

# FACTFILE: GCE CHEMISTRY

## 5.10 POLYMER CHEMISTRY



### Polymer chemistry

#### Learning Outcomes

- 5.10.1 demonstrate understanding that condensation polymers are formed from molecules containing COOH, OH and NH<sub>2</sub> groups and be able to draw polymer structures from monomers and vice versa;
- 5.10.2 understand the formation, structure and uses of the polyester polyethylene terephthalate;
- 5.10.3 understand the formation, structure and uses of the polyamide, nylon; and
- 5.10.4 recall that polyesters and polyamides can be hydrolysed and are therefore biodegradable.

**A polymer is a large molecule formed when monomers are joined together.**

**Monomers are the small molecule which joins together to form a polymer**

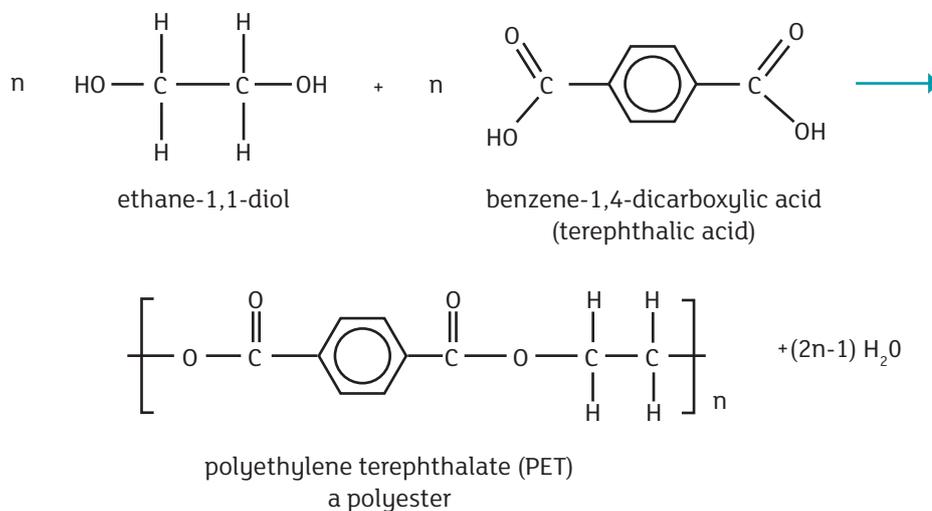
**Polymerisation is the joining together of many small molecules (monomers) to form a large molecule.**

**Condensation polymers are polymers formed by the elimination of small molecules such as hydrogen chloride or water when monomers bond together.**

Condensation polymers often form from molecules containing COOH, OH and NH<sub>2</sub> groups. Polyesters and polyamides are condensation polymers.

**The formation, structure and uses of a polyester – polyethylene terephthalate**

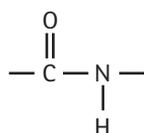
Polyesters are polymers formed in the condensation reaction between a diol and a dicarboxylic acid. They contain ester links. An example is polyethylene terephthalate (PET) which is made from the condensation reaction between ethane-1,2-diol and benzene-1,4-dicarboxylic acid (terephthalic acid)



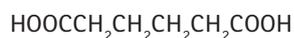
PET is lightweight, shatter resistant and heat stable. It is used in bottles for drinks. It can be recycled. If it is drawn into a fibre it is called terylene and can be used in textiles.

**The formation, structure and uses of a polyamide – nylon**

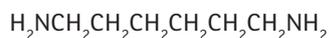
Polyamides are condensation polymers where the repeating units are held together by amide links. An amide link has the structure:



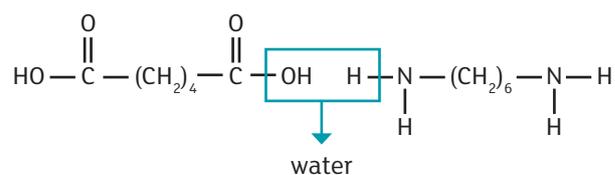
Nylon-6,6 is made from two monomers each of which contain 6 carbon atoms - hence its name. One of the monomers is a 6 carbon acid with a -COOH group at each end - hexanedioic acid.



The other monomer is a 6 carbon chain with an amino group, -NH<sub>2</sub>, at each end. This is 1,6-diaminohexane (also known as hexane-1,6-diamine).



The diagram shows the loss of water between two of the monomers:







## Revision Questions

1 Polyethylene terephthalate is a polyester.

i) Draw the repeating unit for polyethylene terephthalate.

[1]

ii) Give **one** use for polyethylene terephthalate.

.....

.....

[1]

2 Polyamides such as nylon are important industrial chemicals.

i) Write an equation to show the formation of a section of the nylon molecule using the industrial monomers.

[3]

ii) State **two** major uses of nylon.

.....

.....

[2]

iii) Explain using the chemical structure of nylon why it is more easily disposed of than polythene.

