

Polymerisation

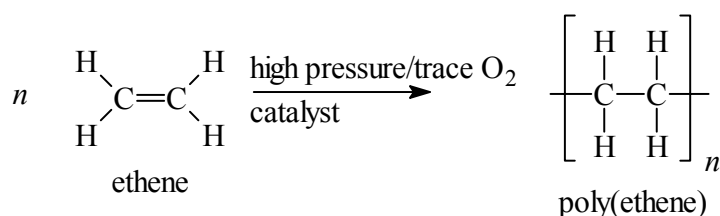
This has three basic sections:

1. Addition Polymerisation
2. Condensation Polymerisation
3. Uses of polymers

Addition Polymerisation

This kind of polymerisation is typified by the presence of a carbon – carbon double bond in the monomer.

A monomer is a small molecule that makes up a polymer.

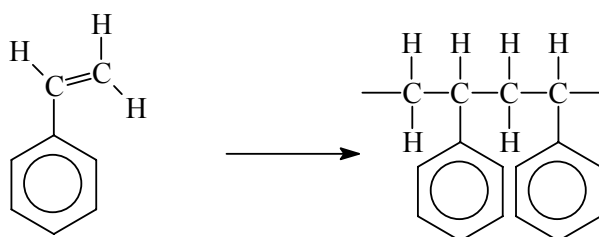


In addition polymerisation:

- The polymer is the only product
- Involves the opening out of a double bond
- The conditions of the reaction can alter the properties of the polymer

You do not need to know the mechanism of addition polymerisation, but it exists mainly by a free radical mechanism. Oxygen is often used to generate a radical that can then proceed to polymerise the alkene.

The board specifies that you know the following polymerisation reaction:



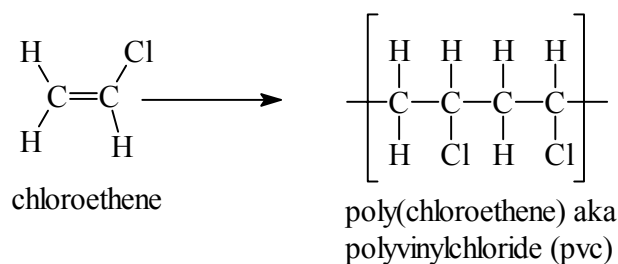
Polymerisation of poly(phenylethene). Otherwise known as polystyrene.

You are expected to be able to do the following things with addition polymers:

1. Predict the repeating unit of the polymer given the monomer
2. Predict the monomer from the polymer – displayed formula and even empirical formula.
3. Know about stereochemistry of addition polymers.

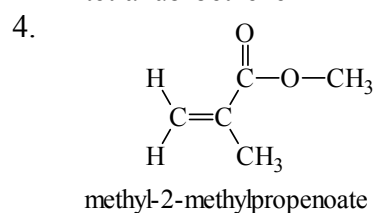
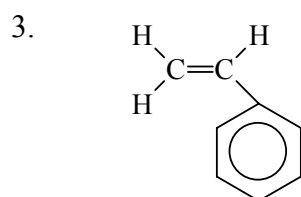
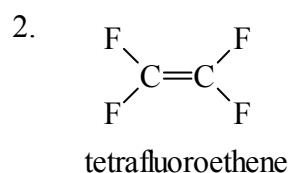
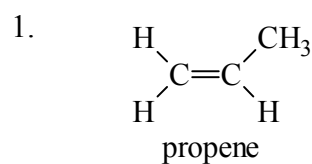
Predicting the repeating unit.

This is easy, basically open out the double bond.



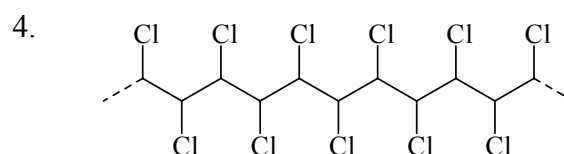
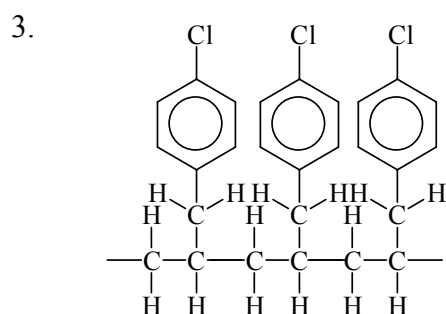
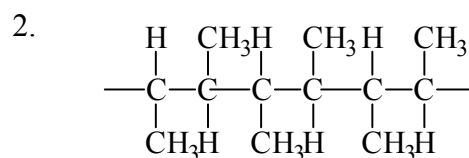
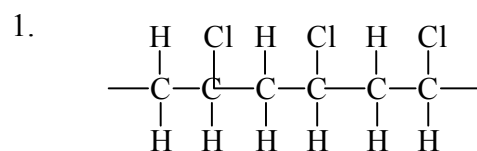
Notice the name of the polymer is the name of the monomer in brackets with the word poly- in front.

