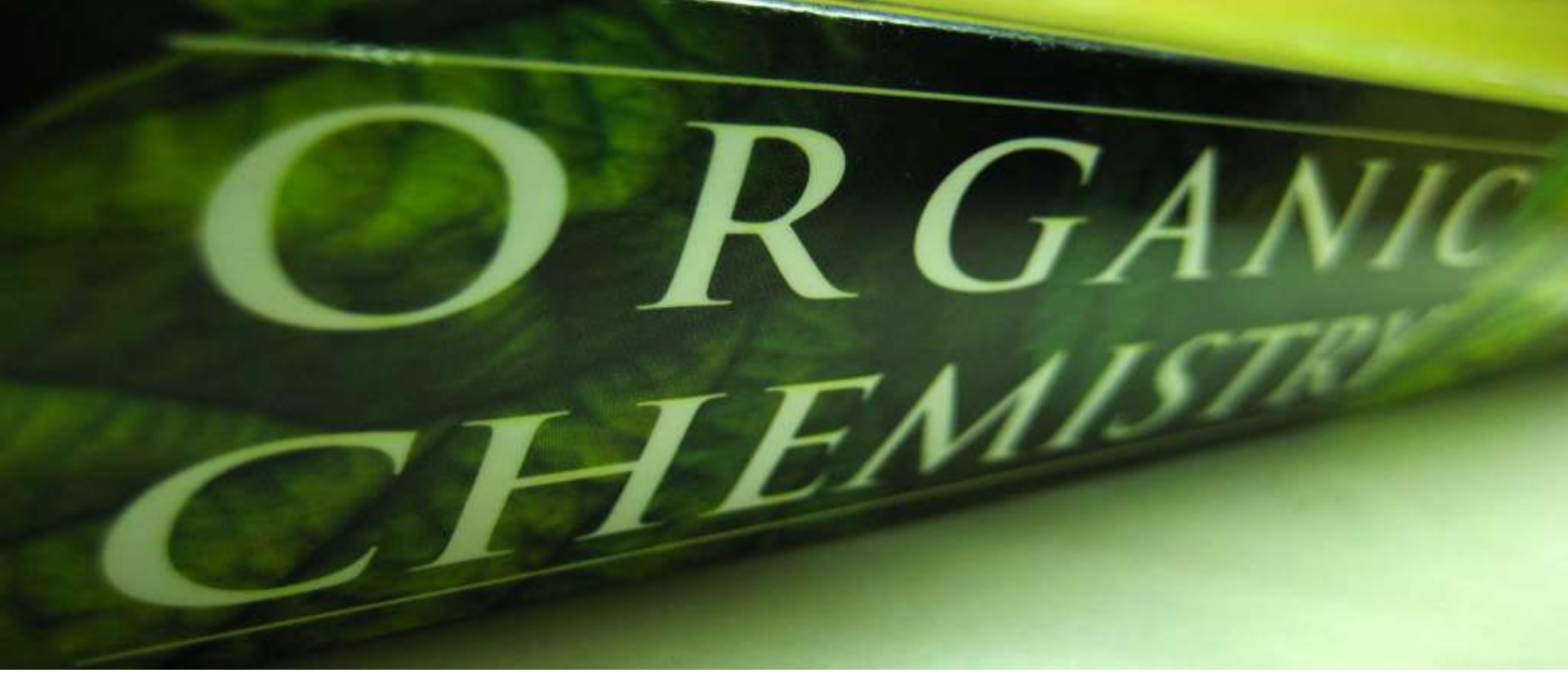

ALKANES

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Learning outcomes

Students should be able to:

1. Describe a homologous series and its general characteristics;

2. Describe the alkanes as a homologous series of saturated hydrocarbons with the general formula C_nH_{2n+2};

3. Draw the structures of branched and unbranched alkanes, C1 to C4 and name the unbranched alkanes C1 to C4;

4. Define isomerism and identify the isomers;

5. Describe the properties of alkanes;

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HOMOLOGOUS SERIES

- There are millions of different organic compounds and chemists have devised a method of classifying them into families with similar formulae and properties.
- Each family of organic compounds is called a **homologous series**.
- A homologous series is a family of compounds with the **same general formula, same functional group** and **similar chemical properties**.

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HOMOLOGOUS SERIES

Alkanes

Alcohols

Alkenes

Carboxylic Acids

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HOMOLOGOUS SERIES

- The alkanes and alkenes are **hydrocarbons** (containing hydrogen and carbon **only**).

C and H

- The alcohols and carboxylic acids contain carbon, hydrogen and **oxygen**.

C, H and O

HOMOLOGOUS SERIES CHARACTERISTICS

- Organic compounds in the same homologous series have the following characteristics:
- Same **general formula**
- Same **functional group**
- Similar **chemical properties but varying in reactivity**
- Physical properties **vary** gradually along the series

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FUNCTIONAL GROUPS AND GENERAL FORMULA

- A functional group is an atom or group of atoms that gives a compound its characteristic chemical properties.
- Organic compounds in the same homologous series have **similar chemical properties** due to the **same functional group**.
- Each member of the series differs from the next by a **$-CH_2-$** unit.

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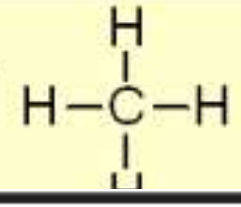
GENERAL FORMULA OF ALKANES?

