CAMBRIDGE INTERNATIONAL AS & A LEVEL CHEMISTRY · 9701

CHEMISTRY



EXAM QUESTION PACK

20 POLYMERISATION

SCORE	PERCENTAGE
/	%

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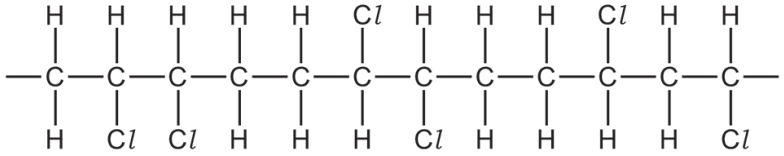
Chapter 20

Polymerisation

20.1 Addition polymerisation

1172. 9701_m22_qp_12 Q: 37

A molecule of a polymer contains the sequence shown.



Which monomer could produce this polymer by addition polymerisation?

A $CHCl{=}CHCl$

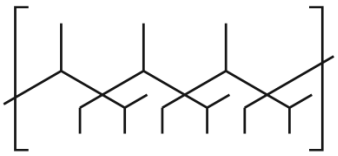
B $CH_2{=}CHCl$

C $CH_3CCl{=}CHCl$

D $CH_3CCl{=}CH_2$

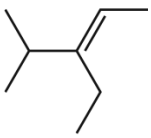
1173. 9701_m20_qp_12 Q: 24

A section of a polymer chain is shown.

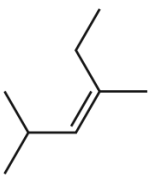


What is the correct monomer?

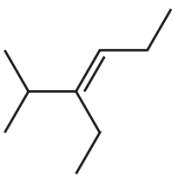
A



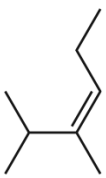
B



C



D



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1174. 9701_s20_qp_12 Q: 29

PVC is used as a packaging material.

What holds the different polymer strands together in a piece of solid PVC?

A covalent bonds

B hydrogen bonds

C ionic bonds

D van der Waals' forces

1175. 9701_w20_qp_11 Q: 22

Which statement is correct when referring to the complete combustion of PVC?

A A gas is made which contributes to global warming.

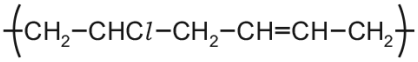
B Carbon dioxide and water are the only products.

C If water is used to clean the exhaust gases, the water becomes alkaline.

D There is no need to treat the exhaust gases as the products are non-hazardous.

1176. 9701_w20_qp_12 Q: 22

A polymer has the following repeat unit. It is made from two different monomers.



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

A CH_2=CHCl and CH_2=CH_2

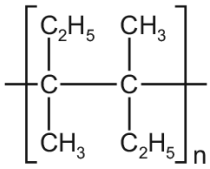
B CH_2=CHCl and CH_2=CH–CH=CH_2

C CH_3–CH_2Cl and CH_3–CH=CH–CH_3

D CH_3–CH=CH–CH_3 and CH_2=CHCl

1177. 9701_s19_qp_12 Q: 22

The diagram shows the repeat unit of an addition polymer.



What is the correct name for the monomer that would form this polymer?

A cis-1,2-diethyl-1,2-dimethylethene

B cis-2-ethyl-3-methylpent-2-ene

C trans-2-ethyl-3-methylpent-2-ene

D trans-3,4-dimethylhex-3-ene

1178. 9701_m18_qp_12 Q: 27

A reaction occurs when a sample of 1-chloropropane is heated under reflux with sodium hydroxide dissolved in ethanol.

Which row is correct?

	type of reaction	name of product
A	elimination	propan-1-ol
B	elimination	propene
C	substitution	propan-1-ol
D	substitution	propene

1179. 9701_s18_qp_13 Q: 22

Which statement is **not** correct?

A Combustion of PVC produces a highly acidic gas.

B PVC molecules are saturated.

C The empirical formula of PVC is the same as the empirical formula of its monomer.

D The repeat unit of PVC is $-(CHClCHCl)-$.