Try these, in each case, draw 2 repeating units and name the polymer formed.



Predicting the monomer from the polymer

This is kind of the opposite to what you have just done, but they may ask you to draw different formulae. For each of these, write the full structural formula, the empirical and the molecular formula. Also put a ring around the repeating unit.



Stereoisomerism in Addition polymers.

Until two chaps called Ziegler and Natta came along in the early 1950s, the quality of polymer that could be obtained was variable.

They discovered a method of controlling the polymerisation process very accurately, using an aluminium/tin catalyst at 50°C and 1.5atm.

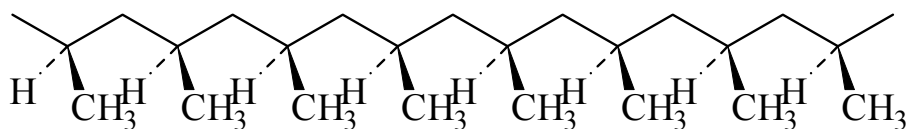
Previous to this only one type of poly(ethene) could be made, called LDPE or low density poly(ethane). The chains formed a tangled mass. By using this new catalysis method they could control the process and produce HDPE this has a much stiffer structure due to areas of crytallinity where the polymer chains are much more ordered.

HDPE has a much higher boiling point due to these more ordered regions. Generally used to make plastic bottles.

Ziegler and Natta also discovered that they could make stereo regular polymers. Isotactic, syndiotactic and atactic.

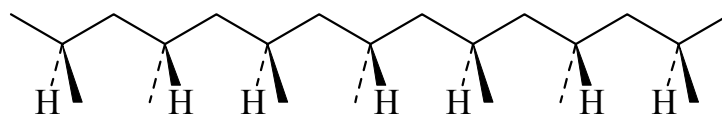
Poly(propene) and stereoisomerism.

1. Isotactic. This is a very regular type of polymer chain. All the methyl groups are on the same side.

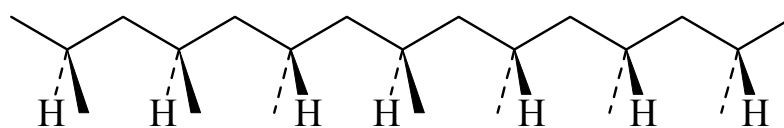


This has an impact on the properties of the polymer.

2. Syndiotactic. A slightly less regular but still very ordered polymer. The methyl groups alternate the side of chain they are on.



3. Atactic. This is a completely random allocation of methyl groups along the carbon skeleton.



This varying degree of randomness will affect the strength and melting point of the polymer. The less random, the stronger the polymer and the higher the melting point

because the chains can get closer together which impacts on the interactions between the polymer chains. More ordered side chains = stronger van der Waals.

Condensation polymers

A condensation polymer generally involves 2 monomers that have different functional groups.

They also involve the elimination of water or another small molecule. Hence the term *condensation* polymer.

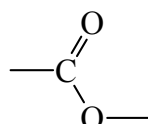
Monomer A + Monomer B \rightarrow Polymer + small molecule (normally water).

Common condensation polymers include polyesters (the ester linkage) and polyamides (the amide linkage as in proteins).

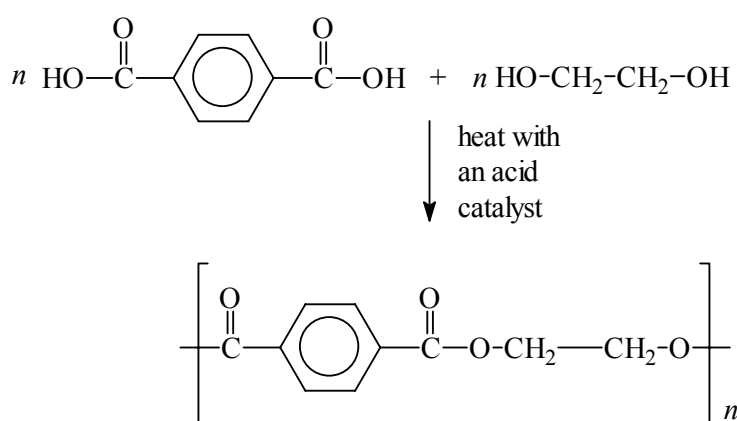
Polyesters

The OCR example here is terylene, a polymer of benzene-1,4-dicarboxylic acid and ethane-1,2-diol.

The ester linkage is based around the reaction between an acid and an alcohol to form an ester + water.



the ester linkage

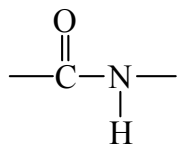


poly(ethan-1,2-diyl benzene-1,4-dicarboxylate)

You need to be able to reproduce this, and possibly predict either what the monomers might be or the polymer.