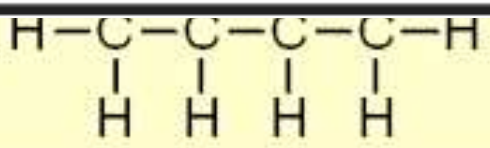
methane

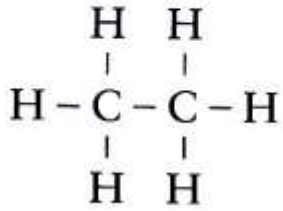
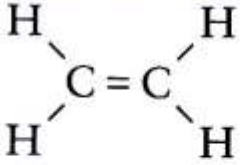
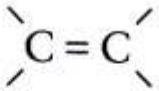
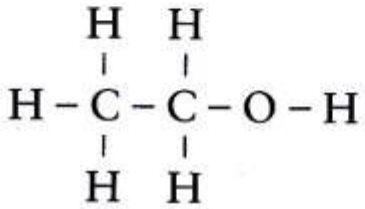
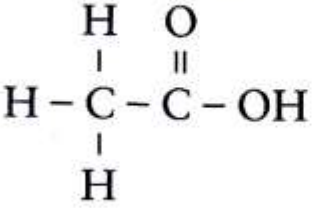
CH_4



$$C_nH_{2n+2}$$

C_4H_{10}



Homologous series	Example	Functional group	General formula
Alkanes	 Ethane	Nil	C_nH_{2n+2} where n = 1, 2, 3...
Alkenes	 Ethene	 Carbon–carbon double bond	C_nH_{2n} where n = 2, 3, 4...
Alcohols	 Ethanol	– O – H Hydroxyl group	$C_nH_{2n+1}OH$ (or $C_nH_{2n+2}O$) where n = 1, 2, 3...
Carboxylic acids	 Ethanoic acid	 Carboxyl group	$C_nH_{2n+1}COOH$ (or $C_nH_{2n+2}O_2$) where n = 0, 1, 2, 3...

NAMING ORGANIC COMPOUNDS

- The name of an organic compound is divided into two parts.
- The first part (prefix) tells us the number of carbon atoms in each molecule.

First part in the name	meth-	eth-	prop-	but-
Number of carbon atoms per molecule	one	two	three	four

- The second part (suffix) tells is which homologous series the compound belongs to

Second part in the name	-ane	-ene	-ol	-oic acid
Homologous series	alkane	alkene	alcohol	carboxylic acid

Name	Molecular Formula
methane	CH_4
ethane	C_2H_6
propane	C_3H_8
butane	C_4H_{10}
pentane	C_5H_{12}
hexane	C_6H_{14}
heptane	C_7H_{16}
octane	C_8H_{18}
nonane	C_9H_{20}
decane	$C_{10}H_{22}$

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No. of C atoms	Name of alkene	Molecular formula
2	Ethene	C_2H_4
3	Propene	C_3H_6
4	Butene	C_4H_8

$$C_nH_{2n}$$

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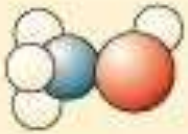
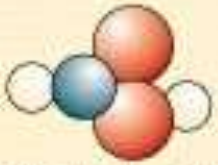
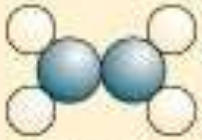
Alkane	Alcohol
CH_4 methane	CH_3OH methanol
CH_3CH_3 ethane	CH_3CH_2OH ethanol
$CH_3CH_2CH_3$ propane	$CH_3CH_2CH_2OH$ propanol
 methane	 methanol

Carboxylic acid	Alkene
HCO_2H methanoic acid	——
CH_3CO_2H ethanoic acid	CH_2CH_2 ethene
$CH_3CH_2CO_2H$ propanoic acid	CH_2CHCH_3 propene
 methanoic acid	 ethene

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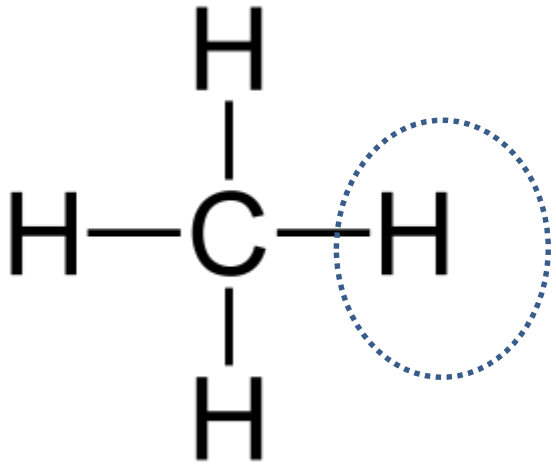
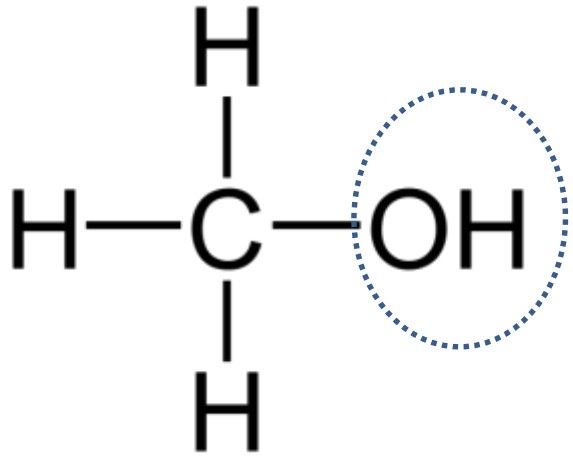