1180. 9701_w18_qp_12 Q: 22

Polyethene is made by the polymerisation of ethene.

Which statement is correct?

A The monomer and the polymer have different empirical formulae.

B The monomer can be oxidised without heat whereas the polymer cannot.

C The monomer can be used as a fuel whereas the polymer cannot.

D The monomer has greater van der Waals' forces than the polymer.

1181. 9701_m17_qp_12 Q: 24

Polymerisation of ethene gives poly(ethene).

How does the bonding between carbon atoms in poly(ethene) compare with that in ethene?

A longer and stronger in poly(ethene)

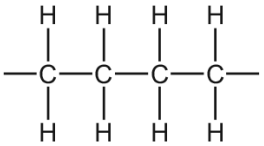
B longer and weaker in poly(ethene)

C shorter and stronger in poly(ethene)

D shorter and weaker in poly(ethene)

1182. 9701_s17_qp_11 Q: 23

The diagram shows a short length of an addition polymer chain.



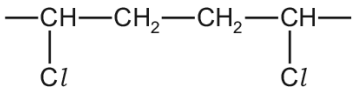
The polymer has a relative molecular mass of approximately 10 000.

Approximately how many monomer units are joined together in each polymer molecule?

A 180 **B** 360 **C** 625 **D** 710

1183. 9701_w17_qp_11 Q: 23

A section of an addition polymer chain is shown.



Which monomer could be used to make this polymer?

A CH_2CHCH_2Cl

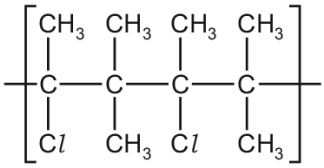
B CH_2CHCl

C $CH_3CHCHCl$

D $CHClCHCH_2CH_2Cl$

1184. 9701_m16_qp_12 Q: 22

A section showing two repeat units of an addition polymer is shown.



What is the identity of the monomer that produced this polymer?

A 2-chloro-3-methylbutane

B 2-chloro-3-methylbut-2-ene

C 2-chloropent-2-ene

D 2,4-dichloro-3,3,4,5-tetramethylhexane

1185. 9701_m16_qp_12 Q: 29

Which statement about poly(chloroethene) is correct?

A The polymer can be cracked to produce chlorinated alkenes.

B The polymer has harmless combustion products.

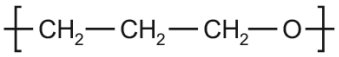
C The polymer is readily biodegradable when buried.

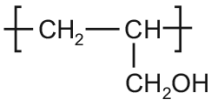
D The repeat unit of the polymer has an M_r of 97.

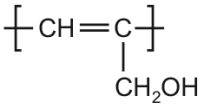
1186. 9701_s16_qp_12 Q: 21

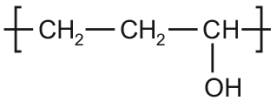
Synthetic resins can be made by polymerisation of a variety of monomers including prop-2-en-1-ol, $CH_2{=}CHCH_2OH$.

Which structure represents the repeat unit in poly(prop-2-en-1-ol)?

A 

B 

C 

D 

1187. 9701_w16_qp_11 Q: 22

PVC is difficult to dispose of. Two possible methods are burying it in landfill sites and disposal by combustion.

Which row of the table is correct?

	rate of biodegradation of PVC in landfill sites	gases produced when PVC combusts
A	fast	CO_2, H_2O, HCl
B	fast	CO_2, H_2O, Cl_2
C	slow	CO_2, H_2O, Cl_2
D	slow	CO_2, H_2O, HCl

1.

Polymerisation of chloroethene gives pvc.

How does the carbon-carbon bond in pvc compare with that in chloroethene?

A	longer	stronger
B	longer	weaker
C	shorter	stronger
D	shorter	weaker

[2002 M/J (22)]

2.

Chloroethene, $CH_2=CHCl$, is the monomer of pvc.

What are the C–C–C bond angles along the polymeric chain in pvc?

A They are all 109 °.

B Half are 109 ° and half are 120 °.

C They are all 120 °.

D They are all 180 °.

