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TOPIC 11.4: ALCOHOLS

random| plasmid

Chromosomes and plasmids are both made of DNA. Chromosomes are large molecules of DNA that contain the genetic information of an organism. Plasmids are small, circular molecules of DNA that can replicate independently of the chromosome. They are often used in genetic engineering to transfer genes between cells.

Chromosomes are made of DNA and proteins. The DNA is wrapped around proteins called histones. This structure is called a nucleosome. The nucleosome is the basic unit of chromatin. Chromatin is the material that makes up chromosomes.

Plasmids are small, circular molecules of DNA that can replicate independently of the chromosome. They are often used in genetic engineering to transfer genes between cells. Plasmids are found in many types of bacteria and some eukaryotic cells.

One model of DNA structure is the double helix model. This model was proposed by James Watson and Francis Crick in 1953. It shows two strands of DNA twisted around each other. The strands are made of sugar and phosphate groups. The bases of the DNA are attached to the sugar groups. The bases of one strand are paired with the bases of the other strand.

The double helix model of DNA structure was supported by X-ray diffraction data. X-ray diffraction is a technique used to study the structure of crystals. It involves shining X-rays on a crystal and measuring the angles at which the rays are diffracted. The diffraction pattern can be used to determine the structure of the crystal.

Through the 1950s, DNA had been known to be the genetic material. However, the structure of DNA was still unknown. The double helix model was proposed in 1953. It was supported by X-ray diffraction data and by the chemical composition of DNA.

The double helix model of DNA structure is a simple model. It shows the basic structure of DNA, but it does not show all the details. For example, it does not show the exact positions of the atoms in the DNA molecule. However, it is a good model for understanding the basic structure of DNA.

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 ₃ OH	$ \begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{OH} \\ \\ \text{H} \end{array} $	CH ₃ -OH
Ethanol	2	C ₂ H ₅ OH	$ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H}-\text{C}-\text{C}-\text{O}-\text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array} $	CH ₃ CH ₂ -OH
Propanol	3	C ₃ H ₇ OH	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{O}-\text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array} $	CH ₃ CH ₂ CH ₂ -OH
Butanol	4	C ₄ H ₉ OH	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \\ \text{H}-\text{C}-\text{C}-\text{C}-\text{C}-\text{O}-\text{H} \\ \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array} $	CH ₃ CH ₂ CH ₂ CH ₂ -OH

Alcohols

Alcohols have the **general formula C_nH_{2n+1}OH** and can be identified by the **hydroxyl -OH functional group**.

Functional group

Alcohols have the **hydroxyl -OH functional group**.

Isomers

Isomerism can occur in alcohols that contain **at least three carbon atoms**.

Isomers have the same molecular formula and similar chemical properties.