Methane

C_nH_{2n+2}



Methanol

$C_nH_{2n+1}OH$

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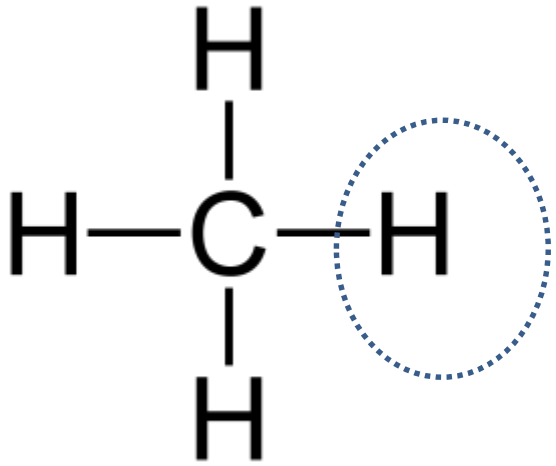
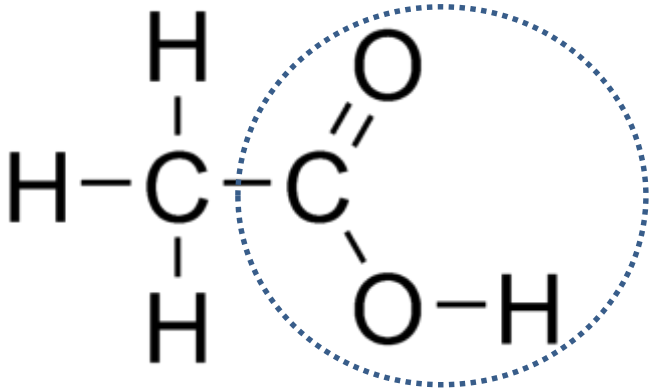


Methane

C_nH_{2n+2}



Ethanoic Acid

$C_nH_{2n+1}COOH$

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WHAT ARE ALKANES?

- Alkanes are a homologous series of **saturated hydrocarbons** that contain **only** carbon-carbon **single covalent bonds.**
- In an alkane molecule, all the outer electrons of each carbon are used in forming single covalent bonds with four other atoms, hence, alkanes are said to be **saturated**.
- Alkanes have the general formula $\mathbf{C_nH_{2n+2}}$ (where $n \geq 1$)

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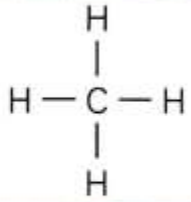
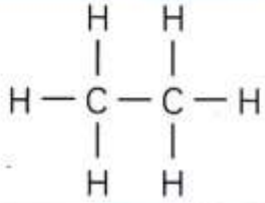
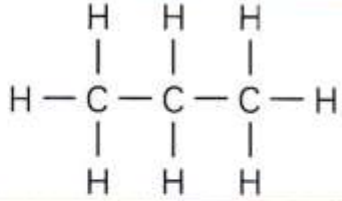
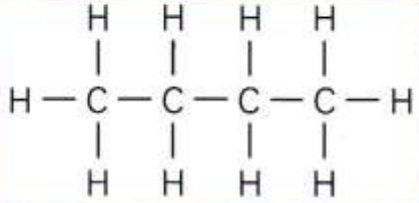
HOW ARE ALKANES REPRESENTED?

No. of C atoms	Name	Molecular formula	Full structural formula	Structural formula
1	methane	CH_4		CH_4
2	ethane	C_2H_6		CH_3CH_3
3	propane	C_3H_8		$CH_3CH_2CH_3$
4	butane	C_4H_{10}		$CH_3CH_2CH_2CH_3$

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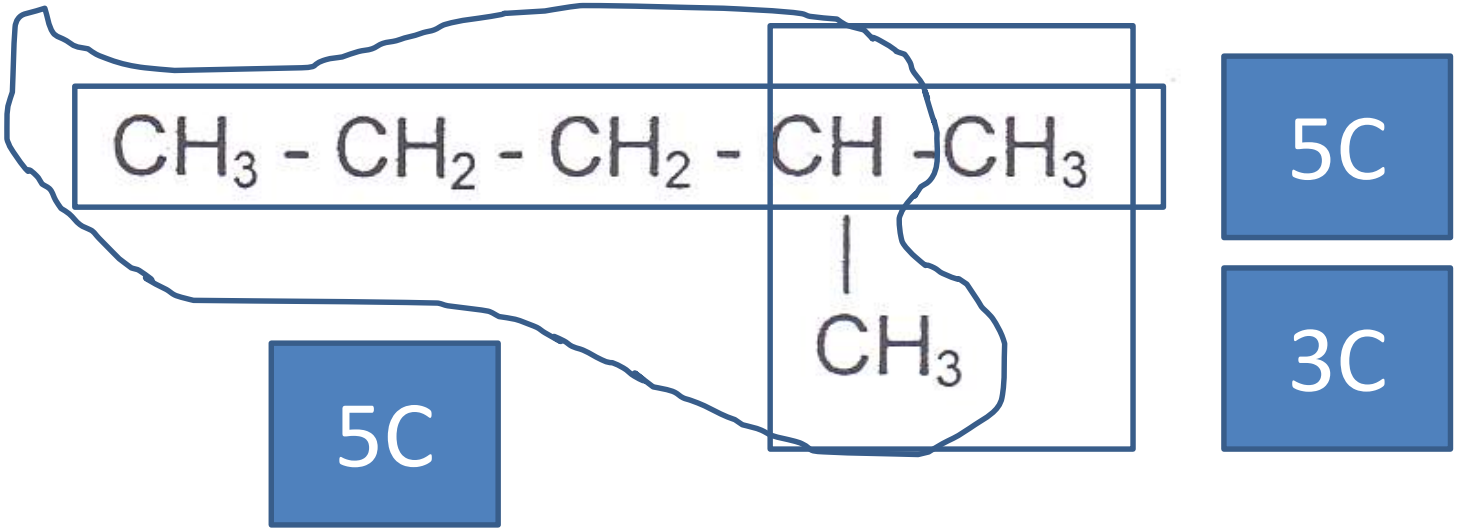
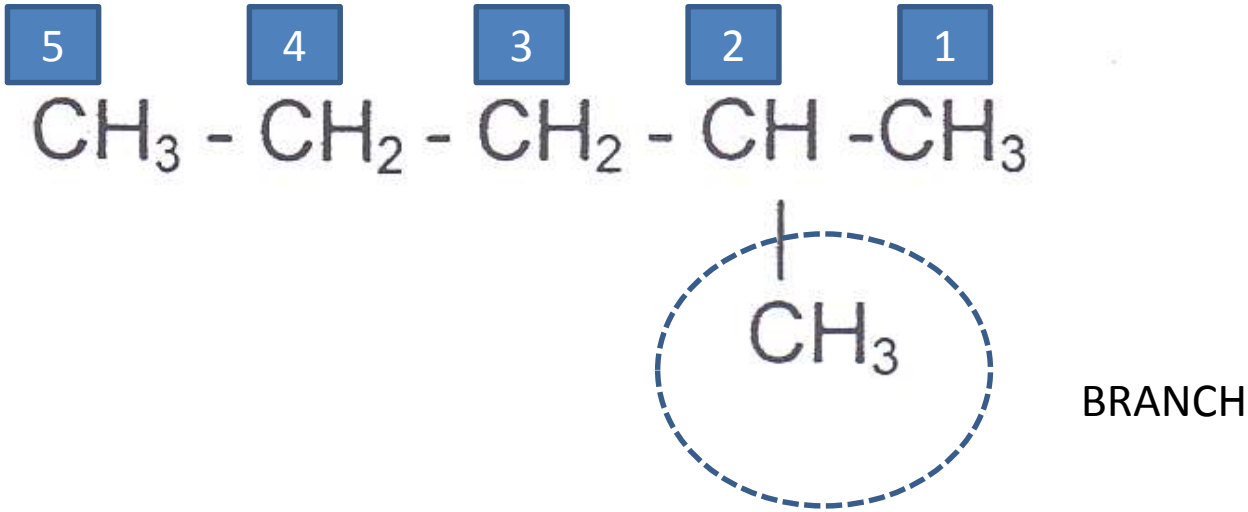
RULES FOR NAMING ALKANES

