Polymerisation

Question Paper 4

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Polymerisation
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 4

Time Allowed:	**75 minutes**
Score:	**/62**
Percentage:	**/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 The increasing awareness of the diminishing supply of crude oil has resulted in a number of initiatives to replace oil-based polymers with those derived from natural products. One such polymer, 'polylactide' or PLA, is produced from corn starch and has a range of applications.

(a) The raw material for the polymer, lactic acid (2-hydroxypropanoic acid), is formed by the fermentation of corn starch using enzymes from bacteria.

(i) Calcium hydroxide is added to the fermentation tanks to prevent the production of lactic acid from slowing down.
Why might high acidity reduce the effectiveness of the enzymes?

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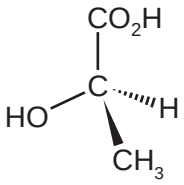
(ii) The structure of lactic acid is shown.



What type of reaction takes place in this polymerisation?

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[2]

(b) Lactic acid exists in two stereoisomeric forms. Draw the other form in the box.

[1]

(c) One of the reasons PLA has attracted so much attention is that it is biodegradeable. This does, however, restrict some potential uses. The simple polymer has a melting point of around 175 °C, but softens between 60-80 °C. However, its thermoplastic properties enable it to have a range of uses in fibres and in food packaging.

(i) Explain why PLA would **not** be a suitable packaging material for foods pickled in vinegar.

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(ii) PLA containers are not used for hot drinks. Suggest why.

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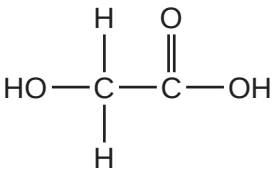
[2]

(d) Lactic acid can also be co-polymerised with glycolic acid.



glycolic acid

(i) Draw a section of the co-polymer showing one repeat unit.

(ii) Suggest what type(s) of bonding will occur between chains of this co-polymer, indicating the groups involved.

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(iii) Suggest one property in which the co-polymer differs from PLA.

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[5]

[Total: 10]

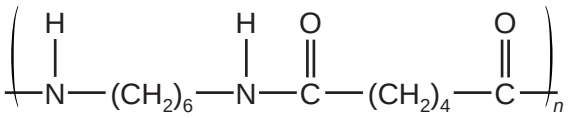
2 The physical properties of polymers depend on the average relative molecular mass of the polymer chains and on the functional groups present in the monomers.

The presence of side-chains in addition polymers can increase the spacing between polymer chains in the bulk substance and hence reduce the overall density.

In condensation polymers it is the *nature* of the side-chain that is often more important since this can lead to cross-linking of the polymer chains forming a three-dimensional structure.

(a) For each of the following polymers, give the structure of the monomer(s) and state the *type of reaction* used to produce the polymer.

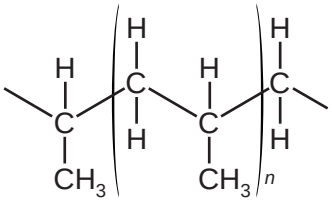
polymer **A**



monomer(s)

type of reaction .....

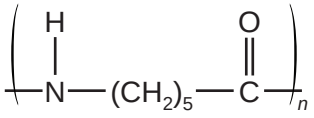
polymer **B**



monomer(s)

type of reaction .....

polymer **C**



monomer(s)

type of reaction .....

[5]

(b) Look at the structures of the three polymers and answer the following questions.

(i) Suggest why the density of **B** is lower than that of **A**.

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(ii) Which polymer will have the weakest forces between chains, and what is the nature of these forces?

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[2]

[Total: 7]

3 Enzymes are a special group of protein molecules present in large amounts in living organisms. Enzymes behave as catalysts but, unlike inorganic catalysts, they generally catalyse only one particular reaction.

(a) Inorganic catalysts often work better on heating, but enzymes rarely work at temperatures much above 45°C. Explain why this is the case.

