone
Carboxylic Acid	–oic acid		Ethanoic acid
Ester	alkyl –oate		Propyl Ethanoate
Amine	alkyl –amine		Ethylamine
Nitrile	–nitrile		Ethane nitrile

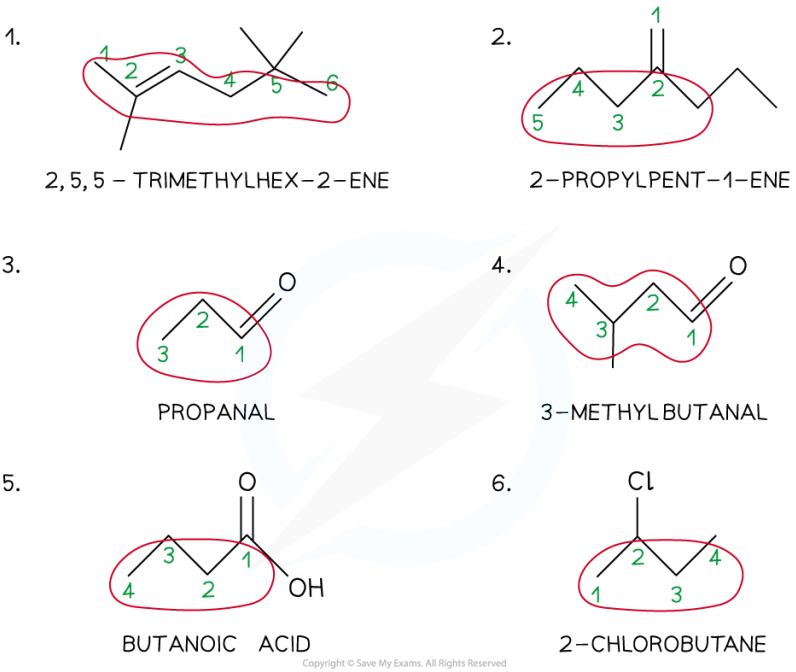
Worked Example

Naming organic molecules Name the following molecules using correct systematic nomenclature:



