Addition polymers

A Level

Part A Chloro-polymer 1

A molecule of a polymer contained the sequence shown.

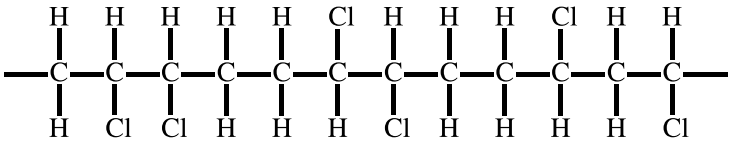

Figure 1: Polymer sequence

What could be the monomer from which this polymer is obtained?

- $CH_3CCl{=}CH_2$
- $CH_3CCl{=}CHCl$
- $CHCl{=}CHCl$
- $CH_2{=}CHCl$

Part B Chloro-polymer 2

A polymer has the following repeat unit.

$$-CH_2-CHCl-CH_2-CH{=}CH-CH_2\text{-}$$

Which pair of monomers could be used to make this polymer?

- CH_3-CH_2Cl and $CH_3-CH{=}CH-CH_3$
- $CH_2{=}CHCl$ and $CH_2{=}CH-CH{=}CH_2$
- $CH_2{=}CHCl$ and $CH_2{=}CH_2$
- $CH_2{=}CCl-CH{=}CH_2$ and $CH_2{=}CH_2$

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Part B adapted with permission from UCLES, A-Level Chemistry, June 1995, Paper 4, Question 30

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Condensation polymers

A Level

Part A 6-aminohexanoic acid

A common type of nylon is made by the self-condensation of 6-aminohexanoic acid, $\mathrm{NH_2(CH_2)_5COOH}$.

What is the repeat unit of the polymer?

- $[\mathrm{NH_3(CH_2)_5COO}]$
- $[\mathrm{NH_3(CH_2)_5NHCO(CH_2)_5CO}]$
- $[\mathrm{NH(CH_2)_5CO}]$
- $[\mathrm{NH_2(CH_2)_5COOH}]$

Part B Condensation polymer

Which of the following is a repeat unit in a condensation polymer?

- $-\mathrm{OCH_2CH_2OOCCH_2CH_2CO}$-
- $-\mathrm{CH_2CHCl}$-
- $-\mathrm{OCH_2CH_2O}$-
- $-\mathrm{CH_2C(CH_3)=CHCH_2}$-
- $-\mathrm{CH_2CH_2CH_2O}$-

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Cyano acrylate

A Level

Part A Superglue

'Superglue' contains the compound

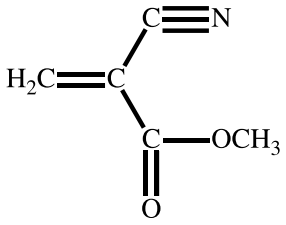
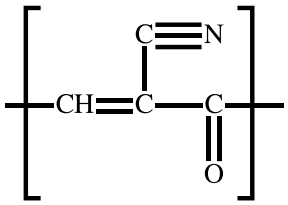


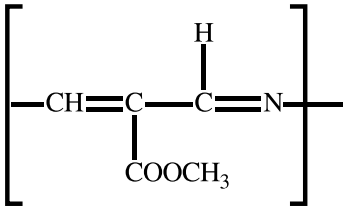
Figure 1: 'Superglue' compound

It is rapidly polymerised by traces of bases on the surface of the objects to be stuck together. Which of the following represents the repeat unit of the polymerised form?

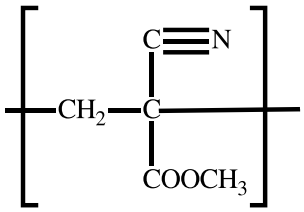
A



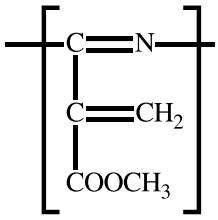
B



C



D



E

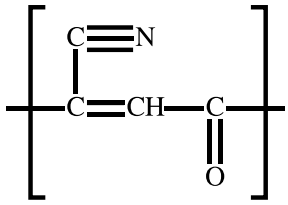


Figure 2: Possible repeat units in 'superglue'

- A
- B
- C
- D
- E

Part B Acrylic fibre

Acrylic fibre is an addition polymer. Part of this polymer chain is shown below.