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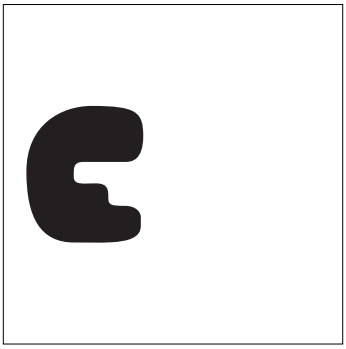
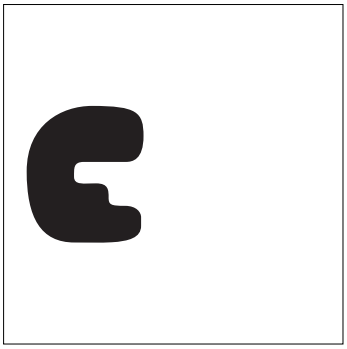
..... [2]

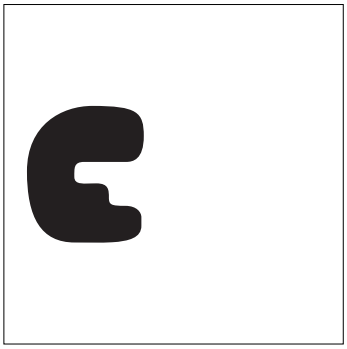
(b) Using the shape below to represent an enzyme, sketch how an enzyme is specific to the breakdown of a particular substrate molecule



enzyme + substrate



enzyme-substrate complex



enzyme + products

[3]

(c) Describe the effects of a competitive, and of a non-competitive inhibitor on the interaction between enzyme and substrate.

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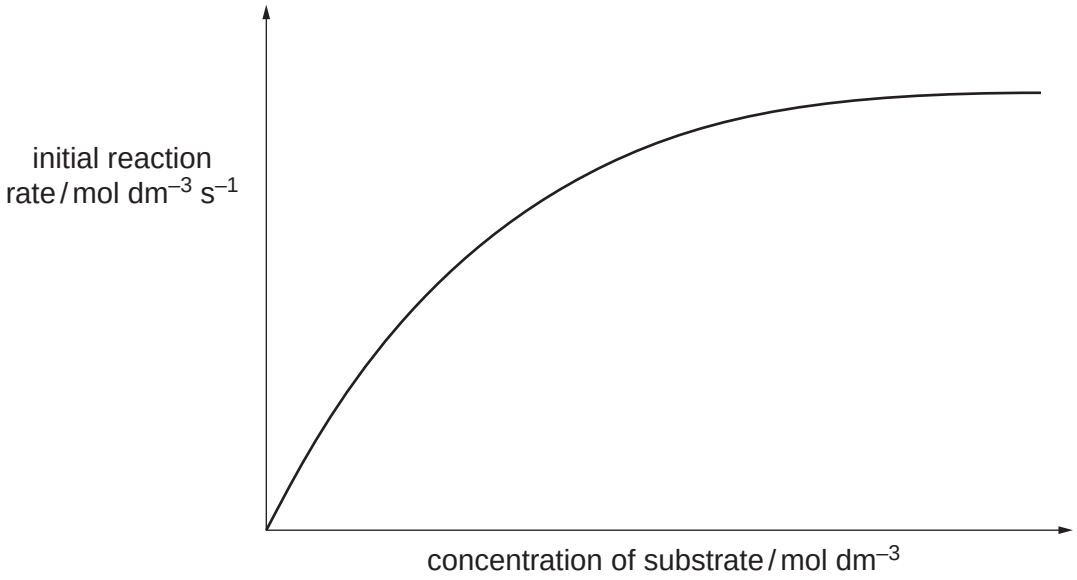
.....[2]

(d) **(i)** The diagram shown illustrates an enzyme-catalysed reaction. On the diagram sketch the graph that would be obtained if the same reaction was carried out in the presence of a **non-competitive** inhibitor.



(ii) Explain why a **non-competitive** inhibitor has this effect on the reaction.

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[3]

[Total: 10]

4 In today's world, many traditional materials have been replaced by different sorts of polymers. This includes rigid polymers such as those used in car bodies to replace steel and flexible polymers like those used in textiles to replace cotton or wool.

(a) **(i)** To form a polymer, what is the **minimum** number of functional groups that the monomer must possess?

.....

(ii) Illustrate your answer to **(i)** with the structure of a possible monomer.