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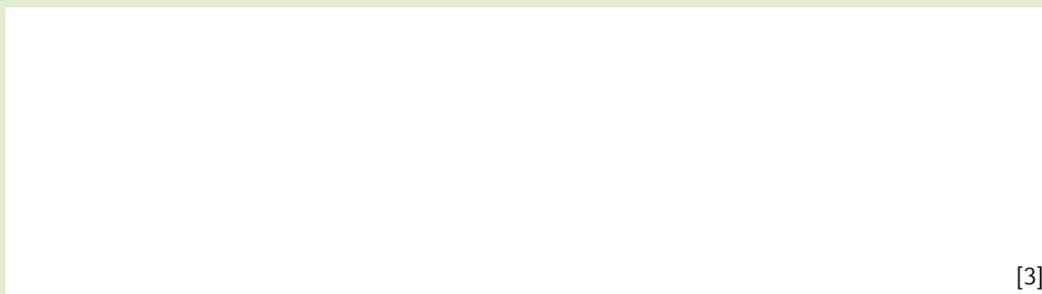
[4]



## Revision Questions

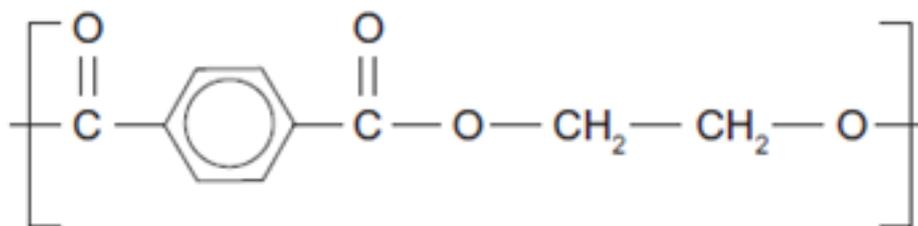
3 Polymers are long chain molecules produced by addition or condensation reactions. Polyesters and polyamides are the two main types of condensation polymer.

a) The polyamide nylon-6,6 is made by a condensation reaction between 1,6-diaminohexane and hexanedioic acid. Draw a section of the polymer showing **two** repeating units.

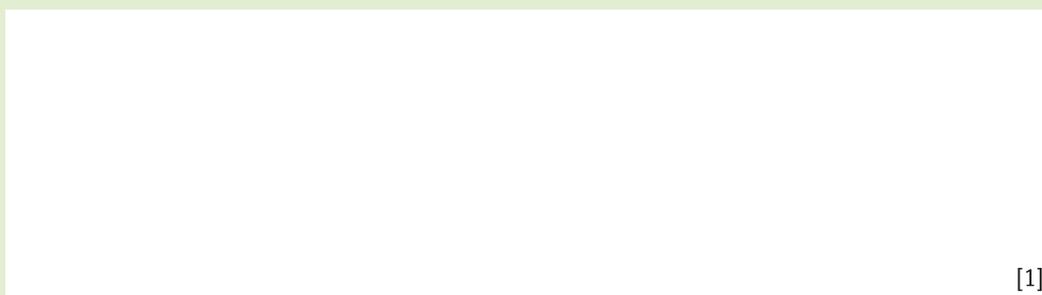


[3]

b) The repeating unit of the polymer PET is shown below:



i) Draw the structure of the smaller of the two monomers.



[1]

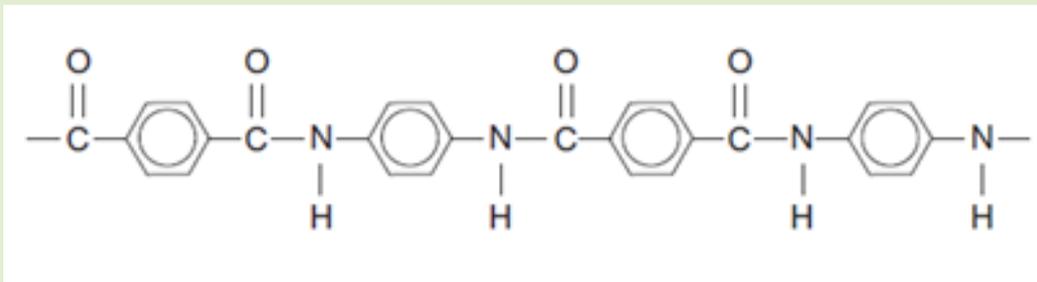
ii) Name this monomer.

..... [1]



## Revision Questions

- 3 c) Kevlar is a polyamide used in bulletproof jackets. A section of the polymer chain is shown below:



- i) How many repeating units are shown?

..... [1]

- ii) Give the structures of the two monomers which can be used to produce Kevlar.

..... [2]

- 4 Polyurethane products have a wide variety of uses including insoles in shoes and structural foams. Polyurethane is made in a two-step process.

- a) Step 1: Ethane-1,2-diol and hexanedioic acid are polymerised to form a polyester.

- i) What type of polymers are polyesters?

..... [1]

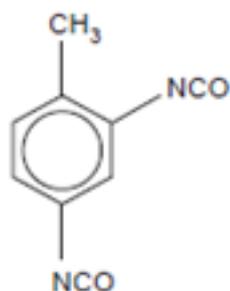
- ii) Draw a diagram of **one** repeating unit of the polyester.

..... [2]



## Revision Questions

- 4 b) Step 2: The polyester is then reacted with a di-isocyanate forming an amide linkage



di-isocyanate

Draw a diagram for the isocyanate group, -NCO, showing all the bonds present.

[1]

- c) Explain why polyurethanes are biodegradable.

[1]