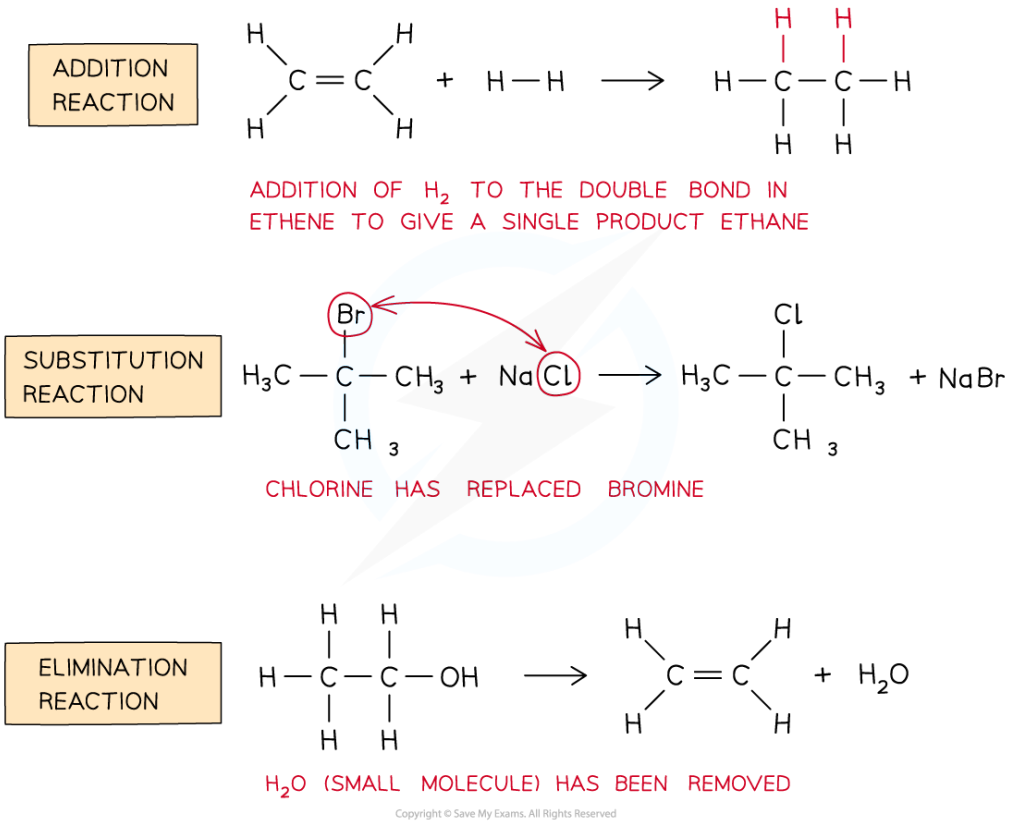
Your notes

Answer



Reaction Classification

- We can classify reactions into different types
  - An **addition** reaction is an organic reaction in which two (or more) molecules combine to give a **single product** with no other products
  - A **substitution** reaction is a reaction that involves **replacing** an atom or group of atoms by another
  - An **elimination** reaction is a reaction in which a small molecule (such as H_2O or HCl) is **removed** from an organic molecule
  - A **hydrolysis** reaction is a reaction in which a compound is **broken down** by **water** (it can also refer to the breakdown of a substance by dilute acids or alkali)
  - A **condensation** reaction is a reaction in which two organic molecules join together and in the process **eliminate** small molecules (such as H_2O or HCl)

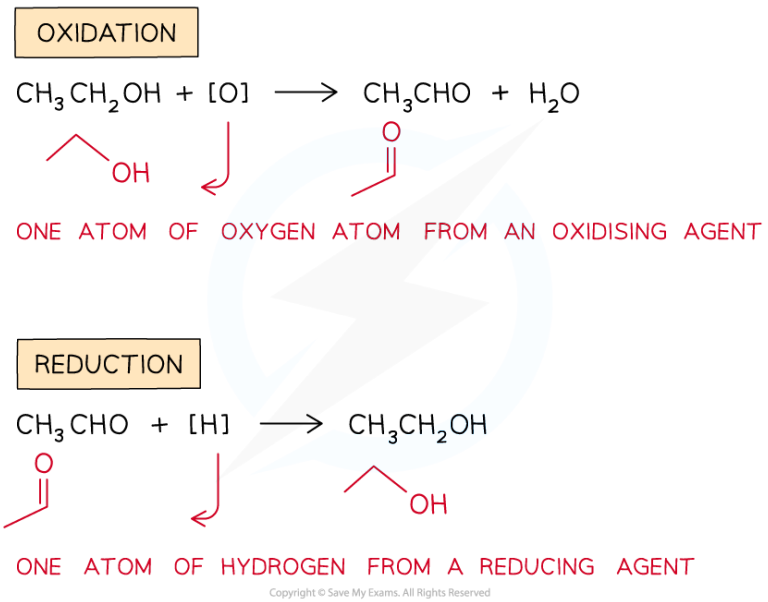


The different types of reactions in organic chemistry

Oxidation & reduction

- An **oxidation** reaction is a reaction in which oxygen is added, electrons are removed or the oxidation number of a substance is increased
  - In organic chemistry it often refers to the addition of oxygen or removal of hydrogen atoms to a substance
  - In equations for organic redox reactions, the symbol [O] can be used to represent one atom of oxygen from an oxidising agent
- A **reduction** reaction is a reaction in which oxygen is removed, electrons are added or the oxidation number of a substance is decreased
  - In organic chemistry it often refers to the removal of oxygen or addition of hydrogen atoms to a substance
  - In equations for organic redox reactions, the symbol [H] can be used to represent one atom of hydrogen from a reducing agent

