35. Polymerisation

35.1 Condensation polymerisation

Paper 4

Question Paper

1 Fig. 6.1 shows two reactions of ethanedioic acid, HOOCCOOH.

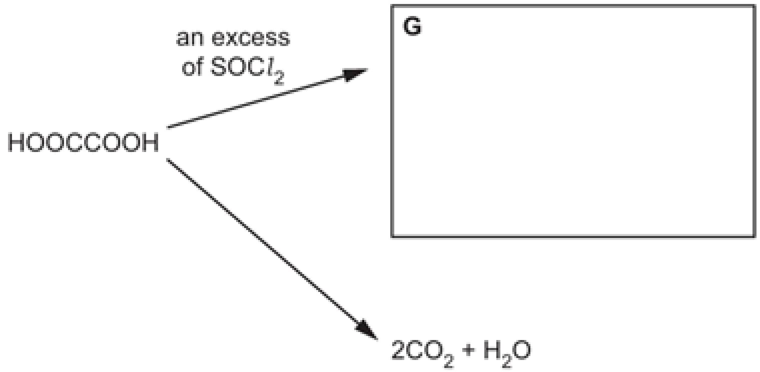


Fig. 6.1

(d) Benzene-1,4-dicarboxylic acid, $HOOCC_6H_4COOH$, can be made from benzene, C_6H_6, in two steps as shown in Fig. 6.2.

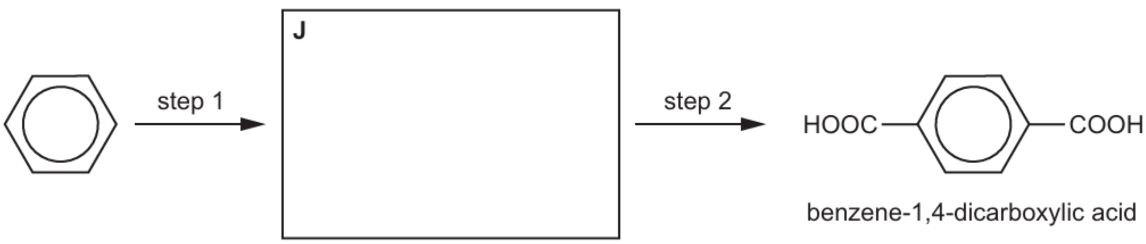


Fig. 6.2

(iii) Draw the structure of exactly **one** repeat unit of the polymer formed when benzene-1,4-dicarboxylic acid reacts with ethane-1,2-diol, $HOCH_2CH_2OH$. The linkage formed between the monomers should be shown fully displayed.

[2]

(iv) State the type of polymerisation that occurs when benzene-1,4-dicarboxylic acid reacts with ethane-1,2-diol and name the linkage formed between the monomers.

type of polymerisation ....

linkage ....

[1]

2 **(c)** Polymers consist of monomers joined together by undergoing either addition or condensation polymerisation.

Compound **H** can react to form an addition polymer, **K**, or a condensation polymer, **L**, depending on the conditions.

(i) Draw **one** repeat unit of addition polymer **K**.

[1]

(ii) Draw **two** repeat units of condensation polymer **L**.

The new functional group formed should be displayed.

[2]

(iii) Explain why condensation polymers can normally biodegrade more readily than addition polymers.

....

.... [1]

3 Lactic acid, $CH_3CH(OH)COOH$, is the only monomer needed to form the polymer polylactic acid, PLA.

(a) (i) Draw a short length of the PLA polymer chain, including a minimum of two monomer residues. The methyl groups may be written as $-CH_3$ but all other bonds should be shown fully displayed.

Label one repeat unit of polylactic acid on your diagram.

[2]

(ii) Give the name of the type of polymerisation involved in the formation of PLA and the name of the functional group that forms between the monomers.

type of polymerisation ....

functional group ....
[1]

(iii) Predict whether PLA is readily biodegradable. Explain your answer.

....

.... [1]

4 **(e)** Acyl chlorides react with sodium carboxylates to form acid anhydrides as shown in Fig. 5.1.

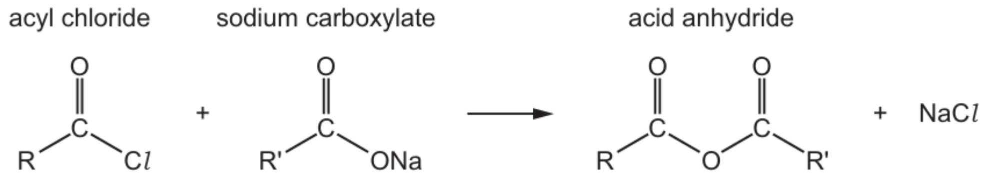


Fig. 5.1

The condensation polymers, polyanhydride and polyester, are formed by similar methods.

