The content on this sheet is assessed on paper 2 only.

Topic 9c—Polymers

* Indicates that these are some examples only: you could be asked about any substance / reaction.

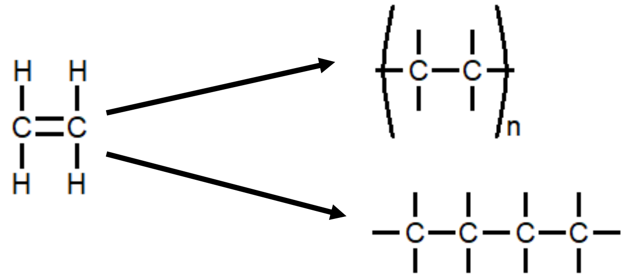
9.17—Polymers

Polymers are substances with a large average mass, made up of chains containing multiple repeat units.

9.18—Making a polymer from ethene

When many molecules of ethene join together, a polymer is made, which is called poly(ethene).

We can show repeat units of ethene in one of two ways:



The second model shows 2 repeat units of ethene.

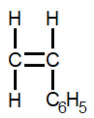
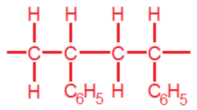
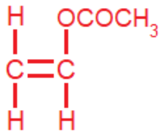
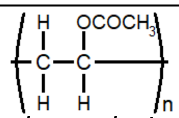
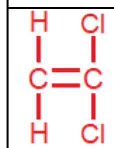
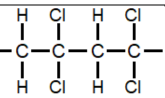
9.19—Making more addition polymers

Similarly to adding ethene molecules together, the following addition polymers can also be formed from molecules containing a C=C bond: Propene (C_3H_6) —> Poly(propene)

Chloroethene (C_2H_5Cl) —> Poly(chloroethene) (*a.k.a. PVC*)

Tetrafluoroethene (C_2F_4) —> Poly(tetrafluoroethene) (*a.k.a. PTFE*)

9.20—Deducing the structure of polymers from monomers & vice versa

Monomer	Polymer
 phenylethene	 Poly(phenyl-ethene) *a.k.a. polystyrene*
 Ethenyl ethanoate	 Poly(ethenyl ethanoate) *a.k.a. polyvinyl acetate (PVA)*
 1,1-dichloro-ethene	 Poly(1,1-dichloro-ethene *a.k.a. Saran wrap (cling film)*

9.21—Uses & properties of polymers (pt. 1)

Poly(ethene) is used for plastic bags as it is flexible and can be made into thin sheets.

Poly(chloroethene) is tough, and a good insulator, so is used to make window frames, and to cover electrical wires.

9.21—Uses & properties of polymers (pt. 2)

Poly(propene) resists shattering, and is tough & flexible, so it used to make buckets, ropes and carpets.

Poly(tetrafluoroethene) is slippery and chemically inert, and so is used as non-stick coating for saucepans.

9.22—Polyesters (HT only)

a—Condensation polymers

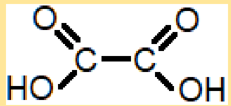
Polyesters are known as condensation polymers as, when they are formed a small molecule is produced as a byproduct of the reaction. This molecule is often water.

b—Formation of polyesters

Polyesters form in a reaction between two monomer molecules:

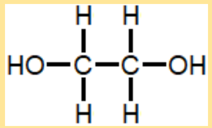
•One monomer molecule containing two carboxylic acid groups.

The example shown here is called ethanedioic acid.

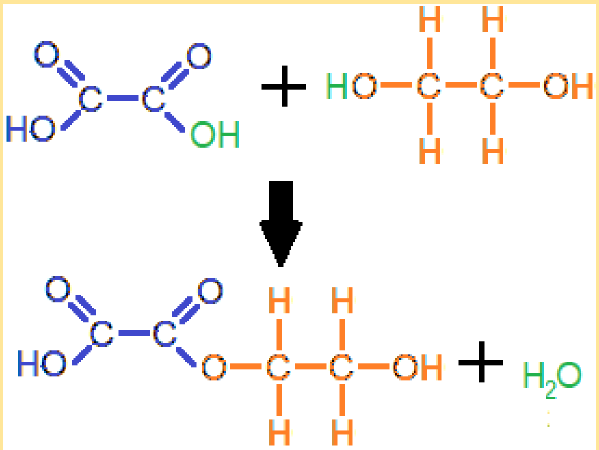


•One molecule containing two alcohol groups.

The example shown here is called ethane-1,2-diol.



When these two molecules react together, an ester link is formed between one of the alcohol groups, and one of the carboxylic acid groups. Water is ejected as a by-product:



The example of the polyester formed here is called ethyl ethanoate.

The C-O-C linked formed here is known as an ester link, hence why these polymers are called polyesters. Note how there is still a carboxylic acid and alcohol group available for further reactions to occur.

c—Formation of a small molecule

Water is formed when ester links are made.

9.23—Problems with polymers

a—Starting materials

A lot of polymers are made from the products of cracking long hydrocarbon molecules from crude oil. For this reason, we can consider a lot of polymers to be non-renewable.

b—Landfill sites

As well as being made from oil products, most of these polymers are also non-biodegradable. This means that they will persist in landfill sites for thousands of years or more, and won't break down.

c—Gases in disposal

One way of avoiding the use of landfill sites for plastics is to burn them. This is beneficial as it can generate energy. However, a major drawback of this is that the gases produced can contribute to global warming (in the case of CO_2) or, in some cases, can be toxic. For example, very toxic gases such as carbonyl fluoride (COF_2) and hydrogen fluoride (HF) can both be released, which need to be removed before the exhaust gases are released into the atmosphere.

d—Recycling

A lot of polymers can be recycled, which removes the need for burning them or leaving them in landfill. However, this produces issues of its own: mainly that the polymers need to be sorted before they can be melted down and made into new items.

9.24—Evaluate the advantages & disadvantages of recycling polymers

Advantages	Disadvantages
It can make a profit as the recycled materials can be sold.	Some objects often contain many different types of plastic, which can make it difficult to sort them.
Reduces the amount of space being taken up in landfill sites.	*See section 9.23 above.*
Conserves natural resources: not as much crude oil is used to make new plastics.	
Reduces the amount of energy which needs to be generated, thereby further reducing the use of fossil fuels.	

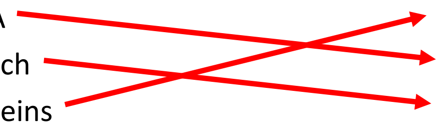
9.25—Natural polymers

Match up the natural polymer to the correct monomer.

a) DNA

b) Starch

c) Proteins



Amino acids (there are many types of these)

Nucleotides (there are four types of these)

Sugars (there are many types of these)