- Find the **longest** carbon chain in the compound. This gives the parent name of the compound.



RULES FOR NAMING ALKANES

- Number each carbon atom in the longest chain, **starting from the end nearest to the branch**. This means that the number appearing in the name is a smaller number.



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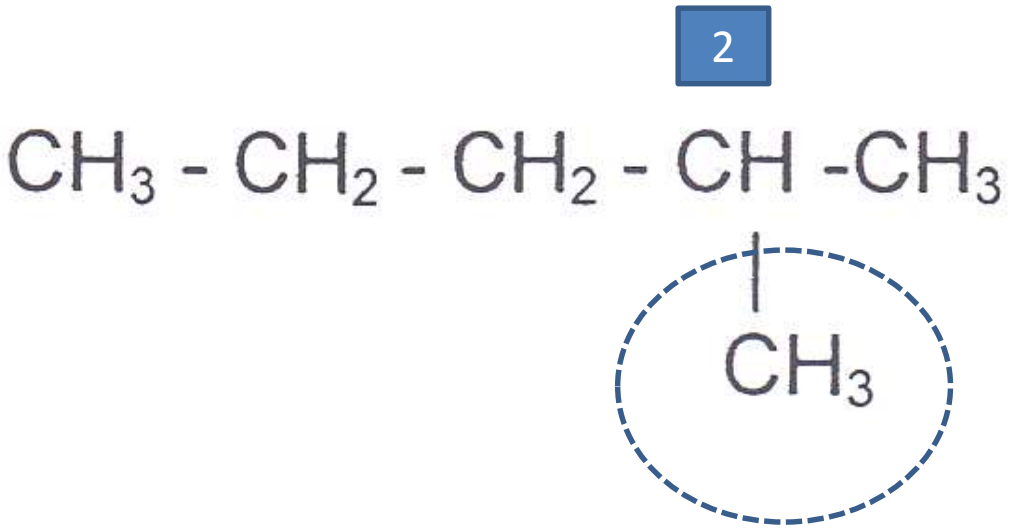
RULES FOR NAMING ALKANES

- Name the group joined to the chain and state the number of the carbon atom to which it is joined.



Methyl Group

2-Methylpentane

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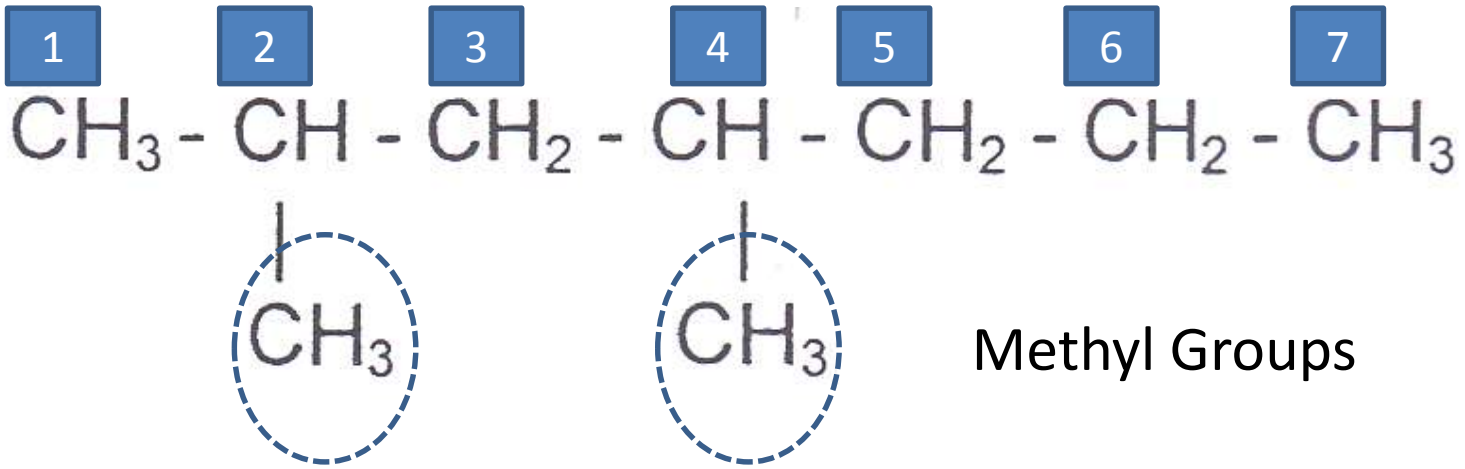
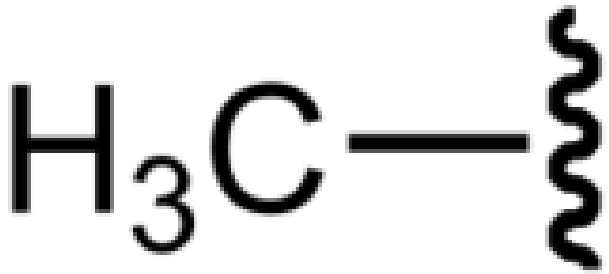
RULES FOR NAMING ALKANES

