AQA Chemistry A-level

3.3.14: Organic Synthesis

Detailed notes

Why do we need organic synthesis?

Synthesis pathways are needed to convert starting materials into a target compound. This is achieved through **multistep pathways** that, for example, lead to oxidation of functional groups, chain lengthening and saturation of double bonds.

When designing a synthetic pathway a chemist must consider several things:

- Product yield - related to Le Chatelier's principle
- Reaction conditions
- If a catalyst is needed
- Reagents
- The process involved - batch or continuous, (questions like - does the reaction mixture need to be purified before the next reactant can be added?)
- Hazards with the reagents or conditions
- Cost
- Formation of **isomers** - for instance, many drug targets are enzymes which are often stereospecific and will only react with one enantiomer, the synthetic pathway should be designed, if possible, to only produce this enantiomer and not a racemic mixture
- Reactivity of functional groups present - this includes other functional groups on the reactant itself, or on reagents and catalysts present.

Maximising the yield

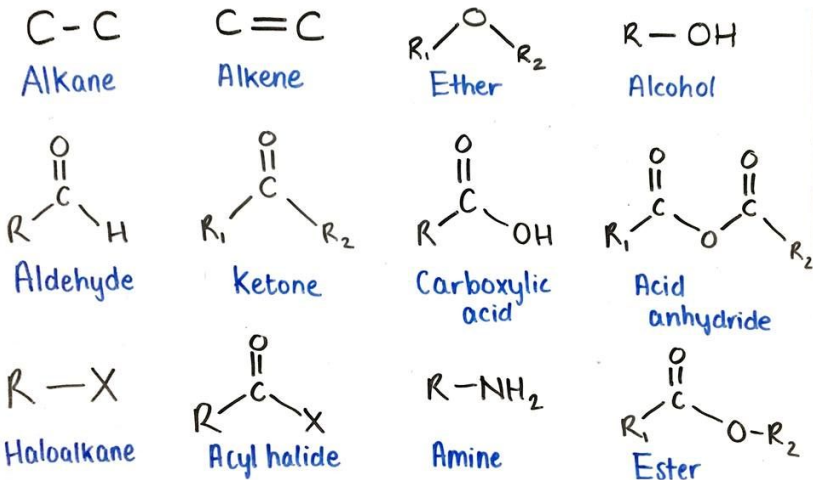
It is important for chemists to yield their product, in order to maximise their profits.The best synthetic pathways are those that keep the number of steps as low as possible, to improve the yield of the final product.

The **yield** of an individual step may be low for two reasons:

1. Product is left in the reaction mixture
2. The reaction is incomplete or irreversible

Functional groups

To best understand organic synthesis, you'll need to know the structures of all the functional groups.



Key reagents

<u>Oxidising agent</u> - Acidified potassium dichromate

- Oxidises primary alcohols to aldehydes and then to carboxylic acids.
    - If left in a reaction mixture an aldehyde will then be oxidised to carboxylic acids, to prevent this and stop at aldehyde an excess of alcohol can be used and distil the aldehyde off once formed. To form a carboxylic acid the reaction mixture is heated under reflux so the aldehyde remains in the mixture to be oxidised further.
- Oxidises secondary alcohols to ketones.

<u>Reducing agents</u>

- $NaBH_4$ - reduces a carbonyl group C=O to an alcohol group C-OH
- H_2 and Nickel catalyst - reduces a C=C double bond
- Tin / HCl - reduces NO_2 to NH_2