The repeat unit for a polyanhydride is shown in Fig. 5.2.

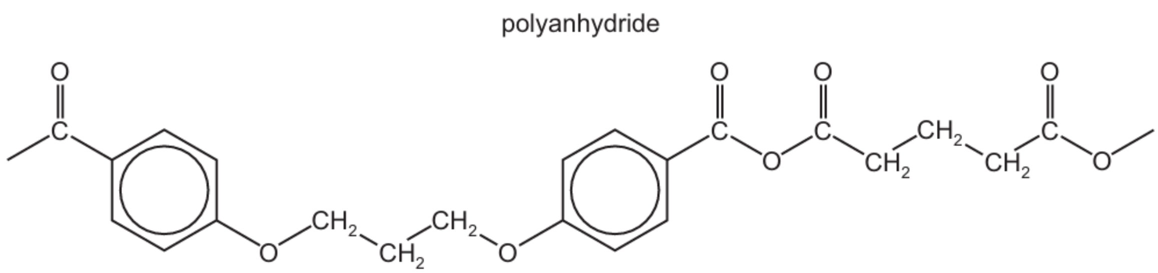


Fig. 5.2

(i) Use Fig. 5.1 and Fig. 5.2 to suggest the structures of the two monomers used to make this polyanhydride.

[2]

5 **(d)** Asparagine can polymerise to form poly(asparagine).

Draw the structure of poly(asparagine), showing **two** repeat units. The peptide linkage should be shown displayed.

[2]

6 **(c)** A section of a polyester is shown.

polyester

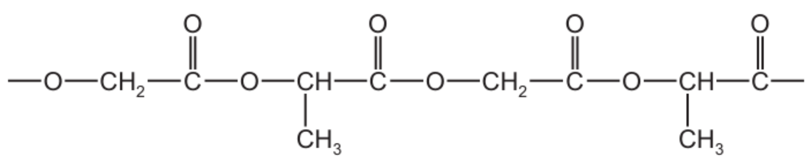


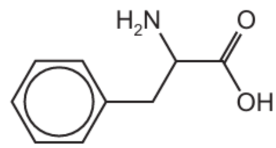
Fig. 8.1

Draw the structures of the two monomers that form this polyester.

[2]

7 **(d)** **P** can be used to produce compound **T**.

T

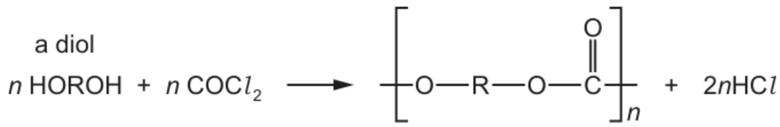


(ii) **T** can polymerise under suitable conditions. No other monomer is involved in this reaction.

Draw a section of the polymer chain formed that includes three **T** monomers. Identify the repeat unit on your diagram.

[2]

8 The class of polymers called polycarbonates are made by the reaction of carbonyl dichloride, $COCl_2$, with a diol.

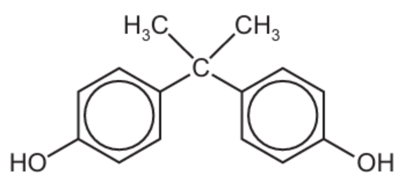


(a) (i) Deduce the *type of polymerisation* shown here.

.... [1]

Nalgene® is a polycarbonate formed from the diol **P** and $COCl_2$.

P



(ii) Draw **one** repeat unit of Nalgene®.

[1]

(iii) Nalgene® is a strong and tough polymer.

Identify **two** types of intermolecular force that are responsible for these properties of Nalgene®.

1 ....

2 ....
[1]

(b) Proteins are polymers of amino acids.

Complete the table to show how the secondary and tertiary structures of proteins are stabilised.

	one intermolecular force responsible	groups involved
secondary structure		
tertiary structure		

[2]

(c) Explain the significance of hydrogen bonding in DNA in relation to the accurate replication of genetic information.

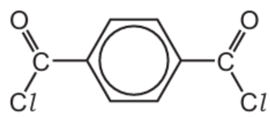
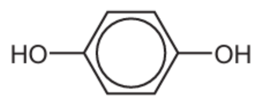
....

