Polymers Notes

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A polymer: a long chain molecule made by joining many smaller molecules called monomers together.

The word polymer comes from the Greek words **poly** meaning "many" and **mer** meaning "part".

A monomer: a small molecule that can join with other molecules like itself to form a polymer.

The word monomer comes from the Greek words **mono** meaning "one" or "single" and **mer** meaning "part".

There are **two** types of polymers:

1. Natural polymers. For example, Starch and other carbohydrates as well as DNA.
2. Synthetic polymers. That is man-made polymers such as poly(chloroethene), poly(ethene) etc.

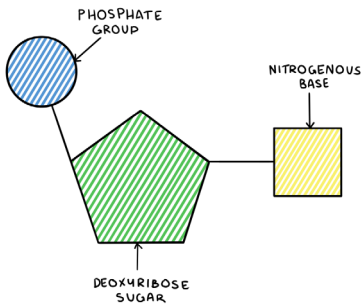
Let's look at the natural polymers first 😊

Natural Polymers

DNA is made up of many small units called nucleotides.

Each nucleotide has a nitrogenous base a deoxyribose sugar and a phosphate group. Only the bases can change. There are four different bases.

The nucleotides join together to form long strands. A molecule of DNA is a polymer made up of two strands of nucleotides making it a polynucleotide.



The figure shows a labelled DNA nucleotide

There are **four** DNA bases:

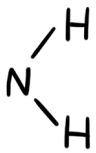
1. **Adenine – A**
2. **Thymine – T**
3. **Cytosine – C**
4. **Guanine – G**

Starch and Cellulose

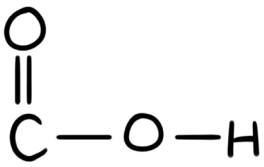
Starch and cellulose are both polymers that are made by plants. The monomers for both starch and cellulose are glucose molecules. Starch and cellulose have very different roles in the plant. Starch is used for storing energy while cellulose is used to make cell walls.

Amino Acids

An amino acid: a monomer found in a protein. All amino acids contain the amine, (NH_2) and carboxylic acid, (COOH) functional groups.



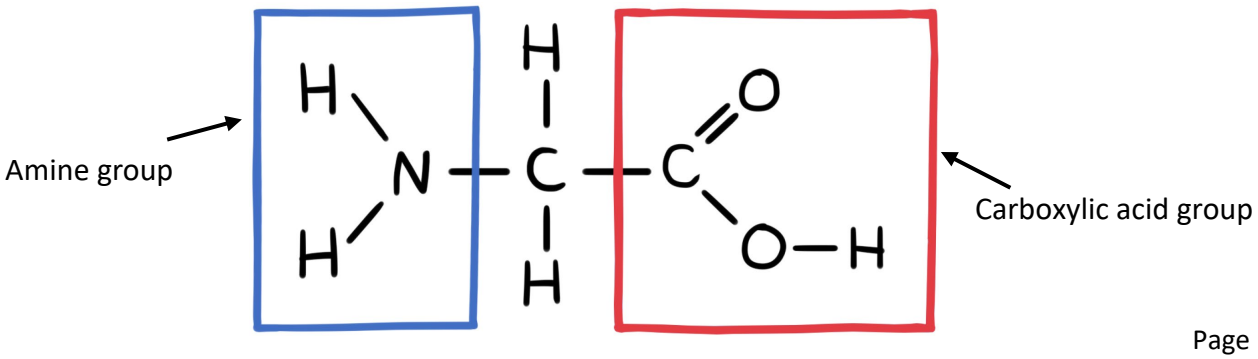
NH_2 Functional group



COOH Functional group

A functional group: a group of atoms responsible for the characteristic reactions of a particular compound.

The figure below shows the structure of **Glycine** which is the simplest amino acid. In the figure we are highlighting the two functional groups that we find in every amino acid.



