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TOPIC 11.4: ALCOHOLS

THE ABOUT

CHAPTER ANALYSIS

MASTERY

- Important topic
- Take note of alcohol's chemical reactions

EXAM

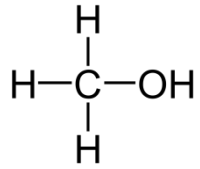
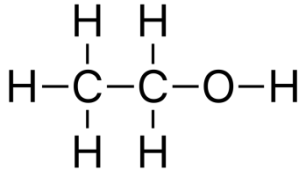
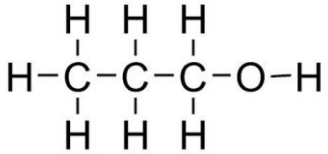
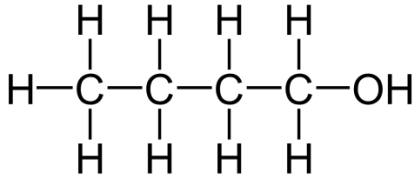
- Alcohols are **commonly tested**
- Understand how **fermentation** works and the conditions needed

WEIGHTAGE

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

KEY CONCEPT

ALCOHOLS
HOMOLOGOUS SERIES
FUNCTIONAL GROUP
GENERAL FORMULA

Name	Carbon atoms	Molecular Formula	Full Structural Formula	Condensed structural formula
Methanol	1	CH_3OH		CH_3-OH
Ethanol	2	C_2H_5OH		CH_3CH_2-OH
Propanol	3	C_3H_7OH		$CH_3CH_2CH_2$-OH
Butanol	4	C_4H_9OH		CH_3 $CH_2CH_2CH_2$-OH

<u>Homologous series: Alcohols</u>

Alcohols contain the **hydroxyl -OH functional group** and have **general formula $C_nH_{2n+1}OH$**.

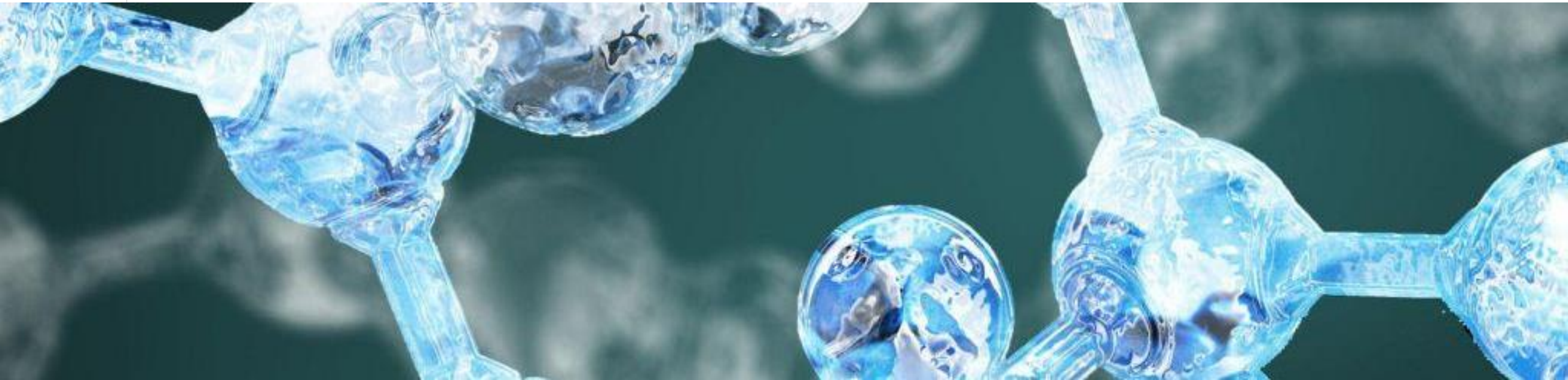
Alcohols containing **at least three carbon atoms display isomerism**.*

Isomers have the same molecular formula and chemical reactivity.