[2002 O/N (23)]

3.

Which properties of poly(alkenes) and of pvc can cause their disposal to be difficult?

1 Poly(alkenes) are highly flammable.

2 Poly(alkenes) are non–biodegradable.

3 pvc produces harmful combustion products.

[2004 M/J (40)]

4.

In many countries plastic waste is collected separately and sorted. Some of this is incinerated to provide heat for power stations.

Why is pvc, polyvinylchloride, removed from any waste that is to be incinerated?

A It can be melted down and re-used.

B Its combustion products are harmful.

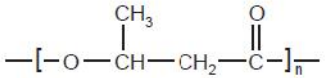
C It destroys the ozone layer.

D It does not burn easily.

[2005 M/J (30)]

5.

PHB (polyhydroxybutyric acid) is a natural polymer produced by a range of micro-organisms. It can also be manufactured from sugar. PHB is readily biodegradable.



PHB (polyhydroxybutyric acid)

What type of reaction will cause PHB to break down?

A addition

B hydrolysis

C reduction

D substitution

[2005 O/N (30)]

6.

Which equation or statement describes what happens when poly(propene) is burned in an excess of air?

A $(C_3H_6)_n + 1\frac{1}{2}nO_2 \rightarrow 3nC + 3nH_2O$

B $(C_3H_6)_n + 4\frac{1}{2}nO_2 \rightarrow 3nCO_2 + 3nH_2O$

C $(C_3H_6)_n + 6nO_2 \rightarrow 3nCO_2 + 3nH_2O$

D Poly(propene) does not burn.

[2006 O/N (25)]

7.

Polymerisation of chloroethene gives PVC.

How does the carbon-carbon bond in PVC compare with that in chloroethene?

A longer and stronger

B longer and weaker

C shorter and stronger

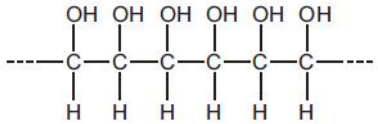
D shorter and weaker

[2009 M/J (23)]

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8.

The following diagram represents the structure of a possible polymer.



By which method might this polymer be made?

A polymerise ethene followed by hydration

B polymerise ethene followed by oxidation with cold acidified $KMnO_4$

C polymerise 1,2-dichloroethene followed by hydrolysis

D polymerise 1,2-dichloroethene followed by oxidation with cold acidified $KMnO_4$

[2009 O/N-11 (23)]

9.

A monomer undergoes addition polymerisation. A 1 mol sample of the monomer is completely polymerised.

How many moles of polymer might, theoretically, be formed?

1 1

2 10^{-6}

3 $\frac{1}{6.02 \times 10^{23}}$

[2009 O/N-11 (31)]

10.

In many countries plastic waste is collected separately and sorted. Some of this is incinerated to provide heat for power stations.

Why is pvc, polyvinylchloride, removed from any waste that is to be incinerated?

A It destroys the ozone layer.

B It does not burn easily.

C It is easily biodegradable.

D Its combustion products are harmful.

[2010 M/J-11 (26)]

11.

Polymerisation of 1,1-dichloroethene produces a dense, high melting point substance that does not allow gases to pass through. It is used as cling wrapping.

Which sequence appears in a short length of the polymer chain?

A $\dagger CH_2CCl_2CH_2CCl_2CH_2CCl_2\dagger$

B $\dagger CHClCHClCHClCHClCHClCHCl\dagger$

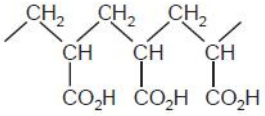
C $\dagger CCl_2CCl_2CCl_2CCl_2CCl_2CCl_2\dagger$

D $\dagger CH_2CCl_2CHClCHClCH_2CCl_2\dagger$

[2010 M/J-11 (27)]

12.

One of the characteristics of addition polymerisation is that the empirical formulae of the polymer and of its monomer are the same. The absorbent material in babies' disposable nappies is made from the addition polymer shown.



From which monomer could this addition polymer be obtained?

