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TOPIC 11.2: ALKANES

THE ABOUT

CHAPTER ANALYSIS

MASTERY

- Important topic
- Take note of ‘isomerism’

EXAM

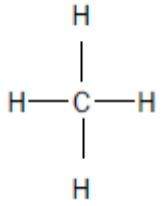
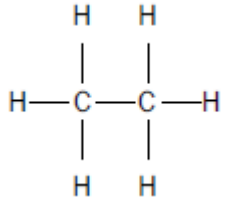
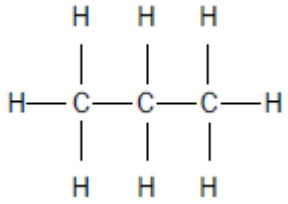
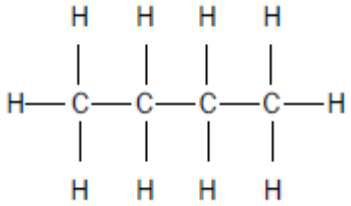
- Alkanes are tested lightly
- Explanation for physical properties is applicable to all other hydrocarbon compounds as well*

WEIGHTAGE

- Heavy overall weightage
- Entire Organic Chemistry portion accounts for 15-20% of each year’s Chemistry paper

KEY CONCEPT

ALKANES
HOMOLOGOUS SERIES
FUNCTIONAL GROUP
GENERAL FORMULA

Name	Carbon atoms	Molecular Formula	Full Structural Formula	Condensed structural formula
Methane	1	CH_4		CH_4
Ethane	2	C_2H_6		CH_3CH_3
Propane	3	C_3H_8		$CH_3CH_2CH_3$
Butane	4	C_4H_{10}		$CH_3CH_2CH_2CH_3$

Homologous series: Alkanes

Alkanes contain only carbon-carbon single covalent bonds and carbon-hydrogen single covalent bonds.

Alkanes are **'saturated'** as every carbon atom is bonded to its maximum of four atoms.

Functional group

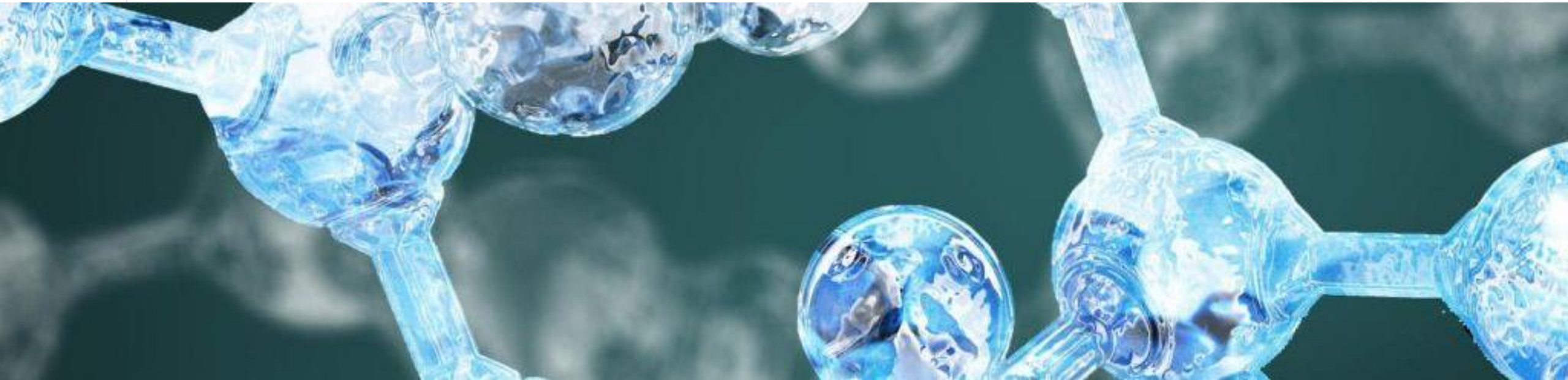
Alkanes have **no functional group**.

General Formula

Alkanes have a **general formula** of $\mathbf{C_nH_{2n+2}}$.