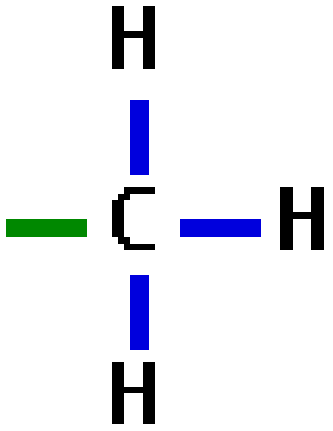
- If the chain has 2 more identical groups joined to it. Prefixes like di-, tri-, tetra- are used to indicate the number of groups present.



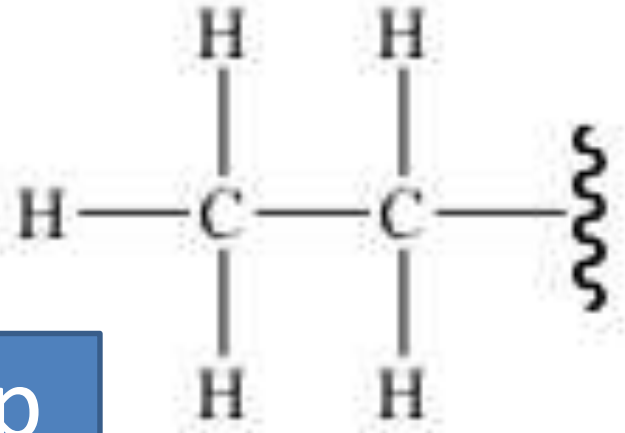
2,4-Dimethylheptane

Two Common Branches





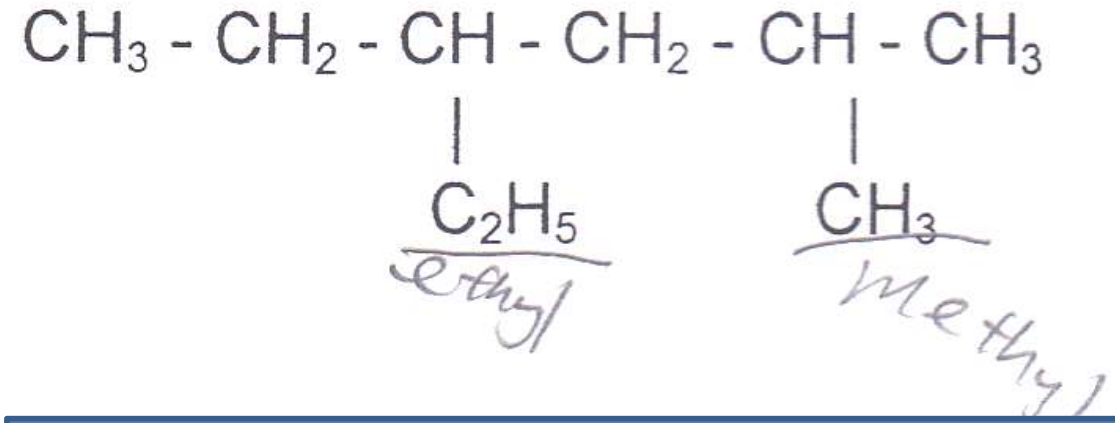
Methyl group



Ethyl Group

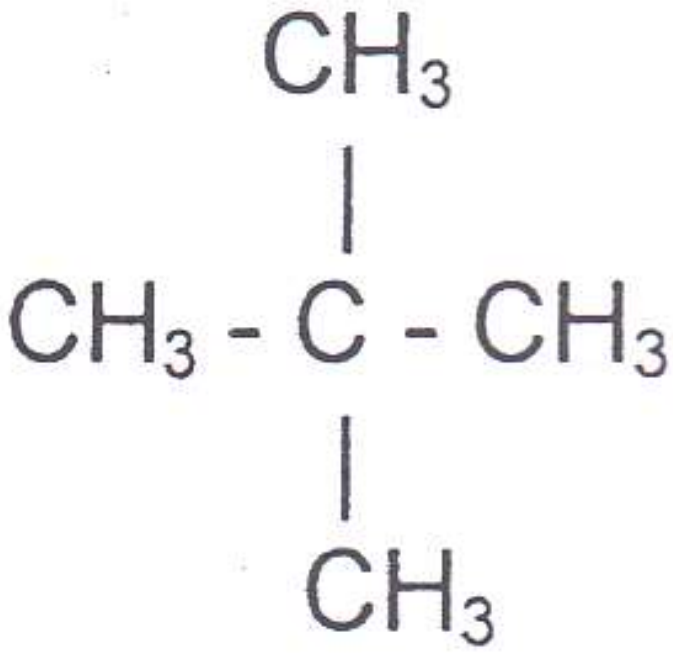
RULES FOR NAMING ALKANES

- If a chain has 2 or more different groups joined to it, the groups are written in alphabetical order i.e. ethyl before methyl.