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

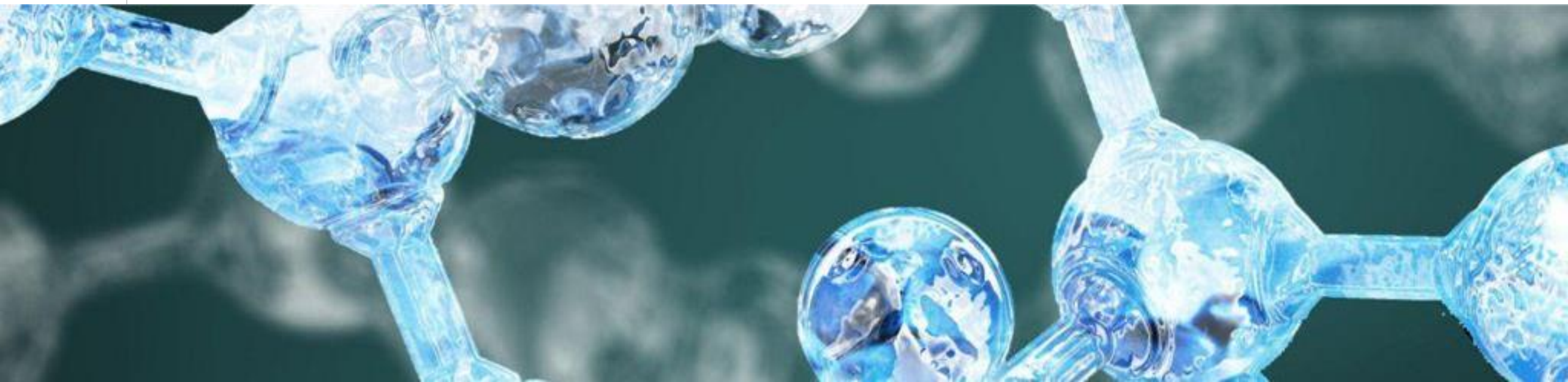
KEY CONCEPT

ALCOHOLS

PHYSICAL PROPERTIES

PRODUCTION OF ALCOHOL

CHEMICAL REACTIONS



PHYSICAL PROPERTIES

Physical property	Reasoning
Melting and boiling points	<p>As the number of carbon atoms in the alcohols increases, the melting and boiling points of alcohols increases as well.</p> <p>As the number of carbon atoms in an alcohol 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 alcohol molecules. Hence, larger alcohol containing more carbon atoms will have higher melting and boiling points.</p>
Volatility	<p>As the number of carbon atoms in the alcohol increases, the volatility of alcohol decreases. (similar to m.p. & b.p.)</p> <p>With a higher relative molecular mass, there would be stronger intermolecular forces of attraction between the alcohol molecules. As such, more energy is needed to overcome the intermolecular forces of attraction between the alcohol molecules.</p> <p>Hence, larger alcohol molecules are less likely to evaporate in room temperature.</p>
Density	As the number of carbon atoms in the alcohols increases, the density of alcohols increases.
Viscosity	<p>As the number of carbon atoms in the alcohols increases, the viscosity of alcohols decreases. (more difficult to flow)</p> <p>Alcohols with longer hydrocarbon chains flow less easily as they tend to get stuck together.</p>
Flammability	As the number of carbon atoms in the alcohols increases, the flammability of alcohols decreases. (more difficult to burn)
Solubility	Alcohols are soluble in water , but as the number of carbon atoms increases, solubility in water decreases.

MAKING ALCOHOL

PRODUCTION OF ALCOHOLS

1) Fermentation

1) Manufacture of ethanol from ethene

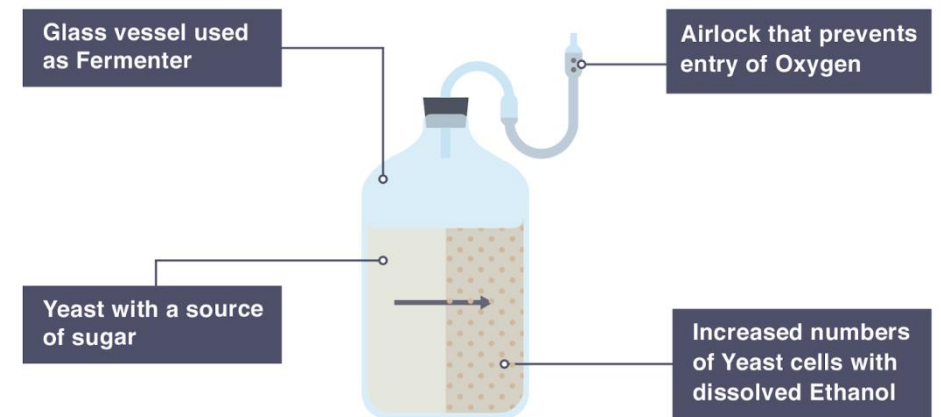
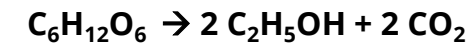
PRODUCTION OF ALCOHOL

1) Fermentation

Fermentation is a chemical reaction where glucose/sugar are broken down by micro-organisms into smaller molecules such as alcohol and carbon dioxide.

For instance, yeast contains enzymes that are used as catalyst for the breakdown **of glucose $C_6H_{12}O_6$ into ethanol C_2H_5OH and carbon dioxide.**

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



MAKING ALCOHOL

PRODUCTION OF ALCOHOLS

1) Fermentation

1) Manufacture of ethanol from ethene

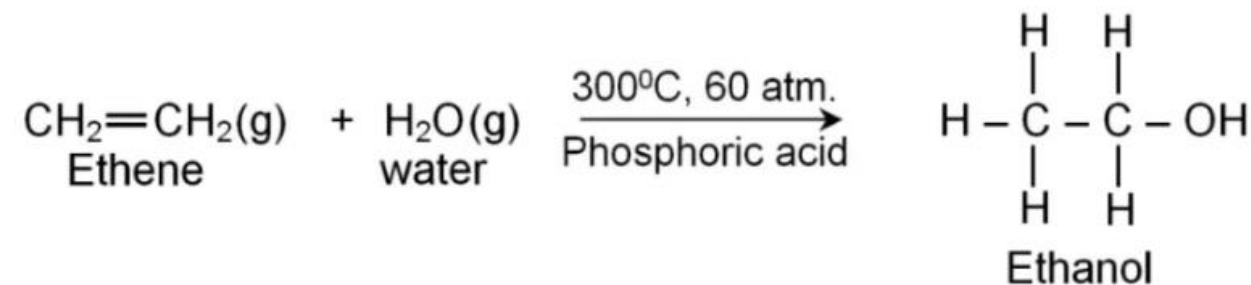
PRODUCTION OF ALCOHOL

2) Manufacture of ethanol from ethene (Hydration)

To produce alcohol, alkene and steam are reacted together at a temperature of **300°C** and at **60 atm**.

