

Topic 11 – Alcohols

Revision Notes

1. General

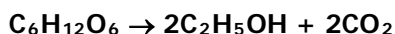
- Functional group is -OH
- General formula is $C_nH_{2n+1}OH$

2. Industrial Production of Ethanol

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

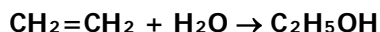
a) Fermentation of Glucose

- Slow reaction, batch process, uses renewable resources.
- Requires enzyme from yeast (zymase), temperature 35-40°C, aqueous (dissolved in water), no air (anaerobic)



b) Hydration of Ethene

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



c) Comparison

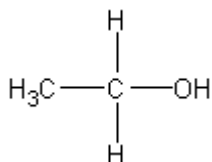
- Glucose is produced from plants, which are a renewable resource as they only take a few months to grow
- Ethene is produced from crude oil, which is a non-renewable resource that takes millions of years to form

d) Carbon neutrality

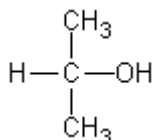
- Ethanol produced by fermentation is a biofuel i.e. it is produced from biological sources (sugar in this case)
- Carbon neutral refers to activities that have no net annual carbon emissions to the atmosphere
- Biofuels are not carbon neutral because it requires energy to grow the crops and convert them into fuel

3. Classifying Alcohols

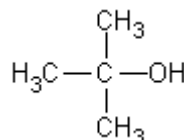
- Classified according to the number of carbons attached to C-OH
- Primary alcohols have 1 carbon attached e.g. ethanol
- Secondary alcohols have 2 carbons attached e.g. propan-2-ol
- Tertiary alcohols have 3 carbons attached e.g. 2-methylpropan-2-ol



Primary 1°



Secondary 2°



Tertiary 3°

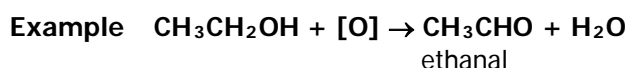
4. Reactions of Alcohols

a) Combustion

- **Example** $\text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O}$
- Balance C's then H's then O's
- Don't forget the O in the OH when balancing

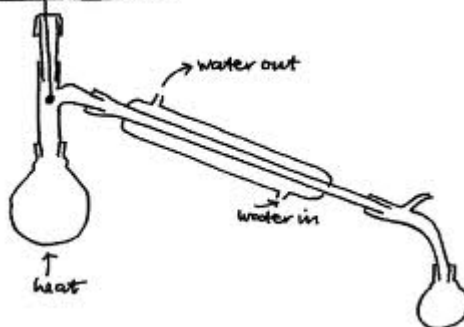
b) Oxidation of primary alcohol to aldehyde

- Here, oxidation means loss of hydrogen
- Oxidising agent represented by [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

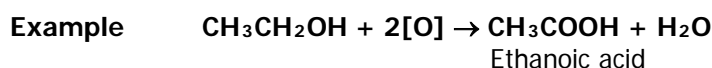
Simple distillation:



- 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

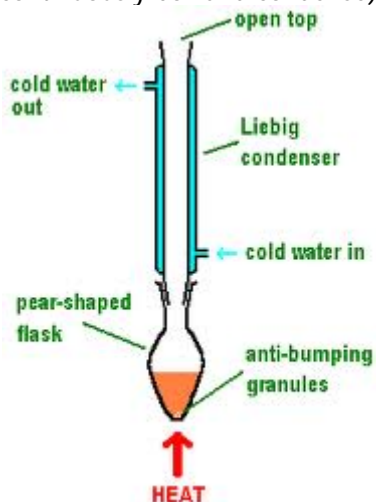
c) Oxidation of primary alcohol to carboxylic acid

- Carboxylic acid has functional group -COOH



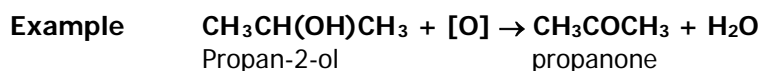
- **Reagents** - oxidising agent is acidified potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7/\text{H}_2\text{SO}_4$)

- **Conditions** – reflux (continuously boil and condense)



d) Oxidation of secondary alcohols to ketones

- A secondary alcohol is oxidised to a ketone (functional group -CO-)

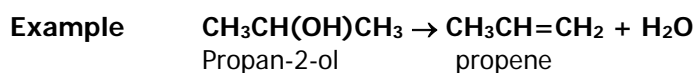


e) Oxidation of tertiary alcohols

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

f) Elimination of water to make alkenes

- Alcohols can be dehydrated using acid catalysts such as H_2SO_4 and H_3PO_4
- An H is removed from one C and an OH from the next C



- This method of making alkenes provides a route for producing addition polymers without using monomers derived from crude oil

5. Distinguishing between aldehydes and ketones

- Aldehydes react with mild oxidising agents such as Tollens' reagent
- Ketones do not react with Tollens' because they are not easily oxidised
- Tollen's reagent is ammoniacal silver nitrate. The compound to be tested is warmed with Tollen's reagent
- With Tollens' aldehydes produce a silver mirror whereas there is no reaction with ketones