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TOPIC 10.3: ALKENES

THE ABOUT

CHAPTER ANALYSIS

MASTERY

- Important topic
- Take note of alkene's various chemical reactions

EXAM

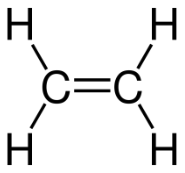
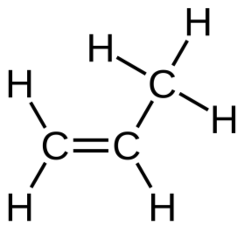
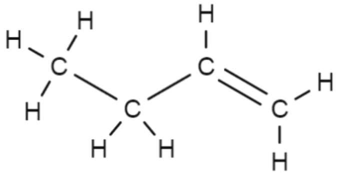
- Alkenes are always tested
- Understand the difference between 'saturated' & 'unsaturated' compounds

WEIGHTAGE

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

KEY CONCEPT

ALKENES
HOMOLOGOUS SERIES
FUNCTIONAL GROUP
GENERAL FORMULA

Name	Carbon atoms	Molecular Formula	Full Structural Formula	Condensed structural formula
Ethene	2	C_2H_4		CH_2CH_2
Propene	3	C_3H_6		CH_2CHCH_3
Butene	4	C_4H_8		$CH_3CH_2CHCH_2$

Alkenes

Alkenes are unsaturated hydrocarbons with a **general formula of C_nH_{2n}.**

As the carbon atoms are **not bonded to the maximum of four atoms**, alkenes are considered to be **'unsaturated'**.

Unsaturated hydrocarbons are hydrocarbons that contain one or more C=C double bond. (For eg: Vegetable oil)

Functional group

Alkenes contain C=C double covalent **bonds.**

KEY CONCEPT

ALKENES
PHYSICAL PROPERTIES
CHEMICAL PROPERTIES
CRACKING

PHYSICAL PROPERTIES

Physical property	Reasoning
Melting and boiling points	**As the number of carbon atoms in the alkene increases**, the **melting and boiling points of alkenes increases as well.** As the **number of carbon atoms in an alkene increases**, **the size of the molecules are bigger and have stronger intermolecular forces of attraction between each other.** As such, more heat energy is needed to overcome the intermolecular forces of attraction between the alkene molecules. Hence, larger alkenes containing more carbon atoms will have higher melting and boiling points.
Volatility	**As the number of carbon atoms in the alkene increases**, the **volatility of alkenes decreases.** (similar to m.p. & b.p.) **With a higher relative molecular mass, there would be stronger intermolecular forces of attraction between the alkene molecules.** As such, more energy is needed to overcome the intermolecular forces of attraction between the alkene molecules. Hence, larger alkene molecules are less likely to evaporate in room temperature.
Density	**As the number of carbon atoms in the alkene increases**, the **density of alkenes increases**.
Viscosity	**As the number of carbon atoms in the alkene increases**, the **viscosity of alkenes decreases**. **(more difficult to flow)** Alkenes with longer hydrocarbon chains flow less easily as they tend to get stuck together.
Flammability	**As the number of carbon atoms in the alkene increases**, the **flammability of alkenes decreases. (more difficult to burn)** The larger alkenes contain a **higher percentage mass of carbon atoms** and would undergo incomplete combustion which results in a smokier flame.
Solubility	All alkenes are **insoluble in water but are soluble in organic solvents** like ethanol.

CHEMICAL REACTIONS

CHEMICAL REACTIONS OF ALKENES

1) **Combustion**
1) **Hydrogenation (add hydrogen gas)**
1) **Bromination (add aqueous bromine)**
1) **Hydration (add water)**
1) **Polymerisation (combined alkenes to form long chain)**

(Hydrogenation, Bromination and Hydration:) Addition reactions

1) COMBUSTION

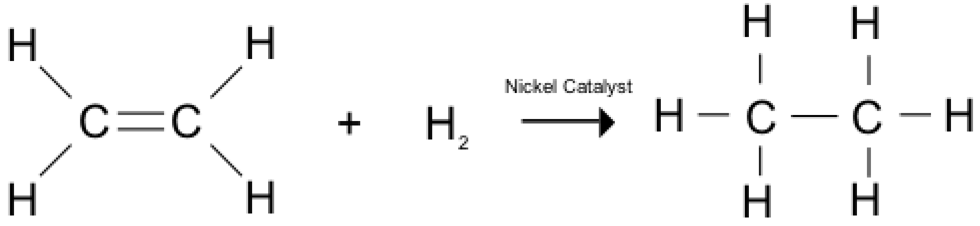
In the presence of excess oxygen, an alkene would undergo **complete combustion**, producing carbon dioxide and water.

$$2\ C_3H_6 + 9\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$$

If there is insufficient oxygen for complete combustion, the alkene would undergo **incomplete combustion**, producing water and carbon monoxide. (similar to alkanes)

$$C_3H_6 + 3\ O_2 \rightarrow 3\ CO + 3\ H_2O$$

2) HYDROGENATION (addition of hydrogen)



Condition: 200°C and nickel catalyst.

Through the process of hydrogenation, alkenes are converted to alkanes. (E.g. vegetable oils can be converted to margarine.)

Margarine is considered a **saturated compound** as it undergoes hydrogenation process and contains no C=C bonds.