However, isomers have **different physical properties such as different boiling points and densities.**

KEY CONCEPT

ALCOHOLS
PHYSICAL PROPERTIES
PRODUCTION OF ALCOHOL
CHEMICAL REACTIONS



PHYSICAL PROPERTIES

Physical properties of alcohol

As the relative molecular mass of the alcohols increases,

- Melting and boiling points of the alcohols increase
- Densities of the alcohols increase
- Viscosities of the alcohols increase
- Flammability of the alcohols decrease
- **Alcohols are soluble in water, but solubility decrease as the carbon atoms increase**

MAKING ALCOHOL

PRODUCTION OF ALCOHOLS

1) **Fermentation**
2) **Manufacture of ethanol from ethene**

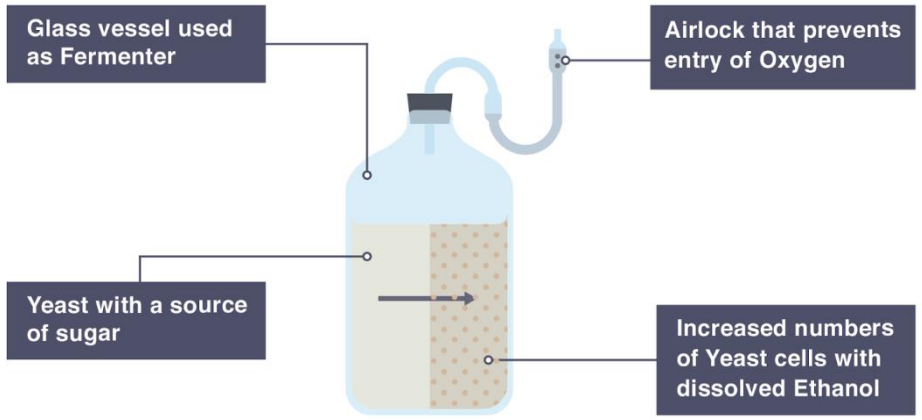
PRODUCTION OF ALCOHOL

1) Fermentation
Fermentation is a chemical reaction in which sugars are broken down into smaller molecules by micro-organisms.

For instance, yeast contains enzymes to catalyse the breakdown **of glucose $C_6H_{12}O_6$ into ethanol C_2H_5OH and carbon dioxide.**

glucose → ethanol + carbon dioxide
(in the presence of yeast)

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



MAKING ALCOHOL

PRODUCTION OF ALCOHOLS

1) **Fermentation**

2) **Manufacture of ethanol from ethene**

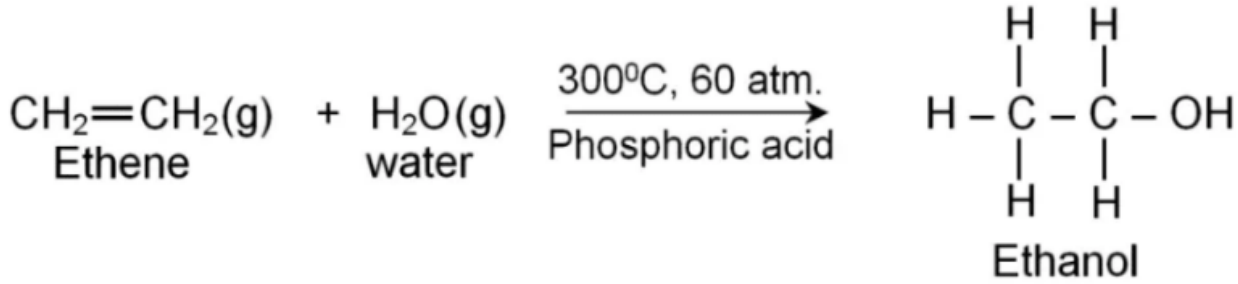
PRODUCTION OF ALCOHOL

2) Manufacture of ethanol from ethene

To produce ethanol, ethene and steam are reacted together at a temperature of **300°C** and at **60 to 70 atm**.

Phosphoric(V) acid acts as a catalyst for the reaction.

The reaction between ethene and steam is represented by the following equation.



Uses of ethanol

Ethanol is used in **alcoholic drinks** such as beer and wine.

