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TOPIC 11.2: ALKANES

THE ABOUT

CHAPTER ANALYSIS

MASTERY

- Important topic
- Take note of ‘isomerism’

EXAM

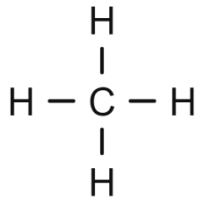
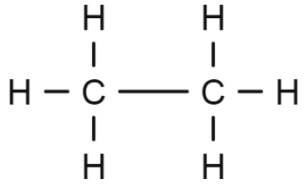
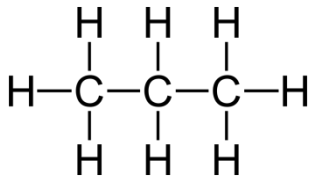
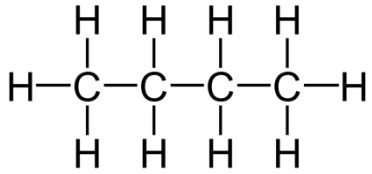
- Alkanes are tested lightly
- Explanation for physical properties is applicable to all other hydrocarbon compounds as well*

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}		$CH_3CH_2CH_2CH_3$

***Need to know how to draw full structural formula and name the alkane.**

Alkanes

Alkanes are hydrocarbons with the general formula C_nH_{2n+2}.

Alkanes contain only C-C single bonds and C-H single bonds .

Alkanes are **'saturated'** as each carbon atom is covalently bonded to a maximum of four other atoms.

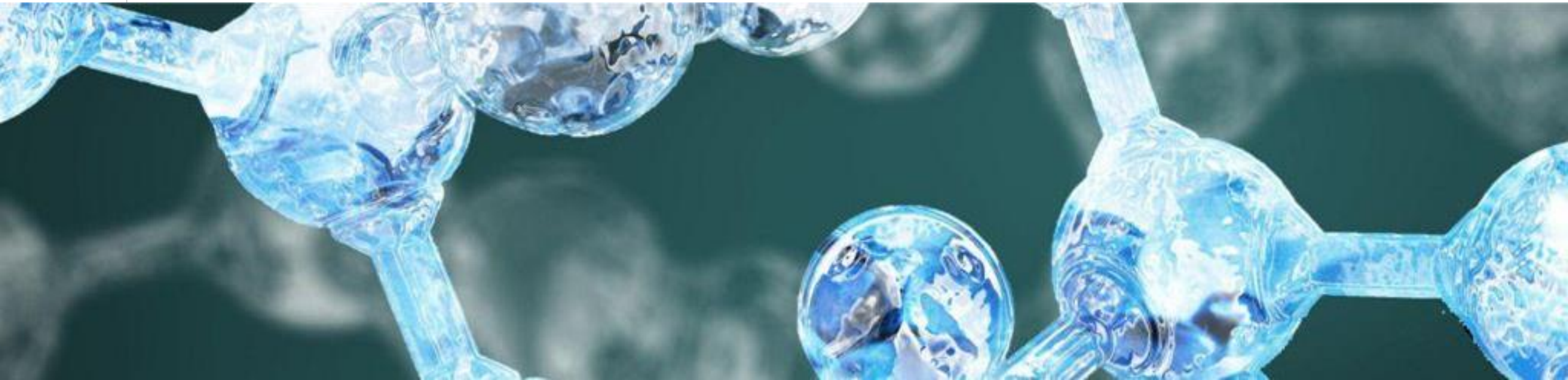
Functional group

Alkanes have **no functional group**.

(Take note that C-C single bond is not a functional group as it does not have any chemical properties!)

KEY CONCEPT

ALKANES
PHYSICAL PROPERTIES
CHEMICAL PROPERTIES
ISOMERISM

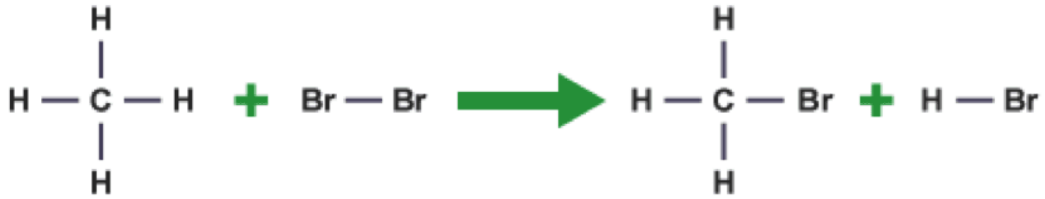


PHYSICAL PROPERTIES

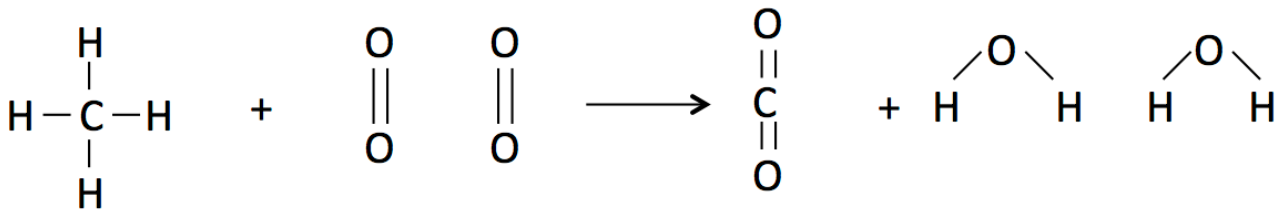
Physical property	Reasoning
Melting and boiling points	**As the number of carbon atoms in the alkane increases**, the **melting and boiling points of alkanes increases as well.** When the **number of carbon atoms in an alkane increases**, **the molecules are bigger and have stronger intermolecular forces of attraction between the alkane molecules.** As such, more heat energy is needed to overcome the intermolecular forces of attraction between the alkane molecules. Hence, larger alkanes containing more carbon atoms will have higher melting and boiling points.
Volatility	When the **number of carbon atoms in an alkane increases, the alkane becomes less volatile it is**. (similar to m.p. & b.p.) **With a higher relative molecular mass, there would be stronger intermolecular forces of attraction between the alkane molecules.** As such, more energy is needed to overcome the intermolecular forces of attraction between the alkane molecules. Hence, larger alkane molecules are less likely to evaporate.
Density	When the **number of carbon atoms in an alkane increases, the density will increase**.
Viscosity	When the **number of carbon atoms in an alkane increases, the viscosity will increase. (more difficult to flow)** Alkanes with longer hydrocarbon chains flow less smoothly as they tend to get stuck together.
Flammability	The **higher the relative molecular mass of an alkane, the lower the flammability**. **(more difficult to burn)** The larger alkanes contain a **higher percentage by mass of carbon atoms** and undergo incomplete combustion to produce a smokier flame.
Solubility	Alkanes are **insoluble in water but are soluble in organic solvents** like ethanol.