A $CH_3CH(OH)CO_2H$

B $HOCH_2CH_2CO_2H$

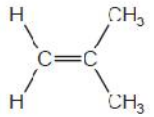
C $H_2C{=}CHCO_2H$

D $HO_2CCH{=}CHCO_2H$

[2010 O/N-11 (20)]

13.

The compound 2-methylpropene, C_4H_8, is a monomer used in the production of synthetic rubber.



In addition to 2-methylpropene there are x other isomers of C_4H_8, structural or otherwise, which contain a double bond.

What is the value of x?

A 1 **B** 2 **C** 3 **D** 4

[2010 O/N-11 (29)]

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14.

Which statement does **not** correctly describe the polymer PVC?

A Combustion of PVC waste produces a highly acidic gas.

B PVC molecules are saturated.

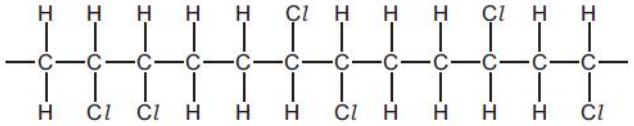
C The empirical formula of PVC is the same as the empirical formula of its monomer.

D The repeat unit of PVC is $-(CHCl CHCl)-$.

[2012 M/J-11 (30)]

15.

A molecule of a polymer contained the sequence shown.



Which monomer could produce this polymer by addition polymerisation?

A $CHCl=CHCl$

B $CH_2=CHCl$

C $CH_3CCl=CHCl$

D $CH_3CCl=CH_2$

[2012 O/N-13 (22)]

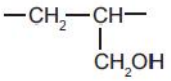
16.

Synthetic resins, plasticisers and many other chemicals can be made by polymerisation of a variety of monomers including prop-2-en-1-ol, $CH_2=CHCH_2OH$.

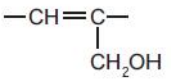
Which structure represents the repeat unit in poly(prop-2-en-1-ol)?

A $-CH_2-CH-CH_2-OH-$

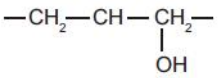
B



C



D



[2013 M/J-11 (29)]

17.

Which fragment could appear in the chain produced by polymerising 1,1-dichloroethene?

A $-CH_2-CH_2-CCl_2-CCl_2-CH_2-CH_2-$

B $-CHCl-CHCl-CHCl-CHCl-CHCl-CHCl-$

C $-CH_2-CCl_2-CH_2-CH_2-CH_2-CCl_2-$

D $-CCl_2-CCl_2-CH_2-CH_2-CH_2-CCl_2-$

[2013 O/N-13 (30)]

18.

Which statement does **not** correctly describe a problem related to the disposal of PVC?

A PVC is slowly degraded in the environment by bacteria and fungi.

B PVC is slowly degraded in the environment by sunlight.

C When PVC is burnt, a significant amount of ethene gas is present in the products.

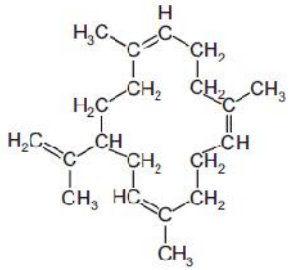
D When PVC is burnt, a significant amount of HCl gas is present in the products.

[2014 M/J-12 (25)]

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19.

The naturally-occurring molecule shown below can be made by the addition of four identical monomer molecules.



What could be the structural formula of the monomer?

A $CH_3CH_2CH_2CH=CH_2$

B $CH_3CH=CHCH=CH_2$

C $CH_2=C(CH_3)CH_2CH_3$

D $CH_2=C(CH_3)CH=CH_2$

[2014 M/J-13 (27)]

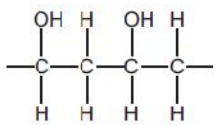
20.

Poly(ethenol) can be used to make plastic bags that dissolve in water.

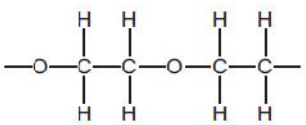
It may be considered to be made by addition polymerisation of $CH_2=CH(OH)$.

