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# TOPIC 10.2: ALKANES

THE ABOUT

# CHAPTER ANALYSIS

**MASTERY**

- Key topic

**EXAM**

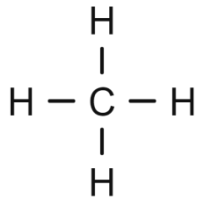
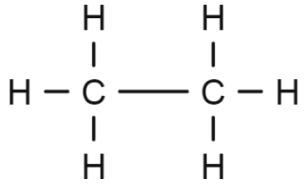
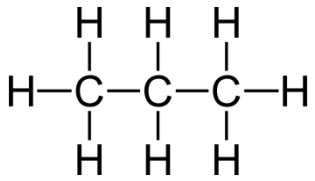
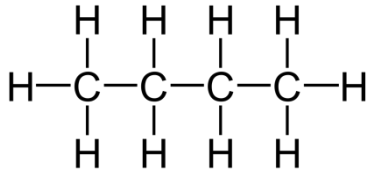
- Alkanes are tested lightly
- Explanation for physical properties is applicable to all other hydrocarbon compounds as well*

**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.

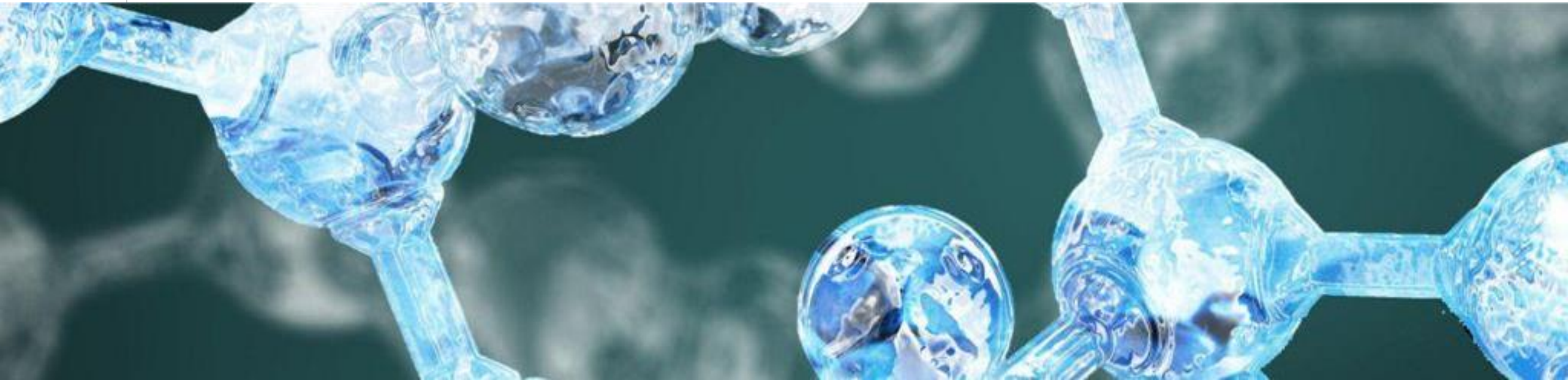
## Functional group

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

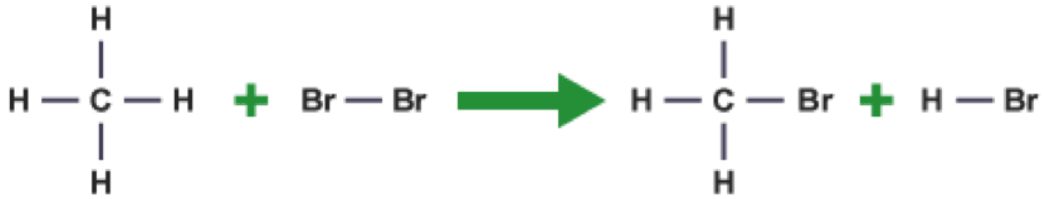


# PHYSICAL PROPERTIES

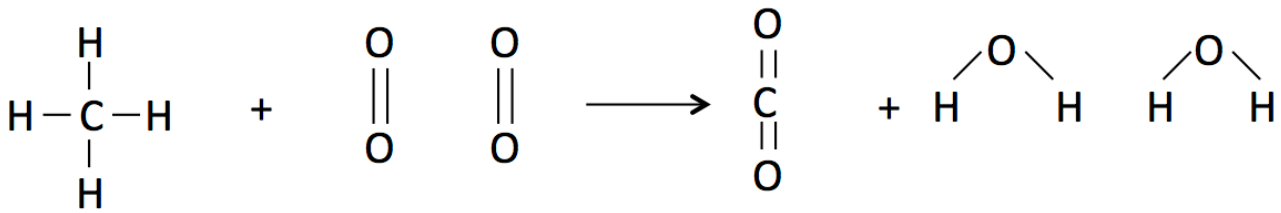
| Physical property | Reasoning |
|---|---|
| **Melting and boiling points** | **As the number of carbon atoms in the alkane increases**, the **melting and boiling points of alkanes increases as well.**<br>When the **number of carbon atoms in an alkane increases**, **the molecules are bigger and have 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.)<br>**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.<br>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)**<br>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)**<br>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.

# LONG CHAIN ALKANE

**$H_2$ gas**

**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)

**Hydrogenation**
(200 °C & nickel)

## ALKANE
C - C

## ALKENE
C = C

## ALCOHOL
-OH

## CARBOXYLIC ACID
-COOH

**Substitution**
(UV light)

**Bromination**
(Test for C=C bonds)

**ALL ORGANIC COMPOUNDS**
**Undergo Combustion**

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

**Incomplete Combustion**

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

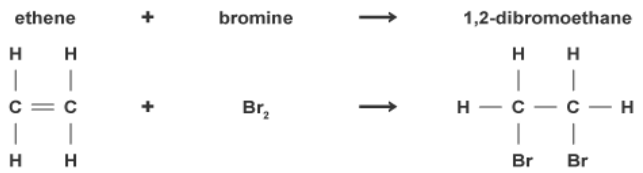
acid + metal → salt + $H_2$
acid + carbonate → salt + $H_2O$ + $CO_2$
acid + base → salt + $H_2O$

**Prefix**

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

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

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



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