Ethanol is used as a **solvent for many organic compounds** that are insoluble in water.

Ethanol is highly volatile and it is also an **ideal solvent for perfume and deodorants**.

Ethanol is used as a **clean fuel** as it undergoes combustion to form carbon dioxide and water without any soot.

CHEMICAL REACTIONS

CHEMICAL REACTIONS OF ALCOHOLS

1) **Combustion**
2) **Oxidation**
3) **Esterification**

Application (Oxidation)

The oxidation of alcohols is used in breathalysers.

The breathalyser contains an oxidising agent, and electronic devices will reflect the concentration of the alcohol in the individual's breath.

1) Combustion

When there is sufficient oxygen, an alcohol undergoes **complete combustion** and produce carbon dioxide and water.

When there is insufficient oxygen, the alkene undergoes **incomplete combustion** and produce water and carbon monoxide.

Soot (carbon) is sometimes produced during incomplete combustion.

2) Oxidation

In the presence of a strong oxidising agent, alcohols are oxidised to form carboxylic acids.

Oxidising agents:
$KMnO_4$ (purple to colourless)
$K_2Cr_2O_7$ (orange to green)

For example, ethanol can be oxidised to ethanoic acid:

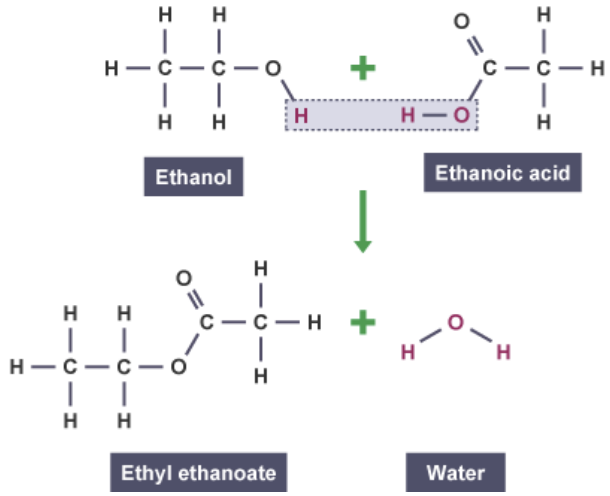
CHEMICAL REACTIONS

CHEMICAL REACTIONS OF ALCOHOLS

1) **Combustion**
2) **Oxidation**
3) **Esterification**

3) Esterification

Alcohols also react with carboxylic acids in the presence of a catalyst to form **esters**, an organic compound containing the -COO functional group.



Conditions: concentrated H_2SO_4, heating under reflux

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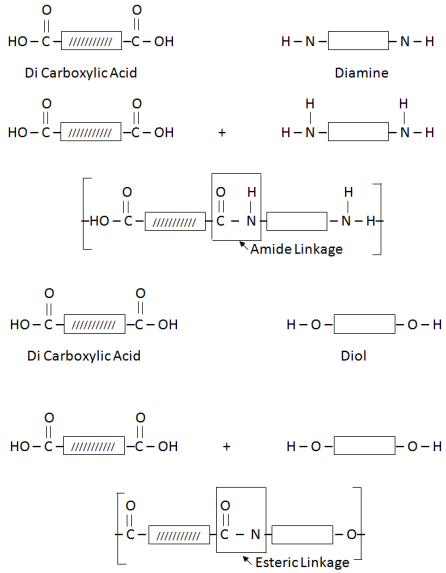
POLYMER

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)

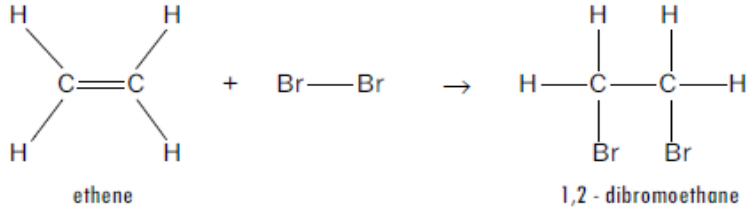
Esterification
(warm, sulfuric acid)

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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