KEY CONCEPT

ALKANES
PHYSICAL PROPERTIES
CHEMICAL PROPERTIES
ISOMERISM



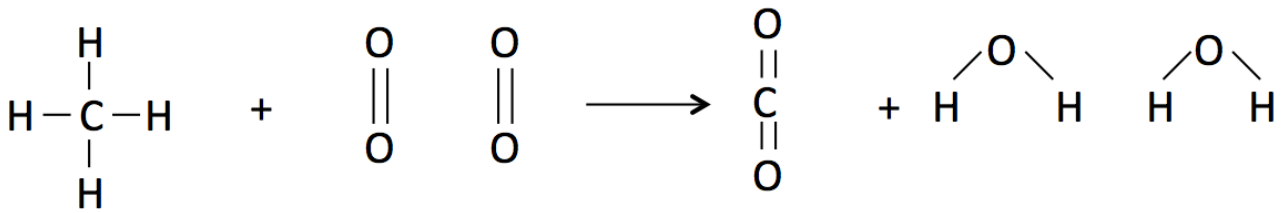
PHYSICAL PROPERTIES

Physical property	Reasoning
Melting and boiling points	The **boiling points of alkanes increase as the number of carbon atoms in the alkane increases**. As the **relative molecular mass of the alkane increases, the strength of intermolecular forces of attraction between the molecules increases**. As such, more energy is needed to overcome the intermolecular forces of attraction between the larger molecules. Hence, alkanes containing more carbon atoms have higher boiling points.
Volatility	The **higher the relative molecular mass of an alkane, the less volatile it is**. The **intermolecular forces of attraction between large alkane molecules** are **stronger** than that between smaller alkane molecules. Hence, larger alkane molecules that are liquid at room temperature are less likely to evaporate.
Density	The **higher the relative molecular mass of an alkane, the higher the density**.
Viscosity	The **higher the relative molecular mass of an alkane, the higher its viscosity.** Alkanes with longer hydrocarbon chains tangles together and flow less easily.
Flammability	The **higher the relative molecular mass of an alkane, the lower the flammability**. The larger alkanes contain a **higher percentage of carbon** and produce a smokier flame as incomplete combustion is more likely to occur.
Solubility	All alkanes are **insoluble in water but are soluble in organic solvents** such as benzene and ethanol.

CHEMICAL REACTIONS

SUBSTITUTION

COMBUSTION



SUBSTITUTION

In the presence of **ultraviolet (UV) light**, alkanes react with halogens via a substitution reaction.

A substitution reaction occurs when one atom or a group of atoms is replaced by another atom or group of atoms.

For example,

$$CH_4\,(g) + Br_2\,(g) \rightarrow CH_3Br\,(g) + HBr\,(g)$$

COMBUSTION

When an alkane undergoes **complete combustion** in excess oxygen, the products formed will be **carbon dioxide and water**.

For instance, methane undergoes complete combustion in excess oxygen:

$$CH_4\,(g) + 2\,O_2\,(g) \rightarrow CO_2\,(g) + 2\,H_2O\,(l)$$

When there is an insufficient supply of oxygen, incomplete combustion of the alkane occurs.

Water and carbon monoxide are produced.

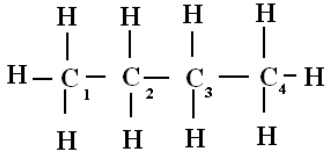
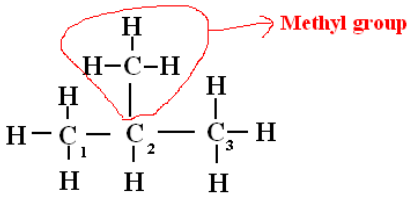
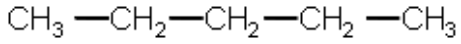
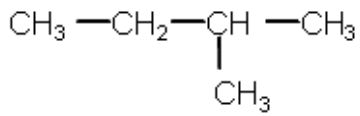
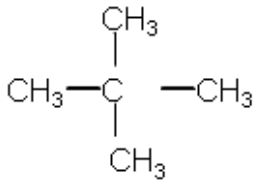
$$2\,CH_4\,(g) + 3\,O_2\,(g) \rightarrow 2\,CO\,(g) + 4\,H_2O\,(l)$$

ISOMERISM (ALKANE)

ISOMERISM

Isomers are compounds with **the same molecular formula** but **different structural formula**.