Which structure represents a length of the polymer chain consisting of two monomer residues?

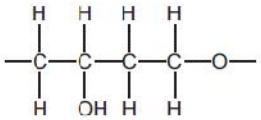
A



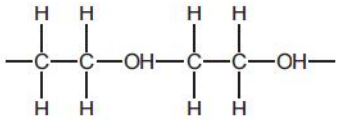
B



C



D



[2014 O/N-13 (28)]

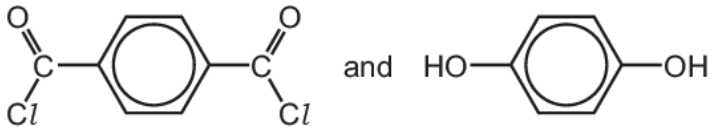
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Polymerisation - 2021

1. Nov/2020/Paper_41/No.10

(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 $HO_2CCH_2CO_2H$	
	
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]

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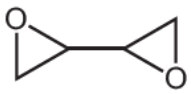
(ii) 2-aminopropanoic acid, $CH_3CH(NH_2)CO_2H$, exists as two stereoisomers.

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.

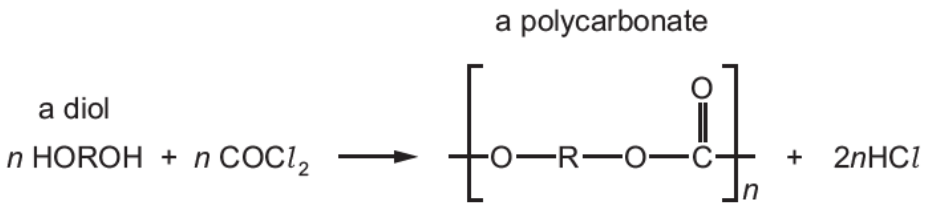
[1]

[Total: 8]

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2. June/2020/Paper_42/No.6

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

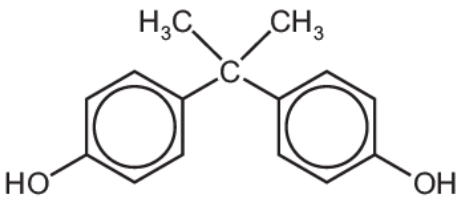


(a) (i) Deduce the *type of polymerisation* shown here.

..... [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]

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(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]

(d) Many polymers are degradable.

State **two** different processes by which some polymers can be degraded.

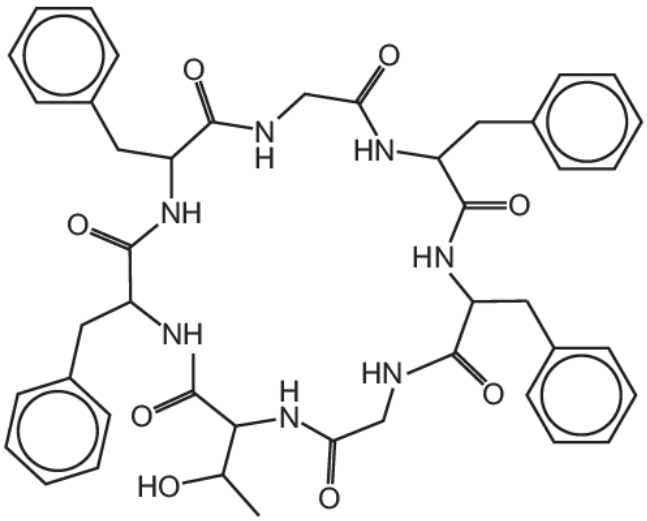
.....

..... [1]

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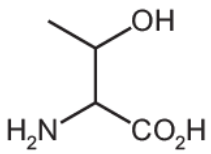
(e) The cyclic peptide **B** is shown.