CHEMICAL REACTIONS

SUBSTITUTION



COMBUSTION



SUBSTITUTION (Free Radical Substitution)

During substitution, alkanes can react with halogens In the presence of **ultraviolet (UV) light**.

For example,

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

It is also possible for Br atoms to replace all the H atoms to become CBr_4.

COMBUSTION

During complete combustion, an alkane burns in excess oxygen to produce **carbon dioxide and water**.

For instance, methane undergoes complete combustion in excess oxygen:

$$2\,C_2H_6\,(g) + 7\,O_2\,(g) \rightarrow 4\,CO_2\,(g) + 6\,H_2O\,(l)$$

Incomplete combustion of the alkane occurs when there is an insufficient oxygen.

In this case, **water and carbon monoxide** are produced.

$$2\,C_2H_6\,(g) + 5\,O_2\,(g) \rightarrow 4\,CO\,(g) + 6\,H_2O\,(l)$$

If there is even lesser amounts of oxygen, there could only be just **carbon (soot) and water** that are produced.

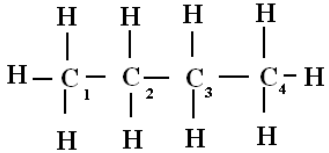
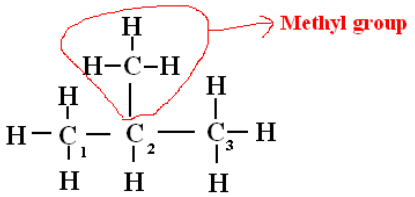
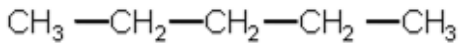
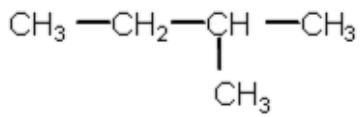
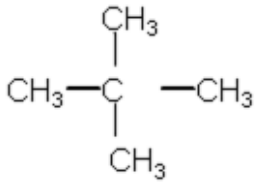
ISOMERISM (ALKANE)

ISOMERISM

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

In order to display isomerism, alkanes would have to contain **at least four carbon atoms**.

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

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

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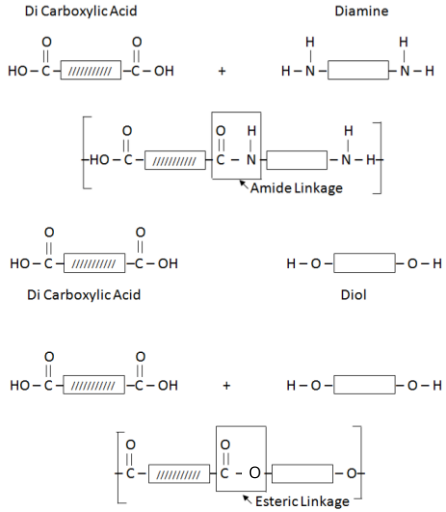
POLYMER

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

$C_6H_{12}O_6 \rightarrow 2\ C_2H_5OH + 2\ CO_2$

Fermentation
(37°C, yeast & no O_2)

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

Hydration
(300 °C & 60 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)

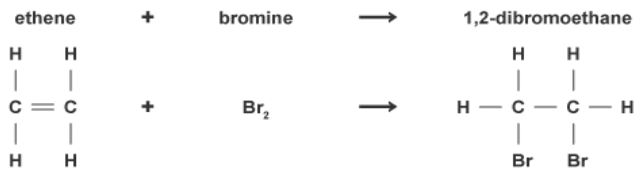
Esterification
(warm, sulfuric acid)

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
-COO-

+ H_2O

ALL ORGANIC COMPOUNDS
Complete Combustion

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

Incomplete Combustion

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

Try it yourself! (TYS Question)

20. How many moles of oxygen would be used when 1 mole of propane, C_3H_8, is completely burnt in the air to form carbon dioxide and water? (N2015/P1/Q37)

A 3
B 4
C 5
D 7

( )

Answer:

20. **C**
The equation for the complete combustion of propane is,
$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$
1 mole of propane completely reacts with 5 moles of oxygen to form carbon dioxide and water.

Try it yourself! (TYS Question)

26. Which statements are true about alkanes? (N2016/P1/Q34)

1 Their general formula is C_nH_{2n}.
2 They are flammable.
3 They react with chlorine.

A 1 and 2 only **B** 2 and 3 only
C 1 and 3 only **D** 1, 2 and 3 ( )

Answer:

26. **B**
Alkanes are flammable and they react with chlorine by substitution. The general formula for alkanes is C_nH_{2n+2}.

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