Your notes



Your notes

In organic chemistry oxidation is often the gain of oxygen or loss of hydrogen atoms and reduction is the gain of hydrogen and loss of oxygen atoms

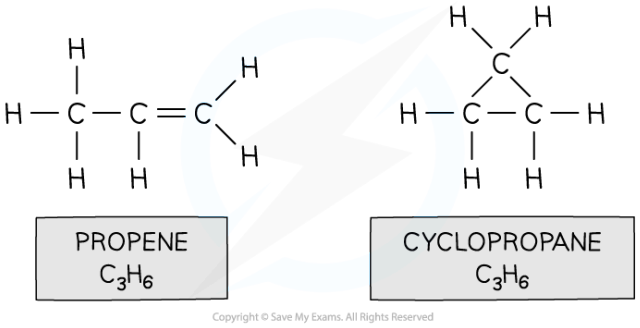
Polymerisation

- In the AS level course all the polymerisation reactions covered are examples of addition polymerisation
- Addition polymerisation is the reaction in which many **monomers** containing at least one C-C double bond form long chains of **polymers** as the only product

Your notes

Isomers – Structural

- **Structural isomers** are compounds that have the same **molecular** formula but different **structural** formulae
  - E.g. propene and cyclopropane

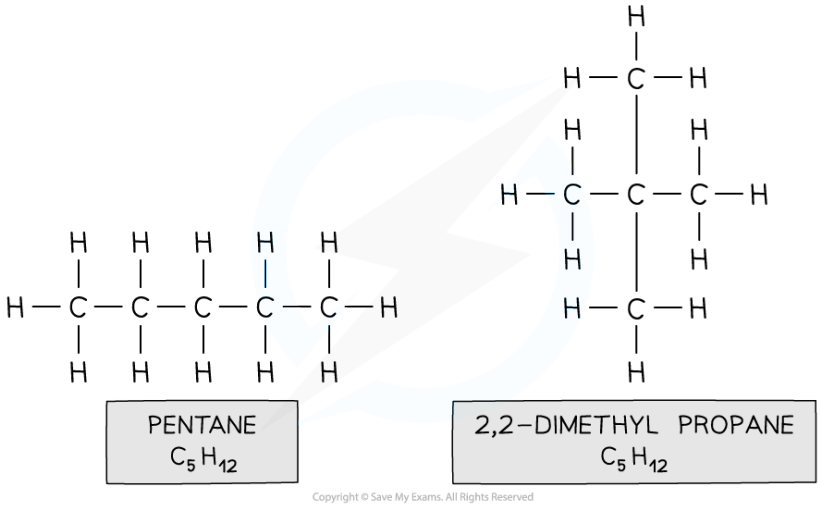


Both propene and cyclopropane are made up of 3 carbon and 6 hydrogen atoms but the structure of the two molecules differs

- There are two different types of structural isomerism you need to be aware of:
  - **Chain** isomerism
  - **Positional** isomerism

Chain isomerism

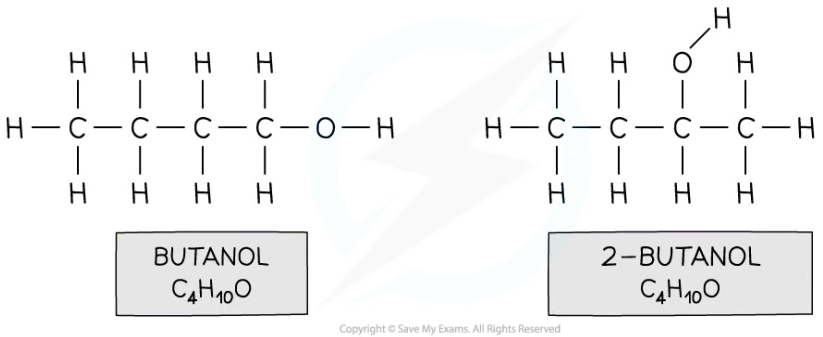
- **Chain isomerism** is when compounds have the same molecular formula, but their longest hydrocarbon chain is not the same
- This is caused by branching
  - E.g. pentane and 2,2–dimethylpropane