B



Cyclic peptide **B** is broken into its monomers by heating under reflux with dilute hydrochloric acid. The amino acid threonine, Thr, and two other organic products are formed.

threonine

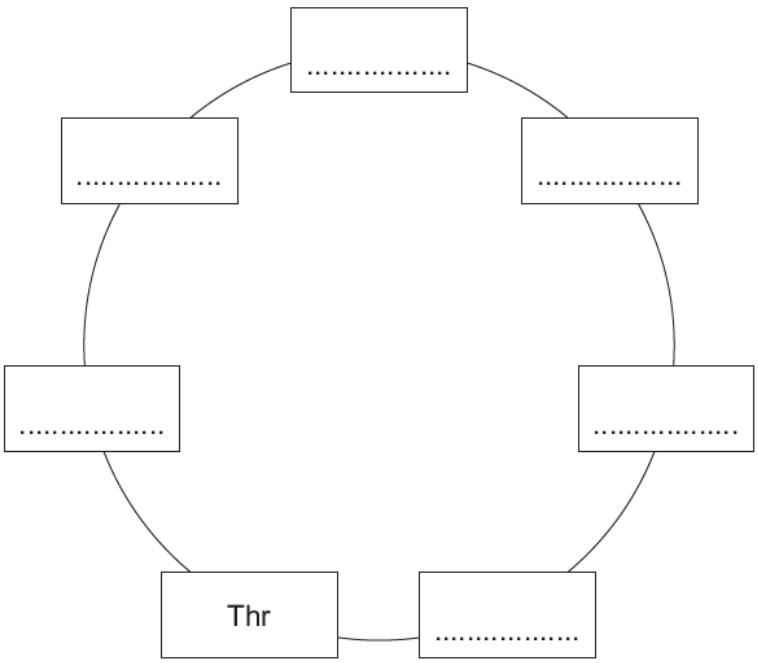


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(i) Draw the structures of the two other organic products formed.

[2]

(ii) Using the 3-letter abbreviations for the amino acids as given in the *Data Booklet*, complete the sequence for the cyclic peptide, **B**.



[1]

(iii) Name **two** analytical techniques that could be used to separate these amino acids.

..... and ..... [1]

[Total: 12]

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Polymerisation - 2023 A2 Chemistry 9701

1. Nov/2023/Paper_9701/42/No.8(a)

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]

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2. June/2023/Paper_9701/41/No.6(c)

Compound **H** has the structural formula CH_2=CHCH(NH_2)COOH.

(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.

.....

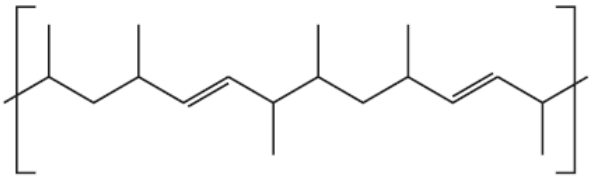
..... [1]

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Polymerisation – 2022 June AS Chemistry 9701

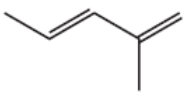
1. June/2022/Paper_11/No.39

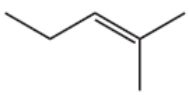
The diagram shows a section of an addition polymer formed from two different monomers.

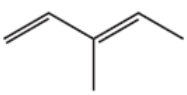


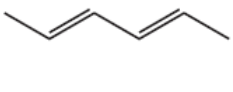
One of the monomers is propene.

What is the other monomer?

A 

B 

C 

D 

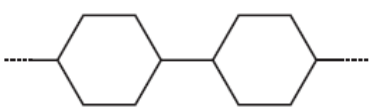
2. June/2022/Paper_12/No.39

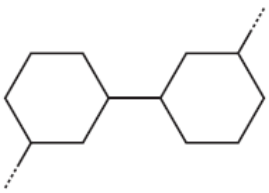
Cyclohexene, as shown in the diagram, can form an addition polymer.

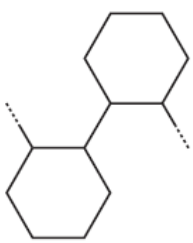
cyclohexene



Which structure represents a section of the polymer?

A 

B 

C 

D 

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3. June/2022/Paper_13/No.40

One molecule of an addition polymer containing 2000 repeat units has an M_r of 112 000.

The polymer molecule contains chiral centres.

What is a possible monomer for this polymer?