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

The following equation below shows the reaction between ethene and steam.



Uses of ethanol

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

Ethanol is used as a organic **solvent for many organic compounds**.

Ethanol has high volatility and it is an **ideal solvent for perfume and deodorants**.

As it can undergo complete combustion to form carbon dioxide and water, ethanol is used as a **clean fuel**.

CHEMICAL REACTIONS

CHEMICAL REACTIONS OF ALCOHOLS

1) Combustion

1) Oxidation

1) Esterification

1) Combustion

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

If there is insufficient oxygen present for complete combustion, the alkene undergoes **incomplete combustion** to produce water and carbon monoxide instead.

Soot (carbon) could also be produced as a by-product during incomplete combustion.

2) Oxidation

Alcohols will be oxidised to form carboxylic acids in the presence of a strong oxidising agent.

Oxidising agents:

KMnO₄ (purple to colourless)

K₂Cr₂O₇ (orange to green)

For example, ethanol can be oxidised to ethanoic acid:



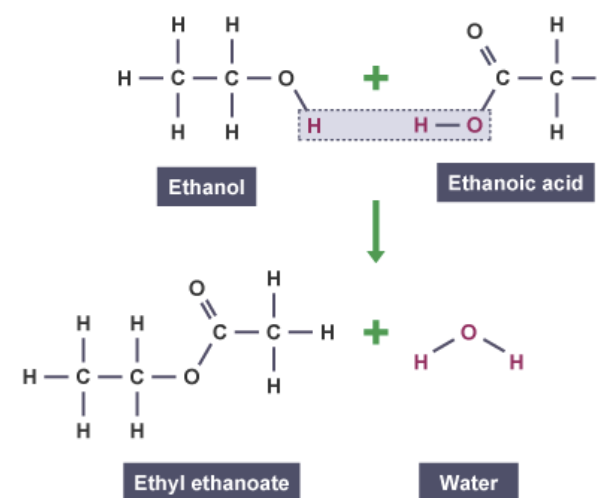
CHEMICAL REACTIONS

CHEMICAL REACTIONS OF ALCOHOLS

- 1) Combustion
- 1) Oxidation
- 1) Esterification

3) Esterification

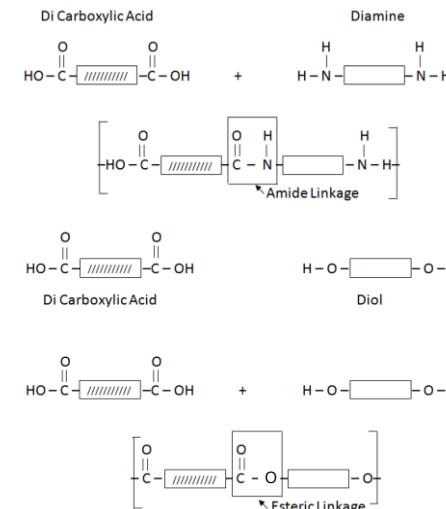
In the presence of a catalyst, **alcohols will react with carboxylic acids** to form **esters**.



Conditions: Concentrated H_2SO_4 , heating under reflux

POLYMER

**Condensation
Polymerisation**
(elimination of water)



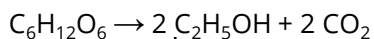
LONG CHAIN ALKANE

H₂ gas
(For Haber process)

Catalytic Cracking
(Al₂O₃ & SiO₂, 600 °C)

**Addition
Polymerisation**
(High temp & pressure)

SUGAR



Fermentation
(37°C, yeast & no O₂)

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

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

ALKANE

C - C

Hydrogenation
(200 °C & nickel)

ALKENE

C = C

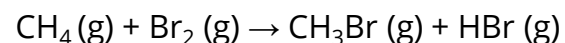
ALCOHOL

-OH

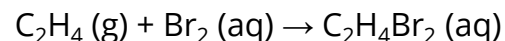
CARBOXYLIC ACID

-COOH

Substitution
(UV light)



Bromination
(Test for C=C bonds)

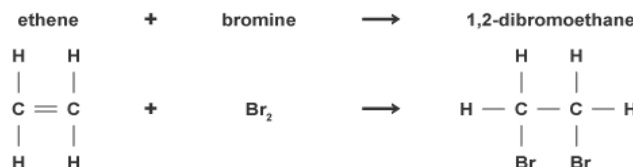


Esterification
(warm, sulfuric acid)

ESTER + H₂O
-COO-

Prefix

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



ALL ORGANIC COMPOUNDS
Complete Combustion



Incomplete Combustion



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