Chem Factsheet

April 2001 Number 17

Organic Chemistry III - Reactions II

To succeed with this topic you need to
- **Be able to name and draw organic molecules (Factsheet 15)**
- **Know the reactions of alkanes, alkenes and halogenoalkanes (Factsheet 16)**

After working through this Factsheet you will

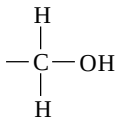
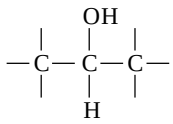
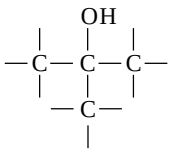
- **Know the reactions of alcohols**
- **Know some of the reactions of aldehydes, ketones and carboxylic acids**
- **Know the ways in which the organic compounds of this Factsheet and Factsheet 16 can be converted from one to another (i.e. synthetic pathways)**

Important
The question at the end of this Factsheet test not only the information in it, but also the information in Factsheet 16. Factsheets 16 and 17 make up the complete work on organic reactions.

Exam Hint *- The secret to answering questions on organic chemistry is not to be put off by the unfamiliar compounds used in the question. Always look for the functional groups / families of the compounds Functional groups always react in the same way!*

Alcohols

Alcohols have the general formula, $C_n H_{2n+1}OH$, and the functional group is –OH. The ending of the name in –ol shows the presence of the –OH group. If two –OH groups are present it is called a **diol**. The position of the –OH group on the carbon chain of a molecule affects its properties, so you need to be able to identify the three types of alcohols:

Primary	Secondary	Tertiary
		
-OH on the end of the carbon chain	2 carbon atoms attached to the OH- carrying C atom	3 carbon atoms attached to the OH- carrying C atom

Reactions

1. Halogenation
Primay, secondary, tertiary alcohols behave the same way. The – OH groups is replaced by Cl , Br or I.

e.g. PCl_5 in dry conditions.
$C_2H_5OH + PCl_5 \rightarrow C_2H_5Cl + HCl + POCl_3$
reaction type: substitution
mechanism: nucleophilic

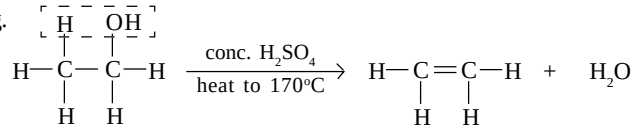
e.g. Solid NaBr with concentrated H_2SO_4 are used to produce HBr,
$C_2H_5OH + HBr \rightarrow C_2H_5Br + H_2O$
reaction type: substitution
mechanism: nucleophilic

e.g. Solid P with solid I_2 to make PI_3,
$3C_2H_5OH + PI_3 \rightarrow 3C_2H_5I + H_3PO_3$
reaction type: substitution
mechanism: nucleophilic

Alcohol $\xrightarrow[\text{agent}]{\text{halogenating}}$ Halogenalkane

Exam Hint *- test for alcohols (i.e. the – OH group).*
*Add solid PCl_5 in **dry conditions**. It is an alcohol if **white 'steamy' fumes** (of HCl) are seen. This is a very important test and, like the bromine water test for a alkene, is a common examination question*

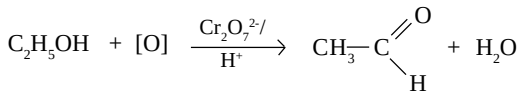
2. Dehydration (i.e. the removal of H_2O)
Add concentrated H_2SO_4 and heat to 170 ^{0}C,

e.g. 

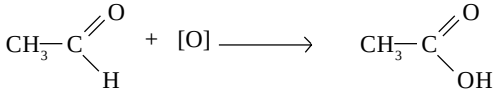
Alcohol $\xrightarrow[\text{agent}]{\text{dehydrating}}$ Alkene

3. Oxidation (only primary and secondary not tertiary)
Potassium dichromate(VI), $K_2Cr_2O_7$, in dilute H_2SO_4 with heating. This is the oxidising agent and it is **orange** in colour, but changes to green as it is reduced. N.B. remember this colour change !

(i) Primary alcohols

e.g. 

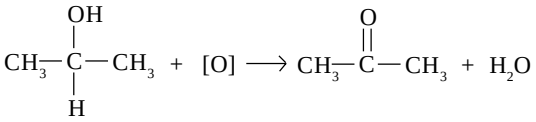
Then – if left, the aldehyde is oxidised further to the carboxylic acid ,

e.g. 

