Combustion and oxidation of alcohols

Alcohols are often flammable and undergo combustion readily in air. Some alcohols can also be oxidised using certain oxidising agents and conditions.

Combustion of alcohols

Alcohols will burn in air to form carbon dioxide and water. The general equation for the reaction is

$C_nH_{2n+1}OH + (1.5n)O_2 \rightarrow (n + 1)H_2O + nCO_2$

so for example:

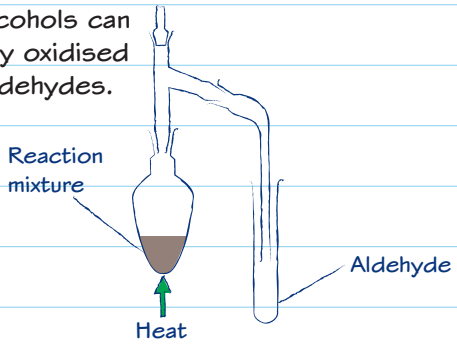
$C_2H_5OH + 3O_2 \rightarrow 3H_2O + 2CO_2$

Although all alcohols can burn in oxygen, only primary and secondary alcohols can be oxidised by oxidising agents. Make sure you can apply your knowledge of covalent bonding to explain why tertiary alcohols will burn but cannot be readily oxidised by oxidising agents such as acidified potassium dichromate(VI).

Practical skills

Oxidation of alcohols

Primary alcohols can be partially oxidised to form aldehydes.



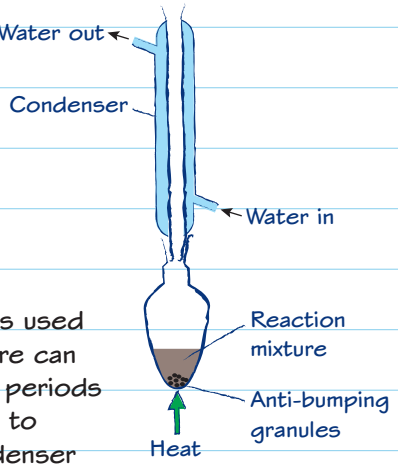
A simple distillation is used to remove the product as soon as it forms to prevent further oxidation.

The reaction mixture consists of the primary alcohol and an oxidising agent, which is often acidified potassium dichromate(VI), $K_2Cr_2O_7 / H^+$.

The equation for such reactions can be simplified using [O] to represent oxygen from the oxidising agent. For example:

$CH_3CH_2OH + [O] \rightarrow CH_3CHO + H_2O$

Primary alcohols can be completely oxidised to form carboxylic acids, and secondary alcohols to form ketones.



Heating under reflux is used so the reaction mixture can be heated for longer periods so the reaction goes to completion. The condenser makes sure any vapour condenses back into the flask to minimise the release of harmful or flammable substances.

$CH_3CH_2CH_2OH + 2[O] \rightarrow CH_3CH_2COOH + H_2O$

propan-1-ol → propanoic acid

$CH_2CH(OH)CH_3 + [O] \rightarrow CH_3COCH_3 + H_2O$

propan-2-ol → propanone

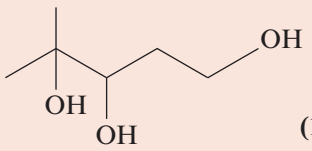
The reaction mixture consists of an alcohol and an **excess** of oxidising agent to ensure complete oxidation. If acidified potassium dichromate (VI) is used, there will be a colour change from orange to green.

There may be more unusual examples in exams.

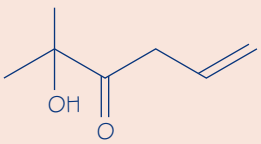
Just identify any primary or secondary alcohol groups and they become carboxylic acids and ketones respectively. You can ignore any tertiary alcohol groups as they do not readily oxidise.

Worked example

Draw the structure of the product formed when the alcohol shown is heated under reflux with excess acidified potassium dichromate(VI).



(1 mark)



Now try this

Write the equation for the incomplete combustion of ethanol, forming a toxic gas and water only.

(2 marks)