Polymerisation

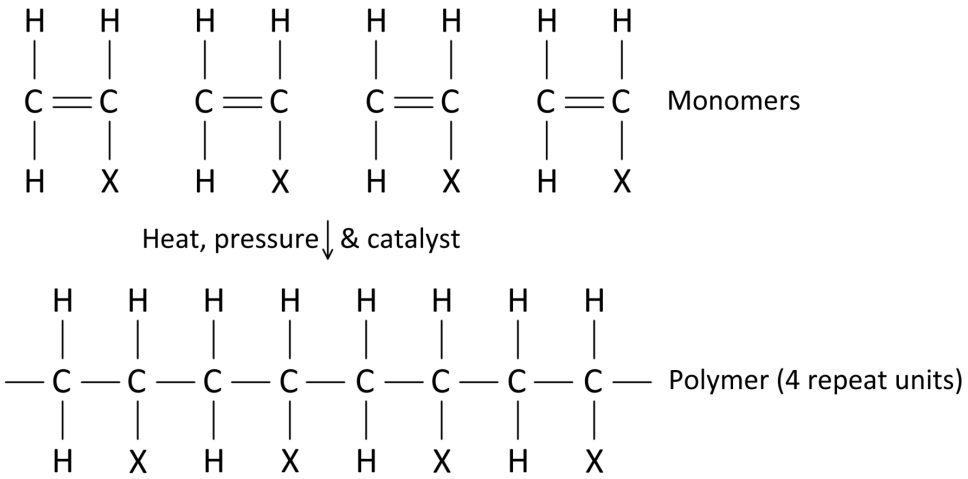
Polymerisation of alkenes is a chemical process in which small alkene molecules, called monomers, join together to form a long chained molecule called a polymer, this is typically done by breaking their carbon to carbon double bonds.

Addition Polymerisation

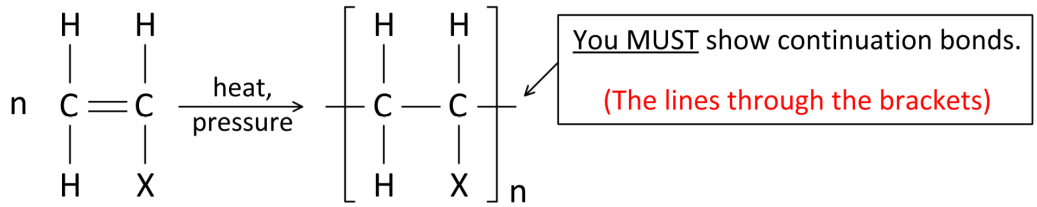
What are addition polymers? These are long chained molecules made by the reaction of addition polymerisation, where many small molecules called monomers join together without producing any by-products.

What happens in this reaction? The double bonds of the alkene molecules break. This creates two new single bonds on each carbon atom, allowing the monomers to connect with other monomers and form one long chain.

The figure below shows the addition polymerisation of ethene to produce poly(ethene).



This reaction is usually written by simply showing the repeat unit:



where n represents a very large number (many thousands)

Condensation Polymerisation

Condensation polymers are made in a different way to addition polymers.

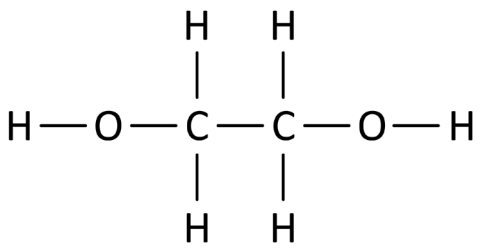
What happens in this reaction? Condensation polymerisation involves monomers with two functional groups. When these monomers react, they join together and lose small molecules, usually water (H_2O). This is why they are called condensation reactions.

The most common type of condensation polymer we need to know about is a polyester.
How do we make a polyester? To make a polyester, we need two different monomers that each have a functional group on both ends of their molecule:

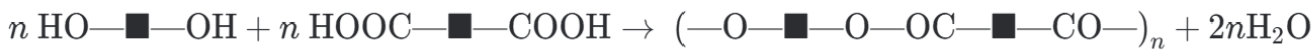
1. **A diol** – this is an alcohol with an –OH group on both ends.
2. **A dicarboxylic acid** – this is a carboxylic acid with a –COOH group on both ends.

When they react, the –OH from the acid and the H from the alcohol break off to form water (H_2O). The two monomers then link together, forming an ester link. Because they both have another functional group on their other ends, the chain can keep growing and growing!

Exam note: we don't have to draw all the carbon and hydrogen atoms in the middle of these monomers. We can just draw a block (a rectangle) to represent the rest of the carbon chain. Check out the example below 😊



Both of these figures show ethanediol 😊



ethanediol | hexanedioic acid | a polyester (hexanedioate) | water

Comparing Addition and Condensation Polymerisation

Addition: Uses one type of monomer an alkene with a C=C double bond. Forms only one product the polymer.

Condensation: Uses monomers with two functional groups. Forms two products the polymer and a small molecule like water).