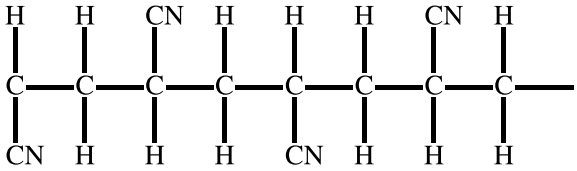
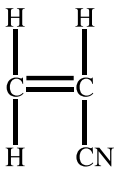


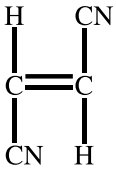
Figure 3: Acrylic fibre polymer

Which monomer would form this polymer?

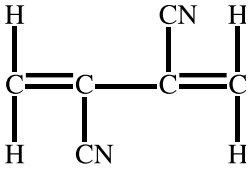
A



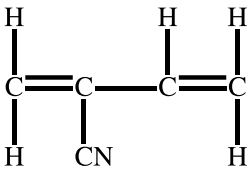
B



C



D



E

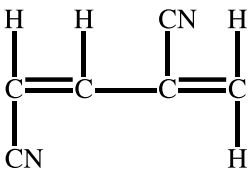


Figure 4: Possible monomer units for acrylic fibre

- A
- B
- C
- D
- E

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Epoxy resins

A Level

Monomer **A** reacts with the diphenol **B** below to give a polymer as shown in the reaction scheme below:

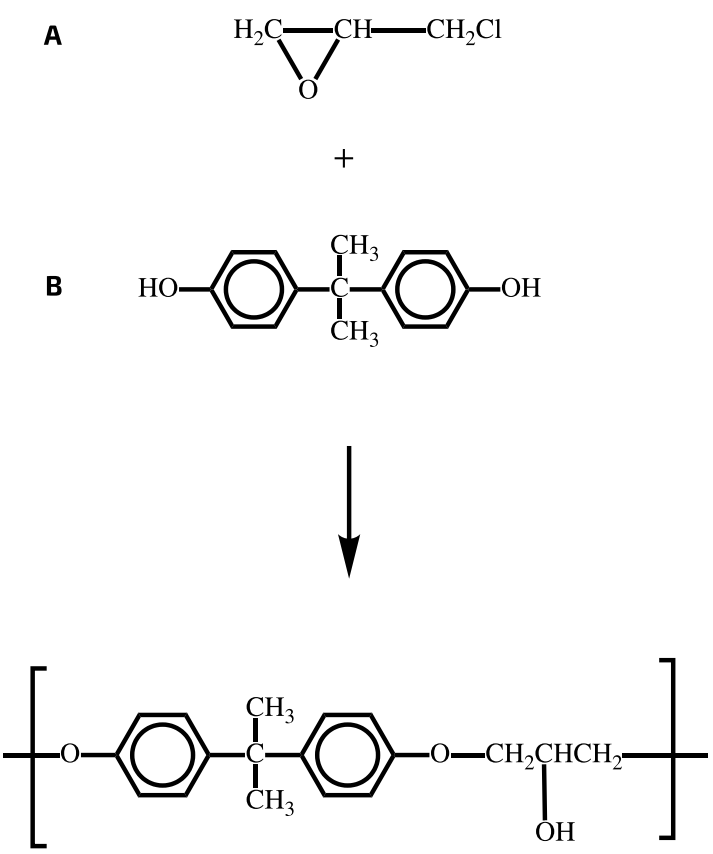

Figure 1: Epoxy resin polymer reaction

Part A Which bonds broken?

From the displayed formula below, state in alphabetical order (e.g. **ab**) which bonds must break for the polymer to be formed.

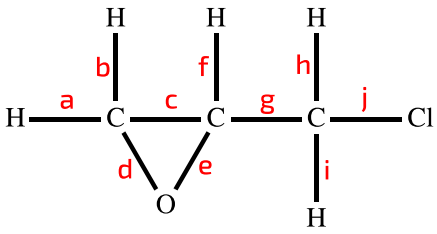

Figure 2: Structure of epoxy monomer unit

Part B What is condensed out?

This is an example of condensation polymerisation.

State which small molecule is condensed out.

Part C How many molecules removed?

How many of these molecules are removed per repeat unit of the polymer?

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More condensation polymers

A Level

Part A Single monomers

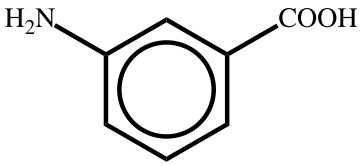
Which of the following compounds could be used by itself to form a condensation polymer?