A $CH_2=CHCH_3$

B $CH_2=C(CH_3)_2$

C $CH_2=CHCH_2CH_3$

D $CH_2=CHCH_2CH_2CH_3$

4. June/2022/Paper_22/No.4(c)

(c) **X** is an addition polymer.

X

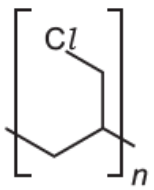


Fig. 4.3

(i) Draw the monomer of **X**.

[1]

(ii) Suggest **one** reason why the disposal of items made from **X** is difficult.

..... [1]

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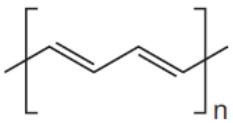
Polymerisation – 2022 Nov AS Chemistry 9701

1. Nov/2022/Paper_11/No.39

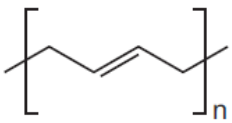
The monomer buta-1,3-diene can undergo addition polymerisation in various ways. Two of the polymers that can be made are called *cis*-poly(buta-1,3-diene) and *trans*-poly(buta-1,3-diene). In these names *cis* and *trans* have their usual meanings.

What is the structure of the repeat unit of *cis*-poly(buta-1,3-diene)?

A



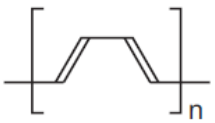
B



C

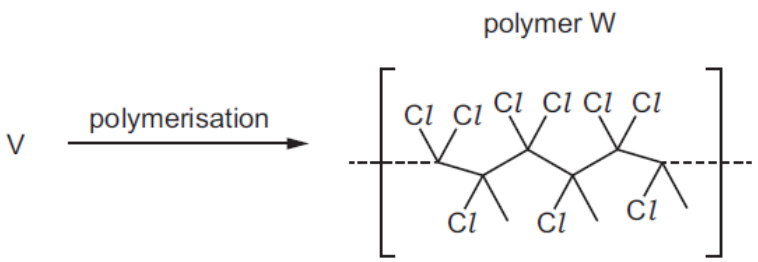


D



2. Nov/2022/Paper_12/No.39

Compound V polymerises to form polymer W. A section of polymer W is shown.



What is the correct name of compound V?

A 1,1,2-trichlorobutene

B 1,1,2-trichloroethene

C 1,1,2-trichloropropene

D 1,1,2-trichloro-2-methylethene

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Polymerisation – 2023 AS Chemistry 9701

1. Nov/2023/Paper_ 9701/12/No.6

Which feature is present in both ethene and poly(ethene)?

A bond angles of 109.5°

B π covalent bonds

C σ covalent bonds

D sp^3 orbitals

2. June/2023/Paper_9701/11/No.39

The diagram shows a section of a polymer molecule.

$$-CH_2-CH=CH-CH_2-CH_2-CH=CH-CH_2-$$

Which monomer will produce this polymer?

A $CH_2=CH_2$

B $CH_3CH=CH_2$

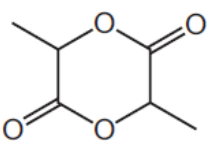
C $CH_3CH=CHCH_3$

D $CH_2=CH-CH=CH_2$

3. June/2023/Paper_9701/12/No.39

Lactide is an intermediate in the manufacture of a synthetic fibre.

lactide



Which compound, on heating with an acid catalyst, can produce lactide?

A hydroxyethanoic acid

B 2-hydroxybutanoic acid

C 2-hydroxypropanoic acid

D 3-hydroxypropanoic acid

4. June/2023/Paper_9701/13/No.39

In polymer G every carbon atom in the polymer chain is bonded to one hydrogen atom and one methyl group.

Which alkene could be polymerised to make polymer G?

A but-1-ene

B but-2-ene

C methylpropene

D propene

5. June/2023/Paper_9701/23/No.6(a)

Compound **W**, CH_2=CHCN, is used to make an addition polymer which is present in carbon fibres.

(a) Draw **one** repeat unit of the addition polymer of **W**.

[1]

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