[2]

(b) State **two** differences between addition and condensation polymerisation.

(i) .....

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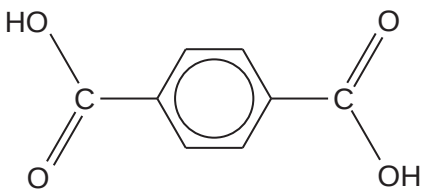
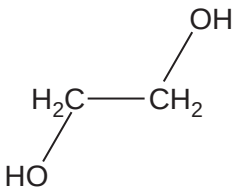
(ii) .....

.....[2]

(c) The polymer formed from the co-polymerisation of the two monomers shown is known as *Terylene.*



benzene-1, 4-dicarboxylic acid



ethane-1-2-diol

(i) The two monomers react by condensation polymerisation. What other molecule is formed in this reaction?

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(ii) Draw the structure of **one** repeat unit of *Terylene.*

(iii) What is the name given to polymers containing the same functional group as *Terylene*?

..... [4]

(d) The monomers ethene and but-1-ene can also co-polymerise to form a polyalkene, but this does not produce a regular alternating structure like *Terylene.* Explain why this is the case, drawing diagrams if you wish.

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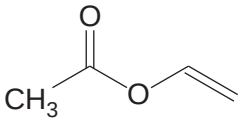
[2]

[Total: 10]

5 **(a)** Polyvinyl acetate, PVA, is a useful adhesive for gluing together articles made from wood, paper or cardboard. The monomer of PVA is ethenyl ethanoate, **B**.

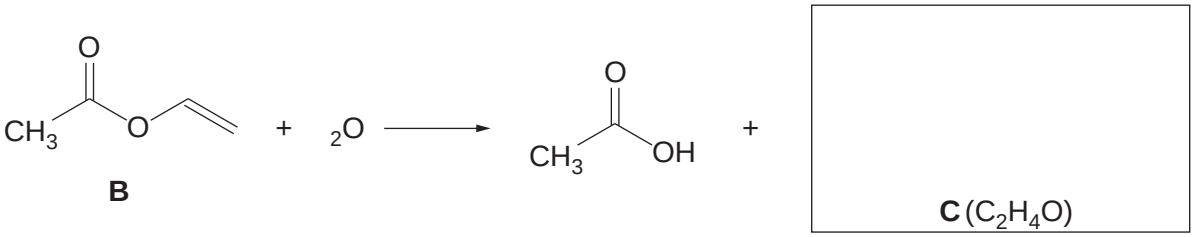


B

PVA is formed from **B** by the process of addition polymerisation.

(i) Draw a section of the PVA molecule containing at least 2 monomer molecules, and identify clearly the repeat unit.

The ester **B** can be hydrolysed in the usual way, according to the following equation.



B

C (C_2H_4O)

(ii) Use this information to suggest a possible structure for **C** and draw it in the box above.

When substance **C** is extracted from the product mixture, it is found that it does **not** decolourise Br_2(aq), but it **does** form a pale yellow precipitate with alkaline aqueous iodine.

(iii) Suggest a structure for **C** that fits this new information.

(iv) Suggest a confirmatory test for the functional group in the structure you have drawn in **(iii)**. Your answer should include the reagent you would use and the observation you would make.

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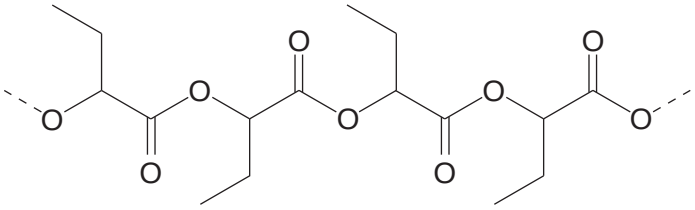
[6]

(b) The following diagram represents a section of another polymer.



D

(i) On the above formula draw brackets, [ ], around the atoms that make up the repeat unit of this polymer.

(ii) Name the functional group in polymer **D**.

.....

(iii) Suggest and draw the structure of the monomer, **E**, that could form this polymer.

(iv) What *type of polymerisation* is involved in making polymer **D** from its monomer?