A $HOCH_2CH_2OH$

B $HOOC(CH_2)_4COOH$

C $H_2N(CH_2)_6NH_2$

D



E

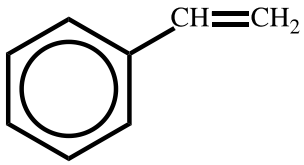


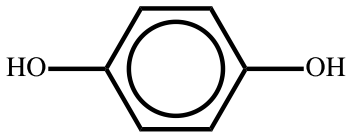
Figure 1: Possible condensation polymer monomers

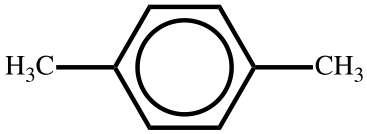
- A
- B
- C
- D
- E

Part B Monomer pairs

Which of the following pairs of compounds are the monomers of a condensation polymer?

A $CH_3OOCCH_2CH_2COOCH_3$ and $CH_2=CHCH=CH_2$

B  and $H_2N(CH_2)_6NH_2$

C $O=CHCH_2CH_2CH=O$ and 

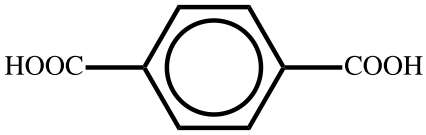
D  and $H_2NCH_2CH_2NH_2$

Figure 2: Possible pairs of momoners of a condensation polymer

- A
- B
- C
- D

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Nylon 66

A Level

Part A Preparation method

Nylon 66 is a condensation polymer derived from hexane-1,6-diamine, $H_2N(CH_2)_6NH_2$, and hexanedioic acid, $HOOC(CH_2)_4COOH$.

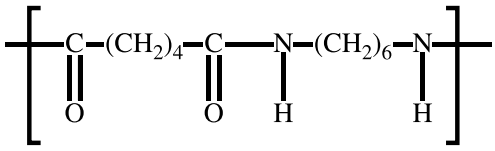

Figure 1: Nylon 66

Which of the following, reacting with the diamine, would provide the most rapid method of preparing the polymer?

- hexane-1,6-diol
- hexanedioyl chloride
- hexanedioic acid
- sodium hexanedioate
- diethyl hexanedioate

Part B Polymerisation reaction

Nylon 66 has the repeat unit:

$$[\mathrm{CO(CH_2)_4CONH(CH_2)_6NH}]$$

When it is made from hexanedioic acid and hexane-1,6-diamine,

1. condensation polymerisation takes place.
2. amide linkages are formed.
3. ammonia is eliminated.

- **1**, **2** and **3** are correct
- **2** and **3** only are correct
- **1** only is correct
- **3** only is correct
- **1** and **2** only are correct

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PMPS polyester

A Level

Part of the structure of the biodegradable polyester PMPS has the structure shown below.

$$-CH_2CH(CH_3)CH_2OOCCH_2CH_2COOCH_2CH(CH_3)CH_2OO-$$

Part A Monomer structures

The the structures of the monomer units which can be used to make this polymer.

Use the structure editor to generate SMILES strings as your answers.

Enter your answer in the format "**A**, **B**" (space after comma).

In the editor, after drawing your structure, click on the round, yellow smiley face to generate a SMILES string. Copy the SMILES string and paste it in the answer box.

Using the structure editor

Part B % mass of carbon

Calculate the percentage by mass of carbon in PMPS to the nearest 0.1%.

Part C % mass of hydrogen

Calculate the percentage by mass of hydrogen in PMPS to the nearest 0.1%.

Part D % mass of oxygen

Calculate the percentage by mass of oxygen in PMPS to the nearest 0.1%.

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Polyamides

A Level

Part A Nylon 6

Nylon 6 has the following formula and undergoes acidic hydrolysis.

$$[\mathrm{NH(CH_2)_5CO}]$$

What is the product of the acidic hydrolysis of *Nylon 6*?

- $\mathrm{H_3N^+(CH_2)_5OH}$
- $\mathrm{HO(CH_2)_5OH}$
- $\mathrm{HOOC(CH_2)_4COOH}$
- $\mathrm{HO(CH_2)_5COOH}$
- $\mathrm{H_3N^+(CH_2)_5COOH}$

Part B Polyamide

Part of the structure of a polymer is shown below.

$$-\mathrm{NHCO(CH_2)_4COO(CH_2)_2NHCO(CH_2)_4COO(CH_2)_2}-$$

Which of the following statements about this polymer are correct?