CHEMICAL REACTIONS

CHEMICAL REACTIONS OF ALKENES

1) Combustion

1) Hydrogenation (add hydrogen gas)

1) Bromination (add aqueous bromine)

1) Hydration (add water)

Addition reactions

1) Polymerisation (combined alkenes to form long chain)

3) BROMINATION (addition of aqueous bromine)

Conditions: Aqueous bromine, room temperature

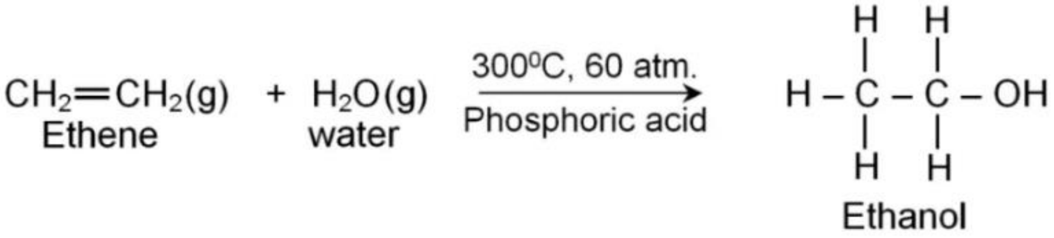
When **aqueous bromine reacts with alkenes occurs**, the **reddish-brown solution decolourises to become colourless.**

Aqueous bromine is used as a **test to distinguish alkanes and alkenes** as only alkenes would react with aqueous bromine in the absence of ultraviolet light.

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

4) HYDRATION (addition of steam)

Addition of steam under the right conditions can cause a reaction with the C=C double bond to produce an alcohol containing the **−OH functional group.**



Conditions:

Temperature of **300°C** and at a pressure of **60 atm**, **Phosphoric(V) acid** as a catalyst.

CHEMICAL REACTIONS

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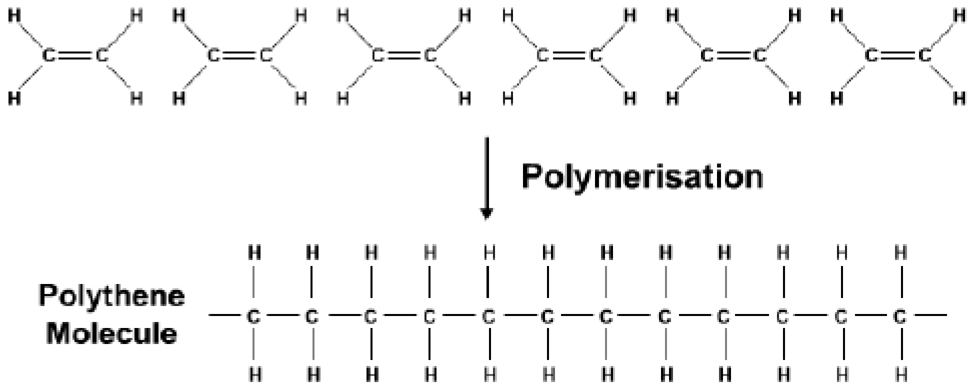
Addition reactions

5) POLYMERISATION

Polymers are formed when **multiple identical alkene molecules (monomers) are joined together to form a large molecule**.

For example, ethene molecules can be joined together through polymerisation to form the polymer: poly(ethene).



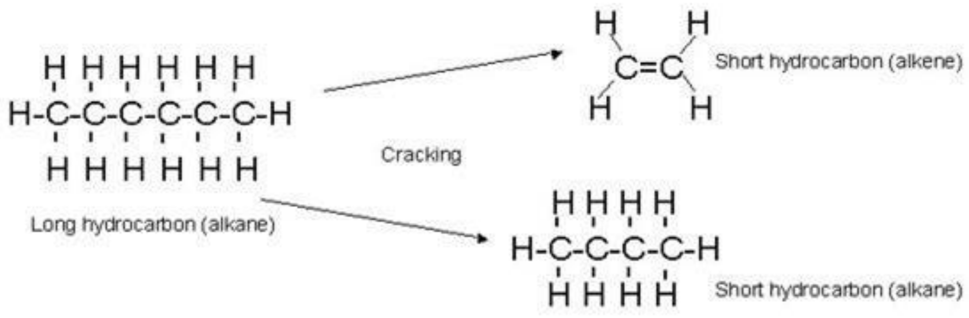
CRACKING

Catalytic cracking

Catalytic cracking is a process where a long-chain hydrocarbons from petroleum are broken down into shorter-chain hydrocarbons in a presence of a catalyst.

The process is used for **producing fuels for vehicles, production of alkenes & production of hydrogen.** Smaller chain alkanes and alkenes are more useful than longer chain alkanes as they are in higher demand.

Conditions: **Aluminium oxide (Al_2O_3)** as catalyst and **silicon (IV) oxide (SiO_2)** at a temperature of **600°C**.



At least one of the products formed will be an alkene. Alkanes, hydrogen and even carbon can be produced from the cracking process as well.

Examples:

Long chain alkane → shorter chain alkane + alkene

$$C_{10}H_{22} \rightarrow C_5H_{12} + C_5H_{10}$$

Long chain alkane → shorter chain alkene + shorter chain alkene + hydrogen

$$C_{10}H_{22} \rightarrow C_6H_{12} + C_4H_8 + H_2$$

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)

ALL ORGANIC COMPOUNDS
Undergo Combustion

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

Incomplete Combustion

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

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

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

ALKANE
C - C

Hydrogenation
(200 °C & nickel)

# ALKENE
C = C

ALCOHOL
-OH

CARBOXYLIC ACID
-COOH

Substitution
(UV light)

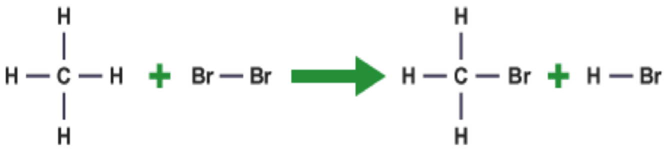
Bromination
(Test for C=C bonds)

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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