Alcohols, Aldehydes and Ketones

From previous work you should be able to

1. State what a homologous series is.
2. Understand what is meant by a functional group.
3. Understand the term oxidation in terms of gaining oxygen, loss of hydrogen and also loss of electrons.
4. Understand the term alcohol.
5. Know about and give the equation for the production of ethanol from glucose using the enzyme zymase found in yeast.

Common alcohol **6.1**

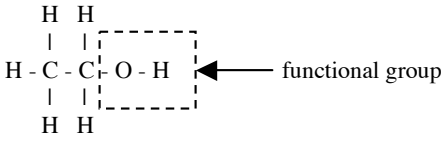
Common alcohol is an organic compound called ethanol. Ethanol is the alcohol, which is present in all drinks. In can safely be consumed in small doses but in large amounts can cause drunkenness and disease of the liver (cirrhosis).
Ethanol is an important chemical in industry and is just one of a homologous series of compounds called alcohols ($C_nH_{2n+1}OH$)

Properties of Ethanol	
Property	Result
Appearance	
Solubility	
pH	
Conduction	
Burning	

Names of alcohols

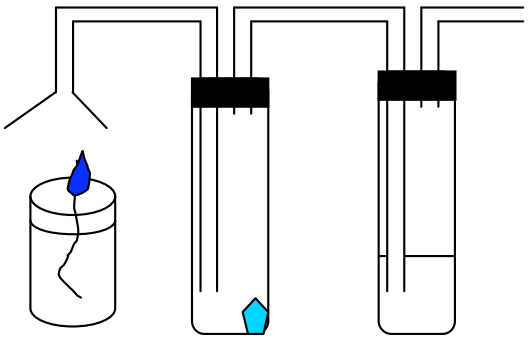
Alkanes	Alcohols
methane CH_4	methanol CH_3OH
ethane	
propane	
butane	
pentane	

Structure of Ethanol



The O - H group is called the hydroxyl group.
Do not confuse with the hydroxide ion.
alcohols do not break up to give ions.

Burning ethanol



Results
The cobalt chloride paper turns blue to pink.
This shows water has been formed.
Ethanol must contain hydrogen; oxygen can be obtained from the air
The limewater turns cloudy.
This shows that carbon dioxide has been formed.
Ethanol must contain carbon; the oxygen can be obtained from the air

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

Conclusion
Ethanol must contain both carbon and hydrogen.

Industrial Ethanol 6.2

The fermentation of carbohydrate has provided a source of ethanol for thousands of years mainly in the form of alcoholic drinks. However the industrial use of ethanol has greatly increased over recent years.

Manufacture of ethanol

1. From fermentation

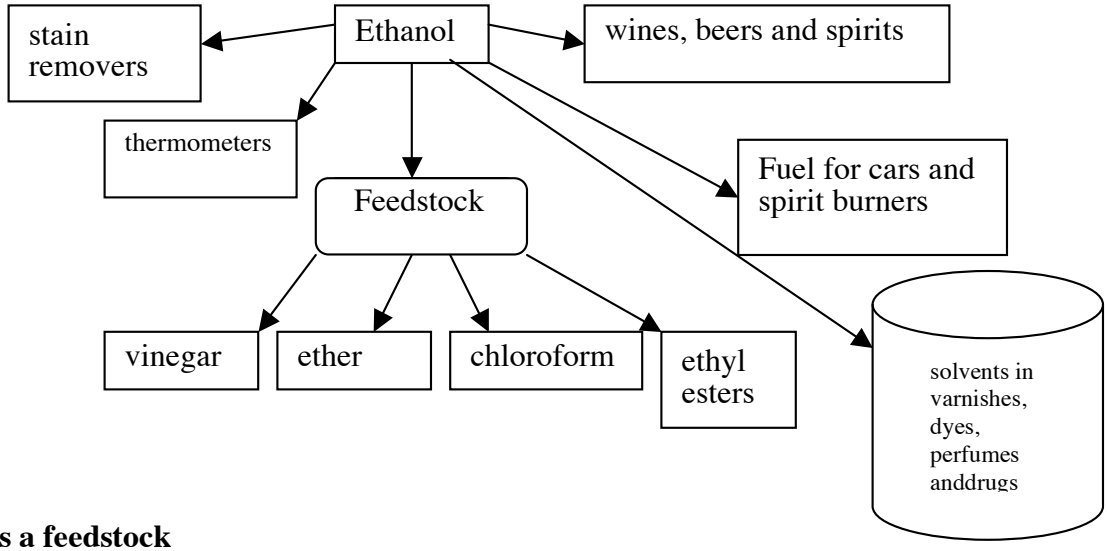
$C_6H_{12}O_6 \Rightarrow C_2H_5OH + CO_2$