1 It could be made from $\mathrm{ClCO(CH_2)_4COCl}$ and $\mathrm{HOCH_2CH_2NH_2}$.
2 It is both a polyamide and a polyester.
3 It would be resistant to alkaline hydrolysis.

- **3** only is correct
- **2** and **3** only are correct
- **1** and **2** only are correct
- **1** only is correct
- **1**, **2** and **3** are correct

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Part B adapted with permission from UCLES, A-Level Chemistry, November 1993, Paper 3, Question 40

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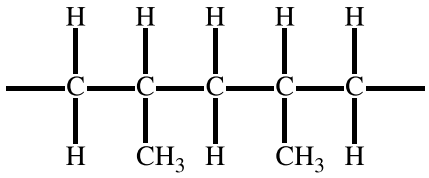
Polymerisation types

A Level

A and **B** show parts of two industrial polymers.

A



B -CONHC$_6$H$_{12}$NHCOC$_4$H$_8$CONH-

Figure 1: Industrial polymers **A** and **B**

Part A Polymerisation A

State the type of polymerisation reaction that produced polymer **A**.

Part B Polymerisation B

State the type of polymerisation reaction that produced polymer **B**.

Part C Monomer A

Draw the full structural formula of the monomer that produced polymer **A** using the structure editor and enter the SMILES string below.

In the editor, after drawing your structure, click on the round, yellow smiley face to generate a SMILES string. Copy the SMILES string and paste it in the answer box.

Using the structure editor

Part D Monomer B

Draw the full structural formula of the nitrogen-containing monomer that produced polymer **B** using the structure editor and enter the SMILES string below.

In the editor, after drawing your structure, click on the round, yellow smiley face to generate a SMILES string. Copy the SMILES string and paste it in the answer box.

Using the structure editor

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Poly(methyl methacrylate)

A Level

Part A Poly(methyl methacrylate)

Poly(methyl methacrylate) is used to make hard contact lenses. Part of its polymer chain is shown.

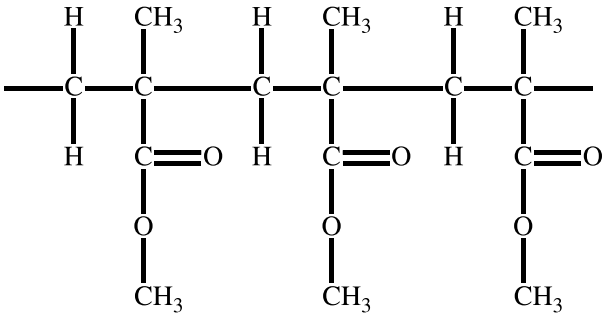


Figure 1: Poly(methyl methacrylate)

Which statements about poly(methyl methacrylate) are correct?

1 It is an addition polymer.
2 Its monomer is $CH_2{=}C(CH_3)COOCH_3$.
3 It is an ester.

- **3** only is correct
- **1** only is correct
- **1**, **2** and **3** are correct
- **1** and **2** only are correct
- **2** and **3** only are correct

Part B Perspex

The structure of the plastic *Perspex* is shown below.

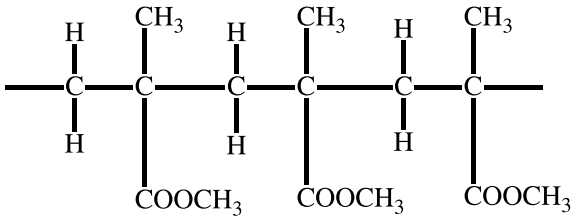
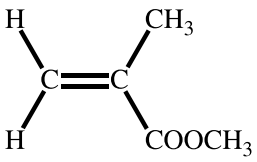


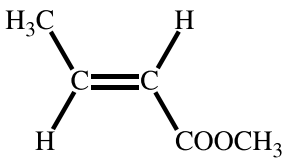
Figure 2: *Perspex*

What is the molecular structure of the monomer from which this plastic is formed?

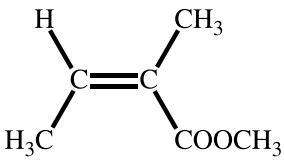
A



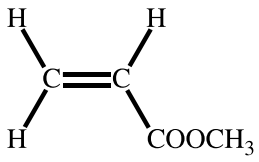
B



C



D



E

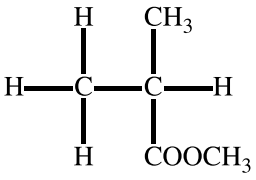


Figure 3: Possible monomers of *Perspex*

- A
- B
- C
- D
- E

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