Alcohol $\xrightarrow{[O]}$ Aldehyde

Aldehyde $\xrightarrow{[O]}$ Carboxylic acid

(ii) Secondary alcohols

e.g. 

Ketones cannot be oxidised further.

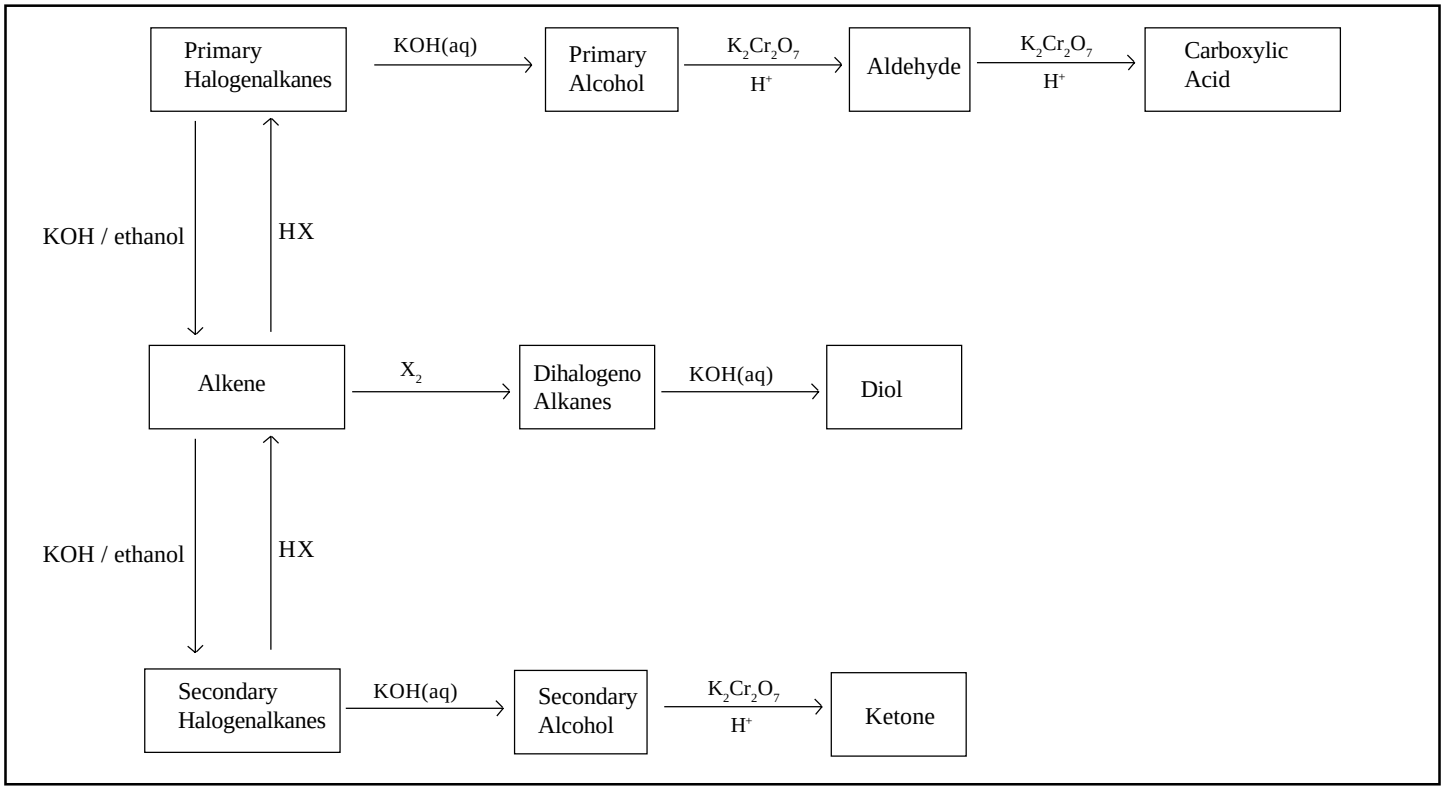
Secondary alcohol $\xrightarrow{[O]}$ Ketone

N.B. In the A2 course these oxidation processes are shown to be capable of being reversed by a **reduction** process,

i.e. Carboxylic acid $\xrightarrow{[H]}$ Aldehyde $\xrightarrow{[H]}$ Primary alcohol