4 –ethyl-2-methylhexane

Name this Alkane



2,2-Dimethypropane

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PHYSICAL PROPERTIES OF ALKANES

- Physical states

Alkanes	C1 to C4	C5 to C17	C18 onwards
Physical state at room temperature	Gas  Butane blowlamp	Liquid  Kerosene lamp	Solid  Bitumen used in road surfacing

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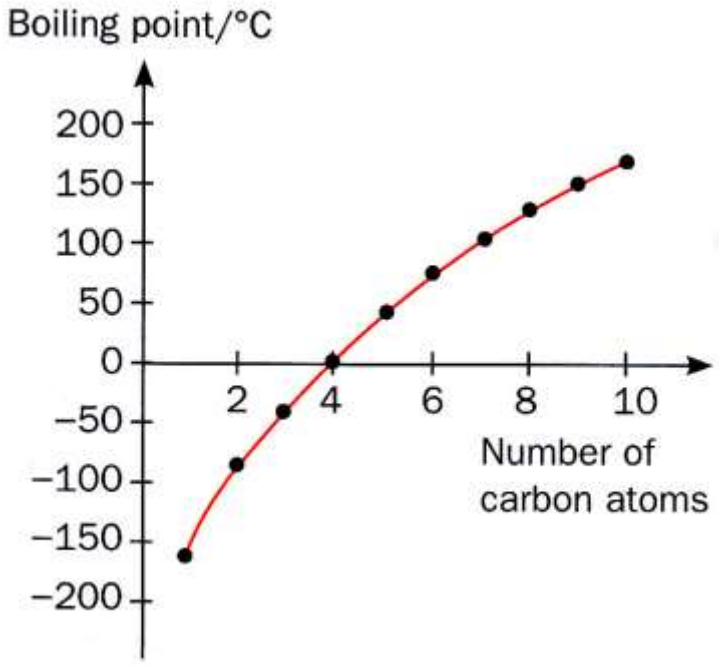
PHYSICAL PROPERTIES OF ALKANES

- As the **number of carbon atoms** in the molecules **increases**, the melting and boiling points **increase**.



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PHYSICAL PROPERTIES OF ALKANES

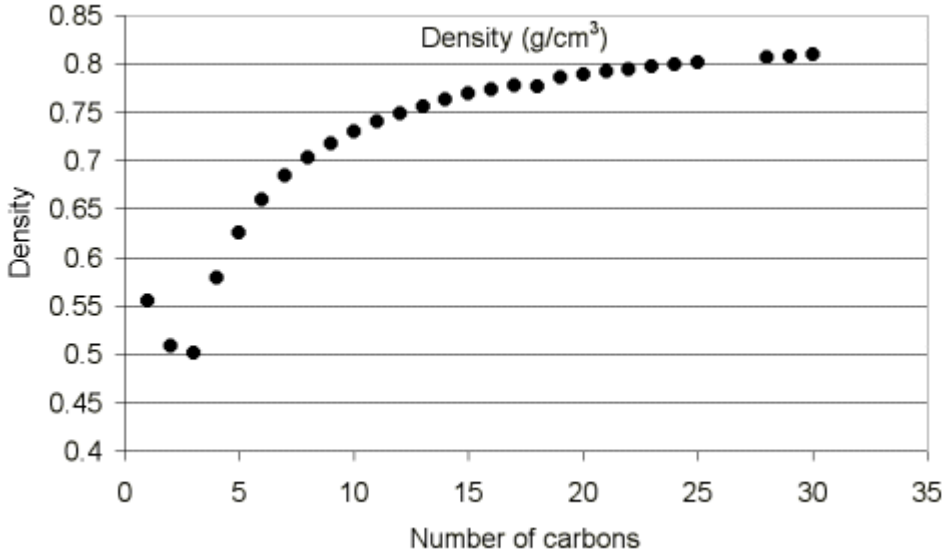
- Generally, alkanes have low melting and boiling points. This is due to the **weak intermolecular forces of attraction** (van der Waals' forces) which can be overcome by a small amount of heat energy.
- As the alkane molecules become larger (increase in the number of carbon atoms in the molecules, the **intermolecular forces of attraction become stronger**. **More heat energy** is needed to **overcome** the intermolecular forces of attraction to separate the molecules and the melting and boiling points increase.

PHYSICAL PROPERTIES OF ALKANES

- As the **number of carbon atoms** in the molecules **increases**, they become **less viscous** (flow less easily).
- This is due to the stronger intermolecular forces of attraction and
- Larger molecules get tangled together easily.

PHYSICAL PROPERTIES OF ALKANES

- As the **number of carbon atoms** in the molecules **increases**, their **densities** also **increase**. Liquid alkanes have densities less than 1g/cm^3 and they float on water.



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PHYSICAL PROPERTIES OF ALKANES

- As the **number of carbon atoms** in the molecules **increases**, they become **less flammable** (more difficult to burn).

- The larger alkane molecules contain a **higher percentage of carbon** and this makes it more difficult to burn.
- The larger alkanes also tend to produce a smokier flame due to incomplete combustion of the alkane molecules.

PHYSICAL PROPERTIES OF ALKANES

- Alkanes are insoluble in water but soluble in organic solvents such as CCl_4.

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CHEMICAL PROPERTIES OF ALKANES

- Alkanes are **generally unreactive**.

- This is because alkane molecules contain single carbon-carbon covalent bonds (C-C) and single carbon-hydrogen covalent bonds (C-H) which are **strong** and **require a lot of energy** to break.