<u>Dehydrating agents</u>

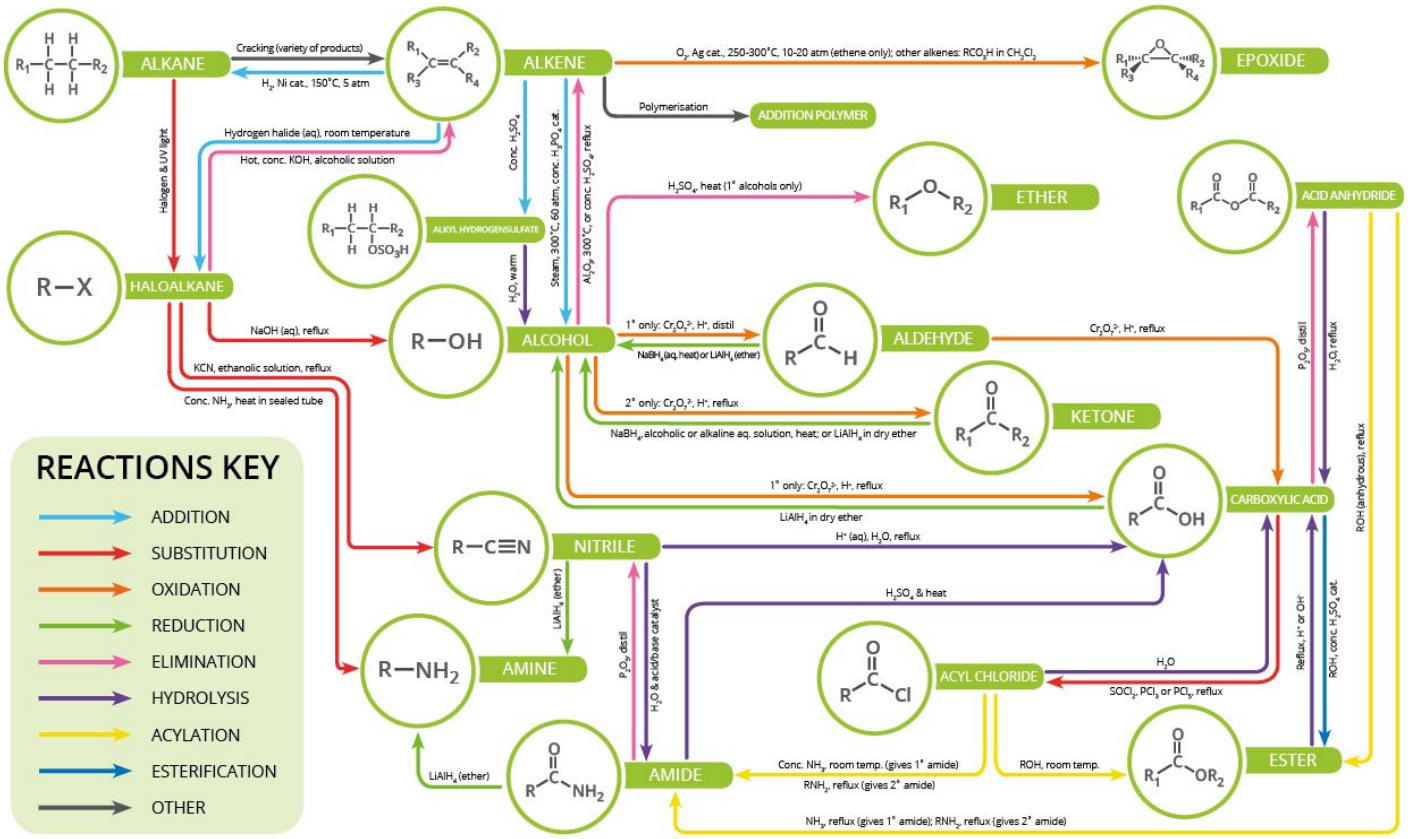
A dehydrating agent is one that removes water (H_2O) from a molecule

- Al_2O_3 - pass vapour over it
- Acid-catalysed elimination by H_3PO_4

Organic synthesis maps

A good overview of this topic is through **organic synthesis maps**. These tell you the conditions and reagents required for conversion from one functional group to another and shows the links between functional groups that require several steps to form others. It is also important to know the type of mechanism the reaction proceeds by.

Aliphatic synthesis map



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Aromatic synthesis

There is less to learn for **aromatic synthesis.** There are 4 key reactions:

1. **Acylation** of benzene to a phenylketone
2. **Nitration** of benzene to nitrobenzene
3. **Reduction** of nitrobenzene to an aromatic amine
4. Conversion of an aromatic amine to an aromatic amide using an acyl halide

The conditions and reagents for these reactions are found in the topics 3.10, 3.11 and 3.09.

Answering exam questions

Organic synthesis is a topic that requires you to draw together information from all of the other organic modules to be able to answer questions that require you to get from a starting material to an end product, with **synthesis pathways** of up to **4 steps**. You will need to be able to:

- Suggest reagents and reaction conditions (such as temperature, pressure and a catalyst)
- Identify reaction intermediate structures from their chemical formula
- Draw mechanisms
- Suggest products