2. Industrial preparation from crude oil

Cracking produces ethene. which can be hydrated using a catalyst to produce ethanol

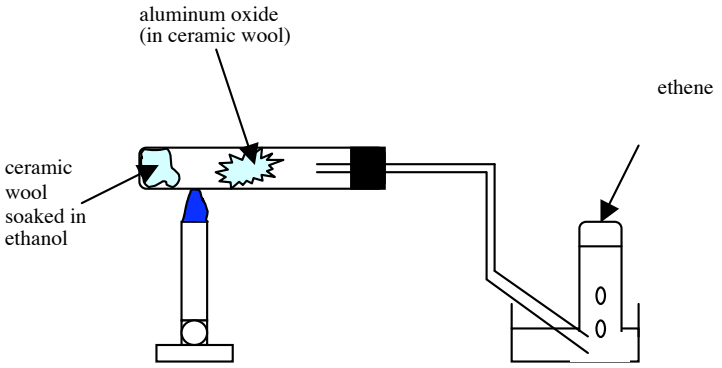
$C_2H_4 + H_2O \Rightarrow C_2H_5OH$

Uses of Ethanol



Ethanol as a feedstock

Ethanol can be used to prepare ethene, which could be important, when fossil fuel run out as ethene is important in the plastics industry.



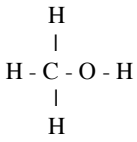
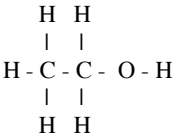
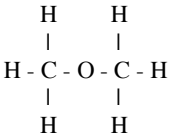
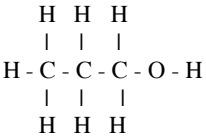
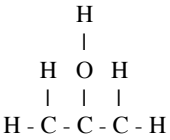
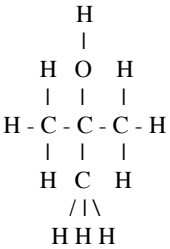
Dehydration Reaction

$C_2H_5OH \Rightarrow C_2H_4 + H_2O$

The ethanol loses a molecule of water

Alcohols 6.3

Alcohols exist as a homologous series with the general formula $C_nH_{2n+1}OH$. This means that all the alcohols will have similar chemical properties and gradually increasing physical properties
Like hydrocarbons alcohols show isomerism i.e. same molecular formula and different structures

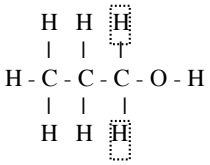
Alcohol	Molecular formula	Structural formula	B.Pt [ºC]	Example of isomers
methanol	CH_3OH		65	-
ethanol	C_2H_5OH		79	 **An isomer but not an alcohol as no hydroxyl group is present**
propanol	C_3H_7OH		97	 propan - 2 - ol **Only alcohol isomers**
butanol	C_4H_9OH		117	 2- methylpropan-2-ol
pentanol	$C_5H_{11}OH$			

Alcohol Structures 6.4

Although all alcohols have similar chemical properties, there are some differences depending upon the detailed structure of the alcohol, especially the position of the hydroxyl group. In addition to straight and branched chains there are also rings and aromatic alcohols as well as alcohols with more than one hydroxyl group.

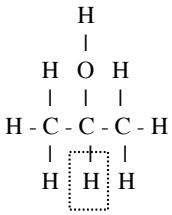
Primary [1°], Secondary [2°] and Teriary [3°] alcohols

Primary [1°]



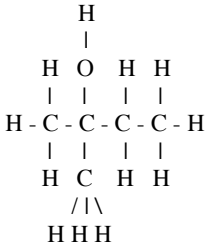
In 1° alcohols the carbon joined to the hydroxyl group is also joined to two other hydrogens and one carbon

Secondary [2°]



In 2° alcohols the carbon joined to the hydroxyl group is also joined to one other hydrogen and two carbons

Teriary [3°]



In 3° alcohols the carbon joined to the hydroxyl group is also joined to three other carbons and no hydrogens