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CHEMICAL PROPERTIES OF ALKANES

- Combustion
- Alkane + oxygen → **carbon dioxide** + **water vapour**
- CH_4 (g) + $2O_2$ (g) → CO_2 (g) + $2H_2O$ (g) ΔH = -890kJ/mol
- The reaction is **highly exothermic** and a large amount of heat energy is released. This is why alkanes make good fuels.

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CHEMICAL PROPERTIES OF ALKANES

- Substitution Reactions

- A substitution reaction is one in which an atom or group of atoms **replace** other atoms in a molecule.

- It is usually a slow reaction that is difficult to control and a mixture of products is usually obtained.

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CHEMICAL PROPERTIES OF ALKANES

- Reaction is initiated by **ultra-violet light** which provides the energy to break the covalent bond in the chlorine molecule to produce chlorine atoms.

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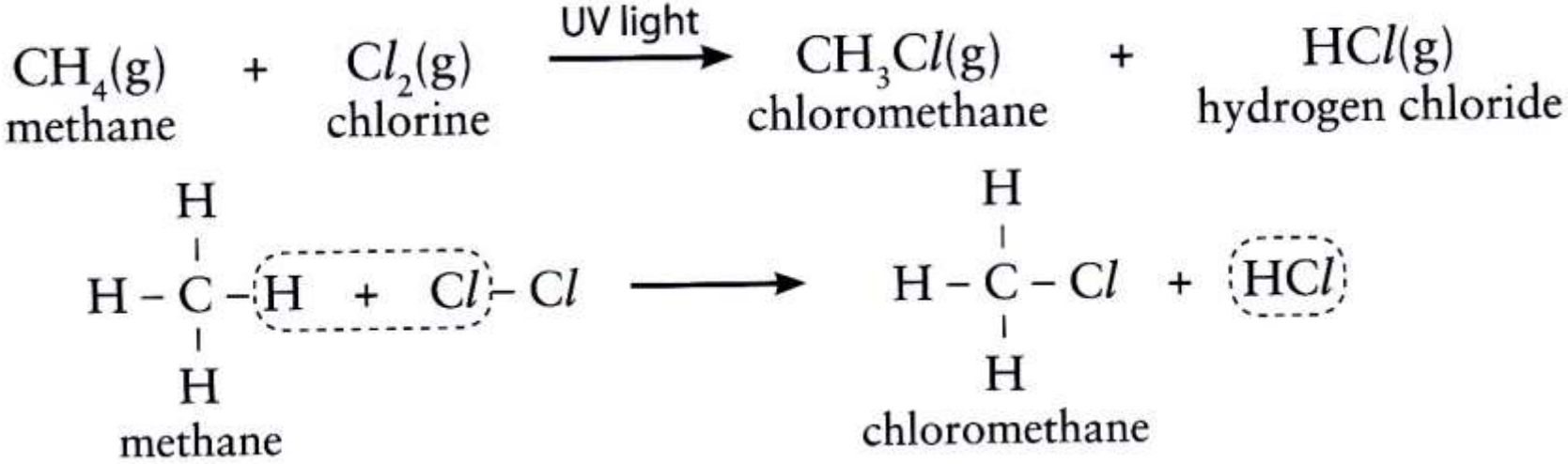
CHEMICAL PROPERTIES OF ALKANES

- For instance, methane reacts with chlorine as follows:



- This is a substitution reaction because the hydrogen atom in methane has been replaced by a chlorine atom.

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CHEMICAL PROPERTIES OF ALKANES

- More hydrogen atoms can be replaced with chlorine atoms to produce a mixture of four organic compounds as follows:
- $CH_3Cl + Cl_2 \rightarrow CH_2Cl_2 + HCl$
- $CH_2Cl_2 + Cl_2 \rightarrow CHCl_3 + HCl$
- $CHCl_3 + Cl_2 \rightarrow CCl_4 + HCl$

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ISOMERISM

- Isomers are compounds with the **same molecular formula** but **different structural formulae**.
- Isomers have **different** melting and boiling points.
- Isomers **may or may not** belong to the same homologous series.

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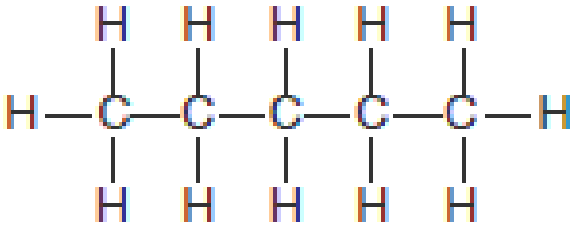
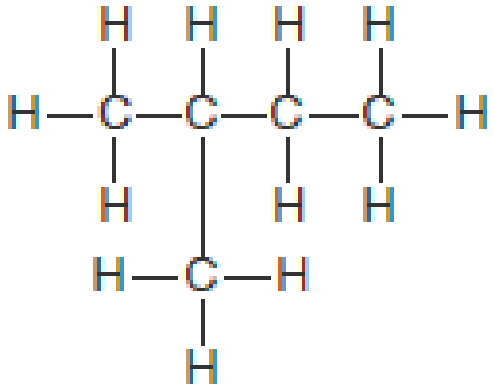
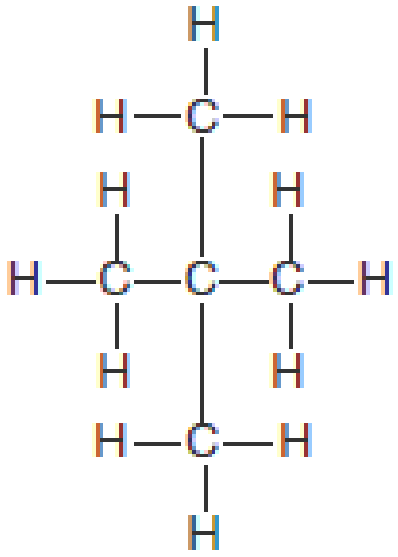


Pentane



2-Methylbutane



2,2-Dimethylpropane

Figure 18.3 Structural isomers of C_5H_{12}.