Polyamides

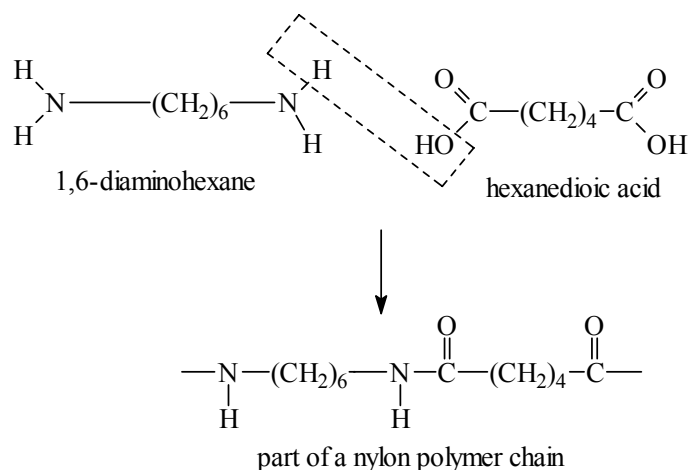
These involve the linkage of two monomers through the amide linkage as in proteins (e.g. silk)



the amide linkage

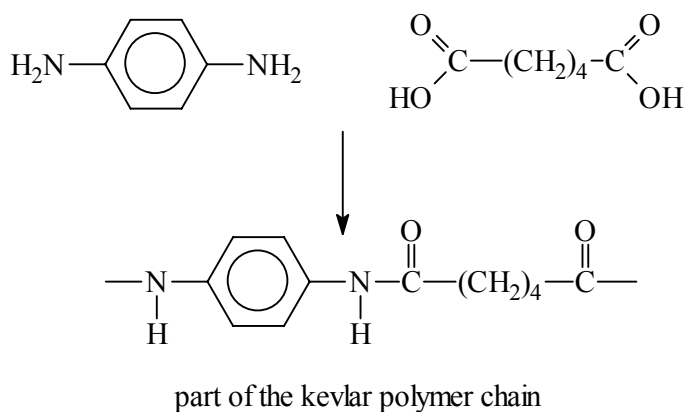
In 1935 Wallace Carothers (who had just discovered polyesters), turned their attention to polyamides. They produced a polymer called nylon 6,6 from a diamine and a dicarboxylic acid.

A polyamide is essentially the same as a polyester except one the molecule containing the alcohol functional group contains a primary amine.



The 6,6 comes from the number of Carbon atoms in the monomers, the first 6 comes from the number of C atoms in the amine monomer, the second comes from the acid.

OCR specify nylon as a need to know polyamide. They also specify Kevlar.

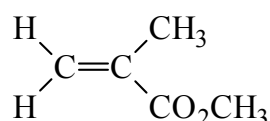


The main use of polyesters and polyamides is as fibres in clothing. Most clothing now has a degree of manufactured fibres woven into the natural material (such as cotton). This gives the material more desirable characteristics, such as stretchiness, and better washability.

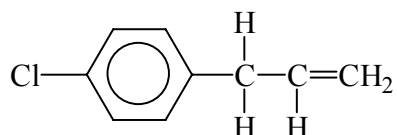
Don't forget that proteins are also polyamides, you must know how the linkage works with natural polymers such as proteins.

Questions

1. The Perspex monomer is shown below:



- a) What kind of polymerisation would you expect it to undergo.
 b) What is meant by the term addition polymerisation?
 c) Draw the repeating unit for Perspex.
- 2 a) Phenylethene (styrene) can undergo polymerisation to form poly(phenylethene). This polymer is also known as polystyrene.
 i) State the name of this type of polymerisation and draw a small section of the polymer
 ii) Why might disposal of this polymer be difficult?
 b) The compound below can be polymerised



- i) Draw a section of the polymer, include 2 repeating units
 ii) Why might this be even more difficult to dispose of than poly(phenylethene)?
3. a) Describe using suitable examples the difference between addition and condensation polymerisation. Name an example of a commercially important polymer produced by each method
 b) Proteins and nylon are polymers that have the same type of bonds linking the monomer molecules. Give an example of a dipeptide and a nylon.
4. Terylene is a polymer derived from benzene-1,4-dicarboxylic acid and ethane-1,2-diol.
 i) Draw a graphical formula to represent benzene-1,4-dicarboxylic acid and ethane-1,2-diol.
 ii) What type of polymer is terylene?

- iii) Draw the structure of the repeating unit of this polymer.
5. Explain how it is possible to create a stereo-regular polymer from poly(propene). Give examples of the different types, and briefly state their properties.