3 isomers of $C_5H_{11}OH$

Cyclohexanol

Dihydric annd trihydric alcohols

ethane-1,2-diol

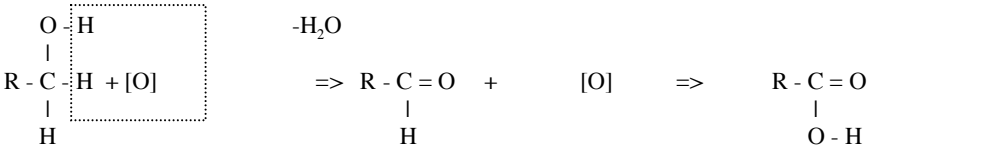
propane-1,2,3-triol

Oxidising Alcohols 6.5

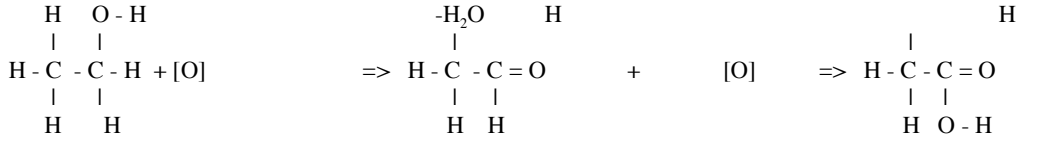
The combustion reactions of alcohols are examples of oxidation since the molecules react with oxygen. However milder oxidation can affect only the functional group.

Oxidation of alcohol depends upon whether the alcohol is 1°; 2° or 3°.

1°

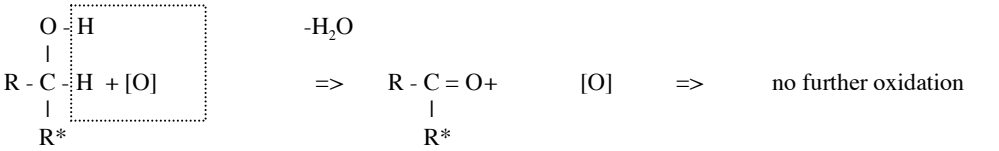


an aldehyde carboxylic acid

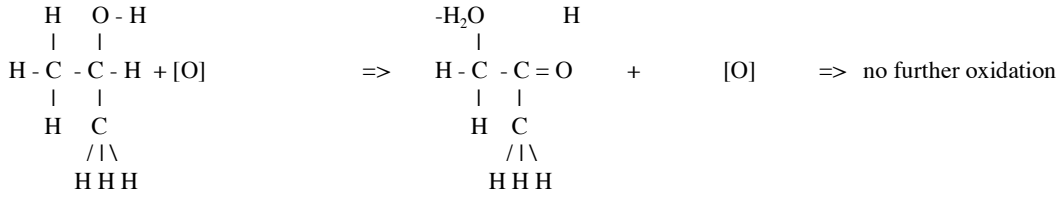


ethanol ethanal ethanoic acid

2°

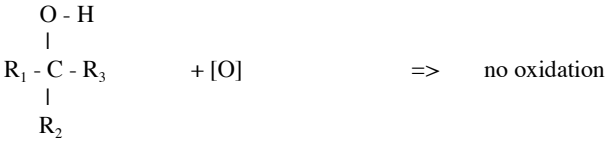


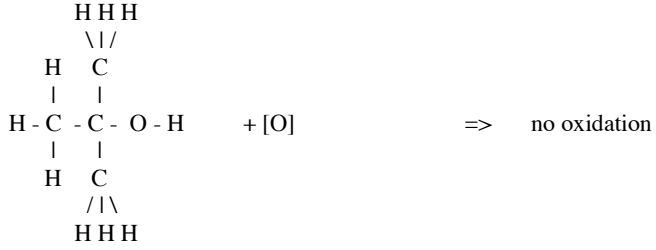
a ketone



propanan - 2 - ol propanone

3°





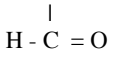
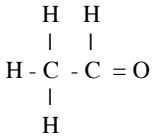
2 methylpropan - 2- ol

Aldehydes and ketones 6.6

Both aldehydes and ketones contain the carbonyl group C = O.

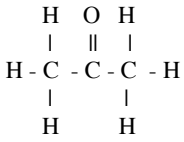
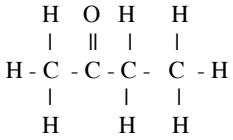
Aldehydes

Theseare carbon compounds which contain a carbonyl group at the end of a chain of carbon atoms. i.e. They contain the -CHO functional group. Aldehydes are also called alkanals, a homologous series with general formula $C_nH_{2n}O$.