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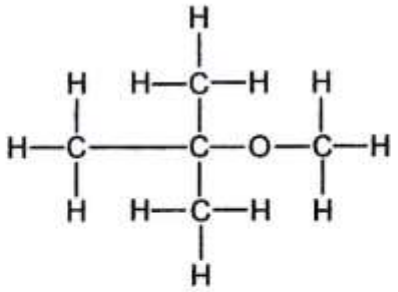
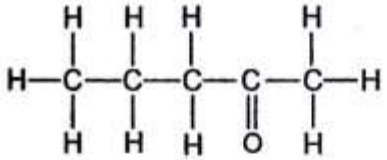
Quiz

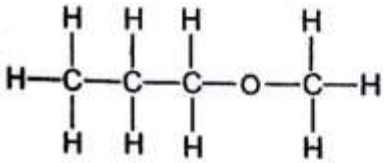


Which compound is an isomer of MTBE? (N2006/P1/Q37)

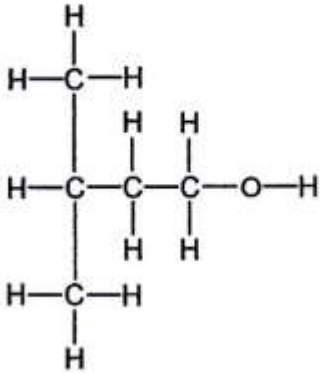
A



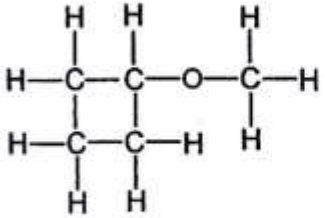
B



C



D



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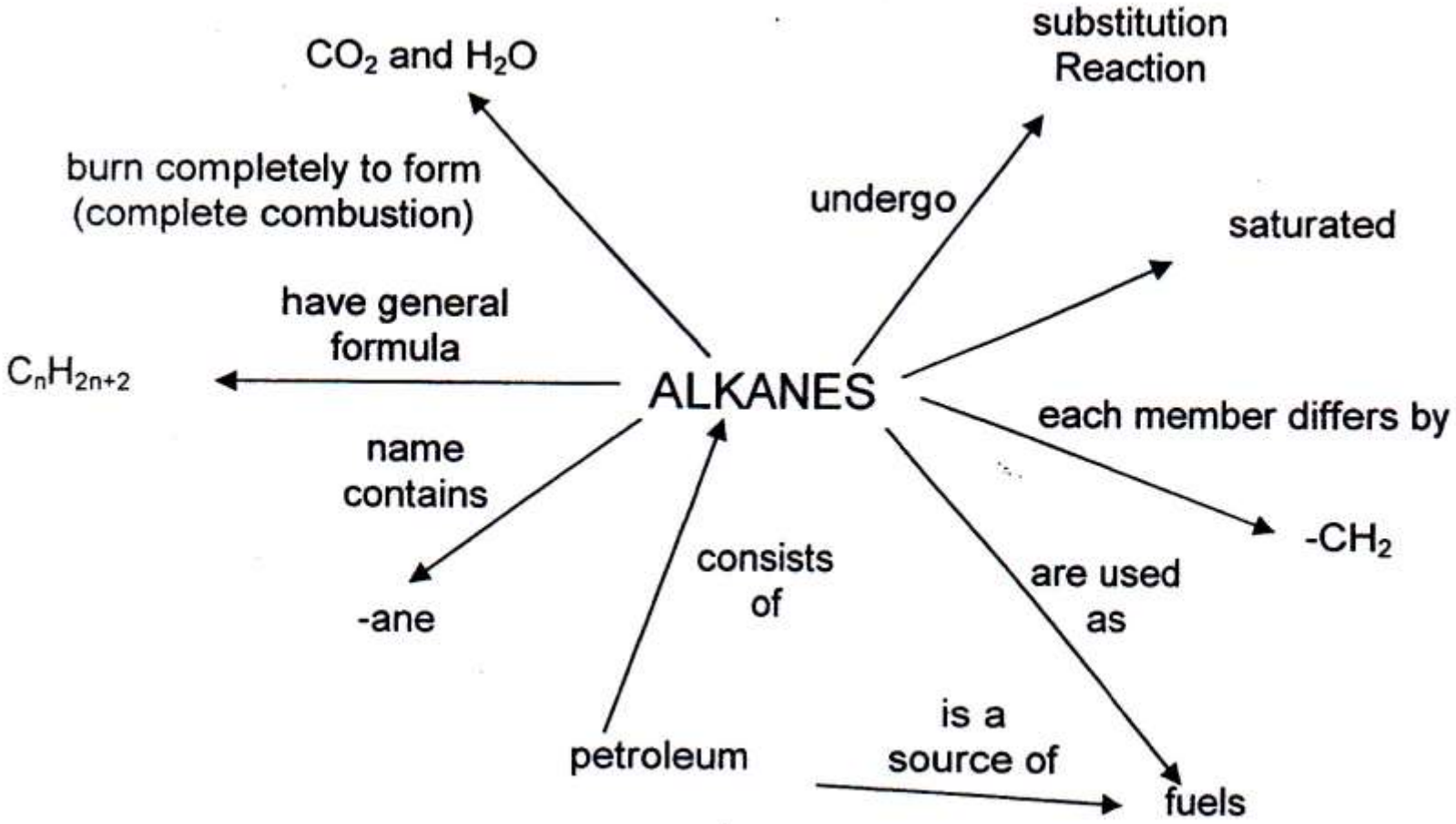
Summary



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