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(v) What is the relationship between the repeat unit of polymer **D** and the repeat unit of PVA?

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[5]

(c) Monomer **E** exists as two stereoisomers. Heating either isomer with Al_2O_3 gives a mixture of two unsaturated carboxylic acids **F** and **G**, which are stereoisomers of each other.

(i) Name the *type of stereoisomerism* shown by compound **E**.

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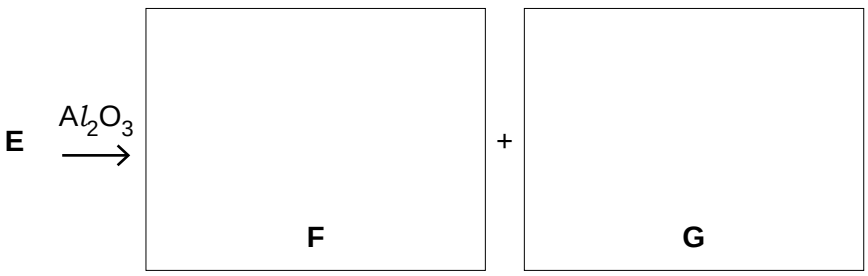
(ii) Suggest structures for **F** and **G**, and name the type of stereoisomerism they show.



type of isomerism .....

[4]

[Total: 15]

6 Enzymes are protein molecules that are highly efficient in catalysing specific chemical reactions in living organisms.

(a) To work in tissues, enzyme molecules generally need to be water-soluble. What does this tell you about the nature of the side-chains on the exterior of the molecules?

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..... [1]

(b) Enzymes function by a substrate molecule interacting with a particular part of the enzyme known as the 'active site'. The substrate is converted into products that are then released, to be replaced by another substrate molecule.

(i) Describe briefly the primary, secondary and tertiary structures of an enzyme.

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(ii) The activity of an enzyme depends upon the tertiary structure of the protein molecule. Explain how the tertiary structure produces an effective active site.

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(iii) Give **two** conditions that can **reduce** the activity of an enzyme, explaining the reason in each case.

I .....

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II .....

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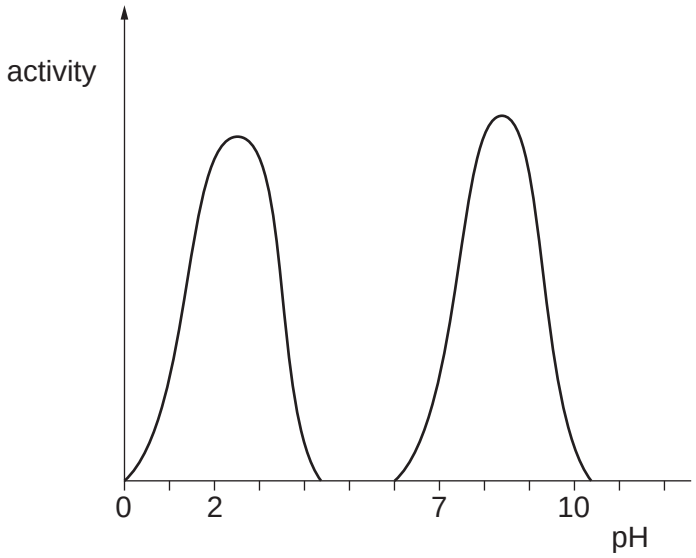
[6]

(c) An individual enzyme operates best at a specific pH. Different enzymes operate best under conditions of different pH. Three enzymes involved in the digestion of food are amylase, pepsin and trypsin.

- Amylase, found in saliva, hydrolyses starch to a mixture of glucose and maltose under approximately neutral conditions.
- Pepsin hydrolyses proteins to peptides in the acid conditions of the stomach.
- Trypsin continues the hydrolysis of peptides to amino acids in the mildly alkaline conditions of the small intestine.

The graph below shows the activity of two of the three enzymes mentioned above.



(i) Label each peak shown with the name of the enzyme responsible, either amylase, pepsin or trypsin.

(ii) On the axes above, sketch the graph that the third enzyme would produce, and label it with the name of that enzyme.

[3]

[Total: 10]