

Topic 10 – Alcohols

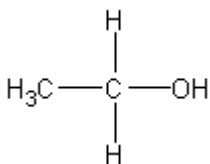
Revision Notes

1. General

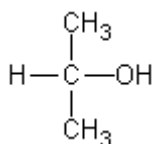
- Functional group is -OH
- General formula is $C_nH_{2n+1}OH$
- The -OH group means that alcohols hydrogen bond with each other. Alcohols have low volatility (high boiling points) for their size because the hydrogen bonds have to be broken
- Alcohols are highly soluble in water because hydrogen bonding occurs between -OH of alcohols and water molecules

2. Classifying Alcohols

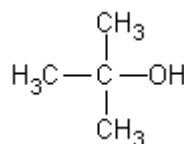
- Classified according to the number of carbons attached to C-OH
- Primary alcohols have 1 carbon attached e.g. ethanol
- Secondary alcohols have 2 carbons attached e.g. propan-2-ol
- Tertiary alcohols have 3 carbons attached e.g. 2-methylpropan-2-ol



Primary 1°



Secondary 2°



Tertiary 3°

3. Reactions of Alcohols

- Reagents = the other chemicals needed
- Conditions = required temperature, pressure, catalyst etc

a) Combustion

- **Example** $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$
- Balance C's then H's then O's
- Don't forget the O in the OH when balancing

b) Dehydration to form an alkene

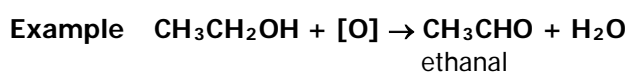
- **Example** $C_2H_5OH \rightarrow CH_2=CH_2 + H_2O$
- Needs heat and a strong acid catalyst (concentrated sulphuric acid or concentrated phosphoric acid)

c) Reaction with a carboxylic acid to form an ester (esterification)

- Carboxylic acids contain the functional group -COOH , esters have the form RCOOR'
- **Example** $\text{C}_2\text{H}_5\text{OH} + \text{CH}_3\text{COOH} \rightarrow \text{CH}_3\text{COOC}_2\text{H}_5 + \text{H}_2\text{O}$
Ethanoic acid ethyl ethanoate
- Conditions catalyst of concentrated H_2SO_4

d) Oxidation of primary alcohol to aldehyde

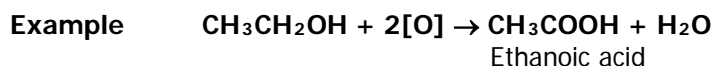
- Here, oxidation means loss of hydrogen
- Oxidising agent represented by $[\text{O}]$ in equations
- Colour change is from orange to green
- Aldehyde has functional group -CHO



- **Reagents** - oxidising agent is acidified potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7/\text{H}_2\text{SO}_4$)
- **Conditions** – distil off aldehyde as it is formed
- Ethanal boils at about room temperature. Ethanol and ethanoic acid have higher boiling points due to hydrogen bonding
- To stop the aldehyde being further oxidised, it needs to be distilled off as it forms. This removes the aldehyde from the oxidising mixture. This is done by dripping a mixture of ethanol and dichromate into the hot acid

e) Oxidation of primary alcohol to carboxylic acid

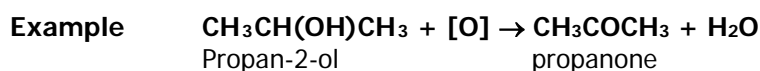
- Colour change is from orange to green



- **Reagents** - oxidising agent is acidified potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7/\text{H}_2\text{SO}_4$)
- **Conditions** – reflux (continuously boil and condense)
- To make sure the aldehyde is further oxidised to the carboxylic acid, it needs to be refluxed with the $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$. Refluxing is continuous boiling and condensing. It allows the alcohol to be simmered with the oxidising agent for a period of time without losing any of the product

f) Oxidation of secondary alcohols

A secondary alcohol is oxidised to a ketone (functional group $>\text{C}=\text{O}$) using $\text{K}_2\text{Cr}_2\text{O}_7/\text{H}_2\text{SO}_4$



g) Oxidation of tertiary alcohols

Tertiary alcohols are resistant to oxidation because there is no H attached to the C of the C-OH

5. Uses of Alcohols

a) Ethanol

- In alcoholic drinks.
- As a solvent (in the form methylated spirits)

b) Methanol

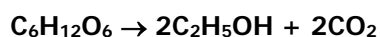
- As a petrol additive to improve combustion
- As a feedstock in the production of organic chemicals

6. Industrial Production of Ethanol

Feedstock = starting material in an industrial process i.e. glucose or ethene here

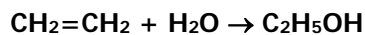
a) Fermentation of Glucose

- Slow reaction, impure product, batch process, uses renewable resources
- Requires enzyme from yeast (zymase), temperature 35-40°C, no air (anaerobic)



b) Hydration of Ethene

- Fast reaction, pure product, continuous process, uses non-renewable resources.
- Requires phosphoric acid catalyst (H_3PO_4), temperature 300°C, pressure 6.5 Mpa



c) Comparison

- Glucose is produced from plants, which are a renewable resource as they only take a few months to grow
- Ethene is produced from crude oil, which is a non-renewable resource that takes millions of years to form