Alkanes containing **at least four carbon atoms** display isomerism.

Alkane	Isomers	Structural formula
Butane	2	 n-butane  2 -Methyl propane
Pentane	3	 Pentane  2 - Methylbutane  2,2 - Dimethylpentane

ISOMERISM (ALKANE)

ISOMERISM

The name of each isomer is derived based on the substituent group it contains and the longest carbon chain it contains.

Isomers have **similar chemical properties** but **slightly different physical properties such as different boiling points & density.**

Carbon atoms	Prefix	Substituent Group
1	Methyl	$-CH_3$
2	Ethyl	$-CH_2CH_3$
3	Propyl	$-CH_2CH_2CH_3$

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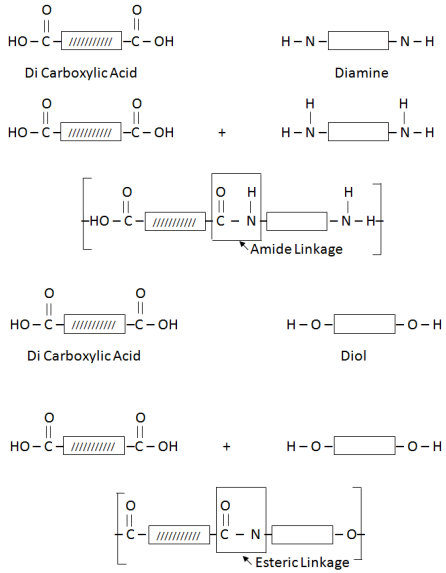
POLYMER

Condensation Polymerisation
(elimination of water)



LONG CHAIN ALKANE

H_2 gas
(For Haber process)

Catalytic Cracking
(Al_2O_3 & SiO_2, 600 °C)

Addition Polymerisation
(High temp & pressure)

SUGAR

$C_6H_{12}O_6 \rightarrow C_2H_5OH + CO_2$

Fermentation
(37°C, yeast & no O_2)

Oxidation
(acidified aqueous potassium manganate(VII) / exposed to air)

Hydration
(300 °C & 60-70 atm, Phosphoric(V) acid)

ALKANE
C - C

Hydrogenation
(200 °C & nickel)

# ALKENE
C = C

ALCOHOL
-OH

CARBOXYLIC ACID
-COOH

Substitution
(UV light)

Bromination
(Test for C=C bonds)

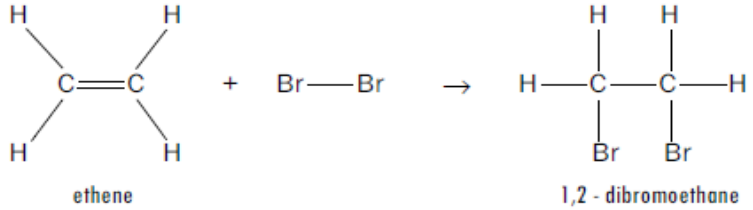
Esterification
(warm, sulfuric acid)

Prefix

Meth- 1
Eth- 2
Prop- 3
But- 4
Pent- 5
Hex- 6
Hep- 7
Oct- 8
Non- 9
Dec- 10

$CH_4 (g) + Br_2 (g) \rightarrow CH_3Br (g) + HBr (g)$

$C_2H_4 (g) + Br_2 (aq) \rightarrow C_2H_4Br_2 (aq)$



ESTER + H_2O
-COO-

ALL ORGANIC COMPOUNDS
Complete Combustion

$X + O_2 (g) \rightarrow CO_2 (g) + 2H_2O (l)$

Incomplete Combustion

$X + O_2 (g) \rightarrow CO (g) + 2H_2O (l)$

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