Both compounds are made up of the same atoms, however the longest carbon chain in pentane is 5 and in 2,2-dimethylpropane it is 3 (with two methyl branches)

Positional isomerism

- **Positional isomers** arise from differences in the position of a functional group in each isomer
  - The functional group can be located on different carbons
  - For example, butan-1-ol and butan-2-ol



Both compounds have an alcohol group and are made up of 4 carbons, 10 hydrogens and one oxygen, however in butanol the functional group is located on the first carbon and in 2-butanol on the second carbon

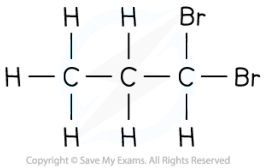
Worked Example

Isomers of dibromopropane How many isomers are there of dibromopropane, $C_3H_6Br_2$?

Your notes

Answer

Step 1: Draw the structural formula of the compound

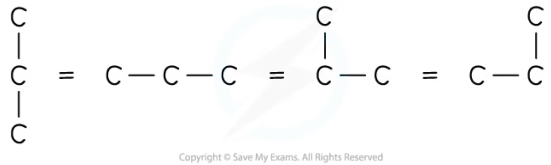


Step 2: Determine whether it is a stereo or structural isomer

There is no restricted bond rotation around the C-C bond, so it is structural isomerism

Step 3: Determine whether it is a functional group, chain or positional isomerism

- Functional group? No, as Br is the only functional group possible
  - Chain? No, as the longest chain can only be 3
  - Positional? Yes, as the two bromine atoms can be bonded to different carbon atoms



$C_3H_6Br_2$ THEREFORE HAS 4 STRUCTURAL ISOMERS

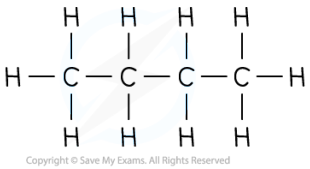
Worked Example

Your notes

Deducing isomers of C_4H_{10} How many isomers are there of the compound with molecular formula C_4H_{10}?

Answer

Step 1: Draw the structural formula of the compound

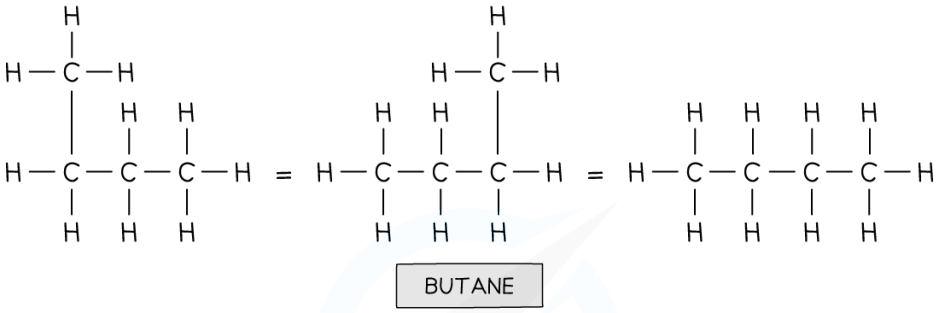


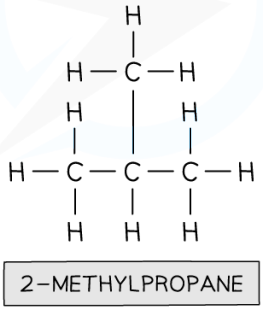
Step 2: Determine whether it is a stereo or structural isomer.

There is no restricted bond rotation around the C-C bond so it is structural isomerism

Step 3: Determine whether it is a functional group, chain or positional isomerism

- Functional group? No, as there are no functional groups
  - Positional? No, as there are no functional groups which can be positioned on different carbon atoms
  - Chain? Yes!





C_4H_{10} THEREFORE HAS 2 STRUCTURAL ISOMERS

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