Aldehyde	Formula showing functional group	Structural formula
methanal	HCHO	
ethanal	CH_3CHO	
propanal	C_2H_5CHO	

Ketones

These are compounds which contain a carbonyl group, in the middle of a chain of carbon atoms i.e. they contain the - CO -
Ketones are also called alkanones forming their own homologous series with the general formula $C_nH_{2n}O$.[same as aldehydes]

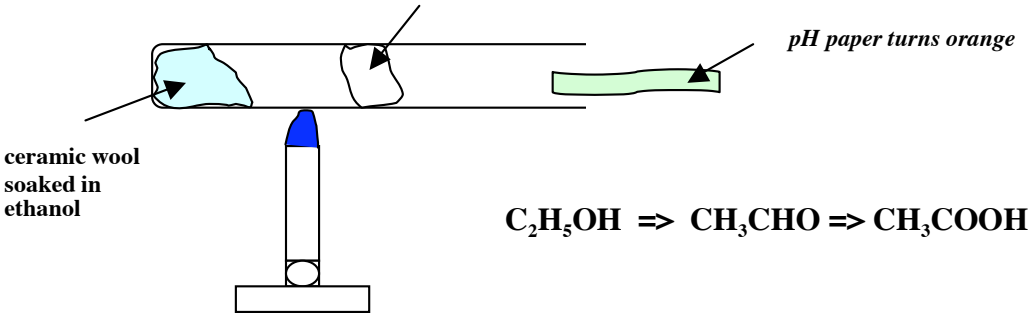
Ketone	Formula showing functional group	Structural formula
propanone	CH_3COCH_3	
butanone	$C_2H_5COCH_3$	
pentan -3 - one	$C_2H_5COC_2H_5$	
	+	
pentan -2 - one	$CH_3COC_3H_7$	

Oxidation of alderhydes
An important difference between aldehydes and ketones is that aldehydes are readily oxised, ketones are not.

Several oxidising agents may be used

Copper(II) oxide

copper(II) oxide wrapped in



C_2H_5OH => CH_3CHO => CH_3COOH

Oxidising agents to differentiate between aldehydes and ketones

Oxidising agent	Obsevations	Explaqnation
acidified potassium dichromate solution	orange => blue/green	$Cr_2O_7^{2-}$ => Cr^{3+}
Benedict's reagent	blue => orange/green	Cu^{2+} => Cu^{+}
Tollens reagent	colourless => silver mirror	Ag^{+} => Ag

Methanol and methanal 6.7

About 50 million tonnes of methanol is manufactured each year, 50% of this is oxidised to methanal. Both of these are used mainly as feedstocks for making a variety of products including drugs and plastics.

1. Synthesis gas

This is a mixture of carbon monoixide and hydrogen, it can be made from the reaction of water with either methane or coal. The reaction is called steam reforming.

$$C + H_2O \xrightarrow{\textbf{1200}^0\textbf{C}} CO + H_2$$

$$CH_4 + H_2O \xrightarrow[\textbf{Ni cat.}\ \textbf{30 atmos.}]{\textbf{900}^o\textbf{C}} CO + 3\,H_2$$

2. Manufacturing methanol

Synthesis gas can be changed into methanol, the ration of CO and H_2 is altered and reacted

$$CO + 2\,H_2 \xrightarrow[\textbf{300}^o\textbf{C}\ \textbf{300 atmos.}]{\textbf{ZnO/Cr}_2\textbf{O}_3\ \textbf{cat}} CH_3OH$$

OR

$$CO + 2\,H_2 \xrightarrow[\textbf{200}^o\textbf{C}\ \textbf{60 atmos.}]{\textbf{CuO/ZnO/Al}_2\textbf{O}_3\ \textbf{cat.}} CH_3OH$$

3.Manufacturing methanal

Methanol can be oxidised to methanal by using oxygen from the air.

$$CH_3OH + 1/2\,O_2 \xrightarrow[\textbf{600}^o\textbf{C}]{\textbf{Ag cat.}} HCHO + H_2O$$

Using methanol and methanal

Methanol	Methanal
Gasoline	Formalin
Silicones	Adhesives
Fabrics	Plastics
Drugs	Explosives
Plastics	Antiseptics