....

.... [2]

9 **(a)** The table shows three pairs of monomers that are capable of polymerisation.

Complete the table by identifying each type of polymerisation.

pair of monomers	type of polymerisation
$HOCH_2CH_2OH$ and $HO_2CCH_2CO_2H$	
 and 	
CH_3CHCF_2 and CH_3CHCH_2	

[1]

(b) 2-aminopropanoic acid, $CH_3CH(NH_2)CO_2H$, can polymerise under suitable conditions. No other monomer is involved in this reaction.

(i) Draw a section of the polymer chain formed including **three** monomer residues. Clearly identify **one** repeat unit on your diagram.

[3]

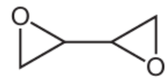
(ii) 2-aminopropanoic acid, $CH_3CH(NH_2)CO_2H$, exists as two stereoisomers.

Draw three-dimensional diagrams to show the two stereoisomers of 2-aminopropanoic acid. State the type of stereoisomerism shown.

type of stereoisomerism ....

[2]

(c) The skeletal formula of compound **W** is shown.



When **W** is mixed with a second compound, called a hardener, a polymerisation reaction occurs, producing a non-solvent-based adhesive.

(i) Give the name of this type of non-solvent-based adhesive.

.... [1]

(ii) The hardener is a diamine. A diamine has an alkyl chain with two amine groups which are not bonded to the same carbon atom.

Draw the structural formula of a compound that would make a suitable hardener.

[1]

10 **(e)** 1,3-diaminopropane, $H_2NCH_2CH_2CH_2NH_2$, can be used to make polyamides.

(i) Identify **one** compound that would react with 1,3-diaminopropane to form a polyamide.

.... [1]

(ii) Draw a section of the polymer chain formed from 1,3-diaminopropane and the compound you chose in **(e)(i)**.

Your answer should:

- include four monomer residues (two of each type of monomer)
- show the amide link fully displayed
- clearly identify **one** repeat unit of this polymer.

[2]

11 **(e)** Serine, $HOCH_2CH(NH_2)CO_2H$, can react with alanine, $CH_3CH(NH_2)CO_2H$, to form three different **structural** isomers, each with the molecular formula $C_6H_{12}N_2O_4$.

Draw the structures of these three structural isomers.

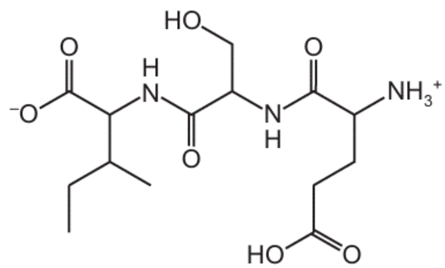
isomer 1 ($C_6H_{12}N_2O_4$)	isomer 2 ($C_6H_{12}N_2O_4$)

isomer 3 ($C_6H_{12}N_2O_4$)

[3]

12 Proteins are natural polymers. When one particular protein is partially hydrolysed the product mixture includes tripeptide **E**.

tripeptide **E**



(c) Polyesters and polyamides are two important types of condensation polymer.

(i) Draw the structure of a compound that can polymerise to produce a polyamide, without the need for a second monomer.

[1]

(ii) Draw the structures of two different compounds that can polymerise together to produce a polyester with **four** carbon atoms per repeat unit. Name the two compounds.

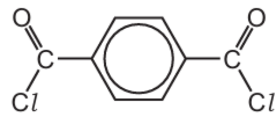
name ....

name ....

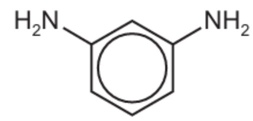
[4]

13 **(a)** A polymer, **P**, can be made from the monomers benzene-1,4-dioyl chloride and benzene-1,3-diamine.

benzene-1,4-dioyl chloride



benzene-1,3-diamine



(i) Draw a section of the polymer chain of **P**. Your structure should include two repeat units.

P

[2]

(b) Proteins are natural polymers. A protein is said to have a primary, secondary and tertiary structure.

(i) Describe what is meant by each of these terms.

primary structure ....

....

secondary structure ....

....

tertiary structure ....

....
[3]

(ii) Name the forces or bonds responsible for holding together the primary structure of a protein molecule.

.... [1]

(iii) Name the forces or bonds responsible for the stabilisation of the secondary structure of a protein molecule, and identify the groups of atoms within the protein molecule that are held together by these forces or bonds.

....

.... [2]