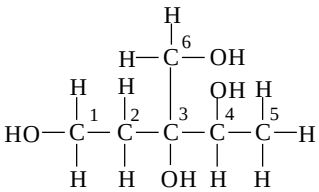
Ketone $\xrightarrow{[H]}$ Secondary alcohol

Synthetic Pathways
Summary Of Reactions From Factsheet 16 & 17



Practice Questions

1. The molecule contains the – OH group in various positions:



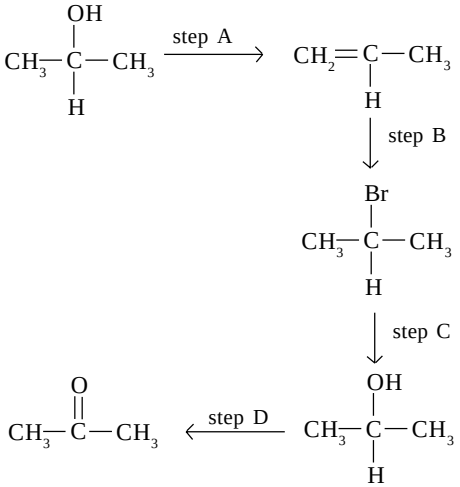
Is the –OH in a primary, secondary or tertiary position in the carbon atom numbered 1, 3, 4 and 6?

2. Propan -1– ol is reacted with the following reagents under the conditions shown. In each case give:
   (i) The balanced chemical equation.
   (ii) The systematic name of the organic product.

   (a) Solid NaBr and concentrated sulphuric acid.
   (b) Heating to 170 °C with concentrated sulphuric acid.
   (c) Heating with potassium dichromate (VI) in dilute sulphuric acid.

3. An unknown liquid gives the following test results:
   (a) Produces white steaming fumes with dry PCl_5
   (b) changes potassium dichromate(VI) in dilute sulphuric acid from yellow to green when heated.
   What family could the liquid belong to?

4. For each of the steps A – D give the regents and the conditions necessary to bring about the conversion:



5. Compound **A** ($C_4H_{10}O$) is oxidised to compound **B** ($C_4H_8O_2$) by heating it with $K_2Cr_2O_7$ and dilute H_2SO_4. **A** produces compound **C** with P and I_2 at room temperature. **C** is converted into **D** by reacting it with ethanolic KOH.

   Identify the compounds **A**, **B**, **C** and **D** by giving their structural formulas and systematic names.

6. An unknown compound gives the following test results:
   (a) decolourises bromine water
   (b) produces a yellow precipitate when reacted with dilute nitric acid followed by silver nitrate solution.
   What functional groups does the compound contain?

Answers

1. C① - primary, C③ - tertiary, C④ - secondary, C⑥ - primary

2. (a) $C_3H_7OH + HBr \rightarrow \underset{\text{1-bromopropane}}{C_3H_7Br} + H_2O$

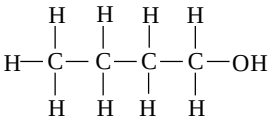
   (b) $C_3H_7OH \rightarrow \underset{\text{propene}}{C_3H_6} + H_2O$

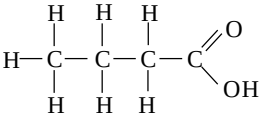
   (c) $C_3H_7OH + [O] \rightarrow \underset{\text{propanal}}{C_2H_5CHO} + H_2O$

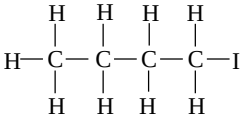
   Or $2C_3H_7OH + 3[O] \rightarrow \underset{\text{propanoic acid}}{2C_2H_5COOH} + H_2O$

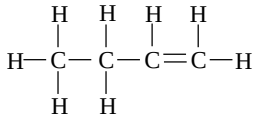
3. Primary or secondary alcohol (**both** need to be named)

4. A – conc. H_2SO_4 at 170 °C
   B – HBr (from conc. H_2SO_4 / NaBr)
   C – KOH(aq)
   D – $K_2Cr_2O_7$ / dil. H_2SO_4 + heat

5. A  butan-1-ol

   B  butanoic acid

   C  1-iodobutane

   D  but-1-ene

6. (a) alkene, 

   (b) iodide, -I

Acknowledgements:
This Factsheet was researched and written by Sam Goodman & Kieron Heath
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