GCSE · AQA · Chemistry

2 hours 18 questions

Exam Questions

Synthetic & Natural Polymers

Addition Polymerisation / Condensation Polymerisation / Amino Acids / DNA & Natural Polymers

Easy (5 questions)	/37
Medium (8 questions)	/31
Hard (5 questions)	/40
Total Marks	**/108**

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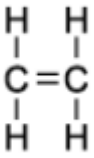
Easy Questions

1 (a) This question is about ethene, the structure of which is shown in **Figure 1.**

Figure 1



Why is this molecule described as **unsaturated?**

Answer

The alkene is unsaturated because:

- It has a double bond; [1 mark]
  Accept it does not only have single bonds

[Total: 1 mark]

- Unsaturated molecules have at least one double bond
- Saturated molecules have only single bonds

(1 mark)

(b) Ethene can undergo a polymerisation reaction.

Complete the sentences using the words in the box.

high	poly(ethene)	polymers	poly(ethane)
ten	monomers	a few	many

During polymerisation, _____ ethene molecules join together to form the large molecule, _____.

These large molecules are called _____

Answer

The correct sentences are:

During polymerisation, **many** ethene molecules join together to form the large molecule, **poly(ethene).**

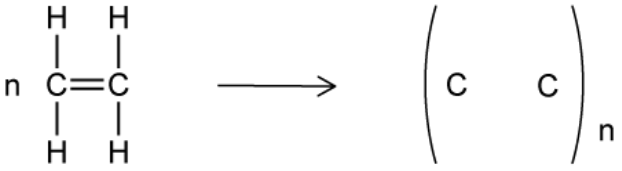
These large molecules are called **polymers.**

- Many; [1 mark]
- Poly(ethene) [1 mark]
- Polymers; [1 mark]

[Total: 3 marks]

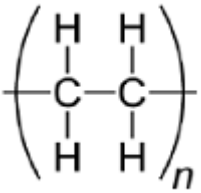
(3 marks)

(c) Complete the repeating unit of the polymer formed by ethene.



Answer

The repeating unit is :



- Two extending bonds coming out of either side of the brackets; [1 mark]
- Five single bonds (4 between the C-H and one between the C-C); [1 mark]

[Total: 2 marks]

- The double bond is broken so that monomers can add together
- The lines coming out of the brackets indicate that the monomer is joined to others
- The n represents a large number of monomers that will be joined together

(2 marks)

(d) What type of polymer does ethene form?

Tick (✓) **one** box.

Condensation		Addition		Substitution	

Answer

The type of polymer formed is:

- Addition; [1 mark]

[Total: 1 mark]

- Addition polymers are formed from monomers that have a double bond
- Condensation polymers are formed from either:
  - One type of monomer that has different functional groups
  - Two types of monomer that have the same functional group

(1 mark)

2 (a) This question is about naturally occurring polymers.

Sugars such as glucose can form naturally occurring polymers.

Name the **three** elements found in glucose.

Answer

The three elements in glucose are:

- Carbon; [1 mark]
- Hydrogen; [1 mark]
- Oxygen; [1 mark]

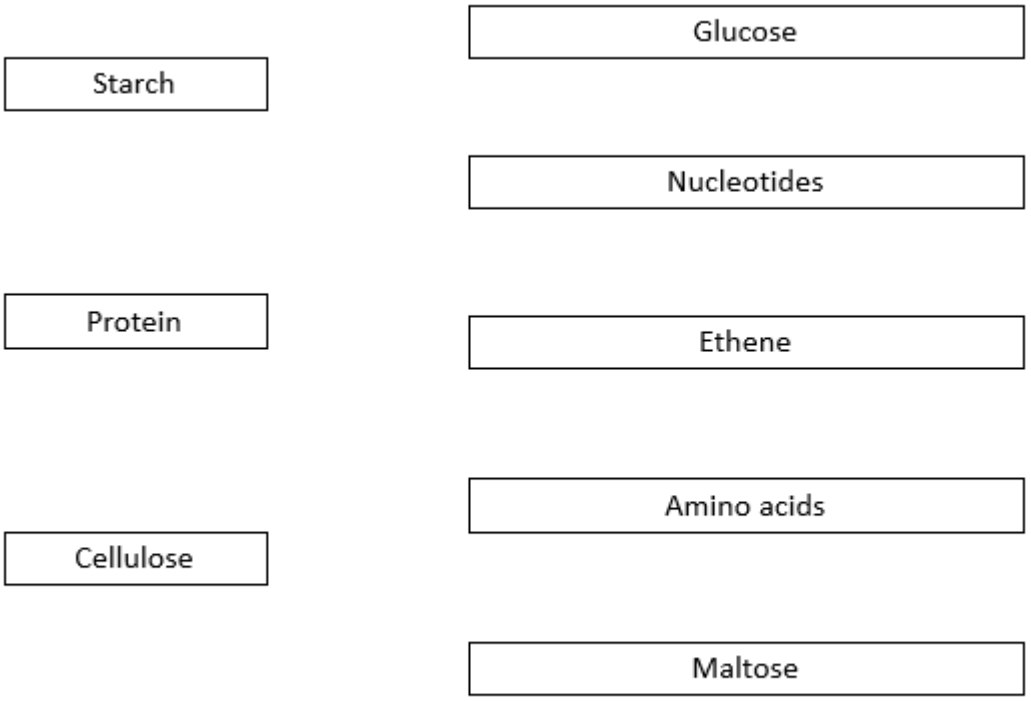
[Total: 3 marks]

- The formula of glucose is $C_6H_{12}O_6$

(3 marks)

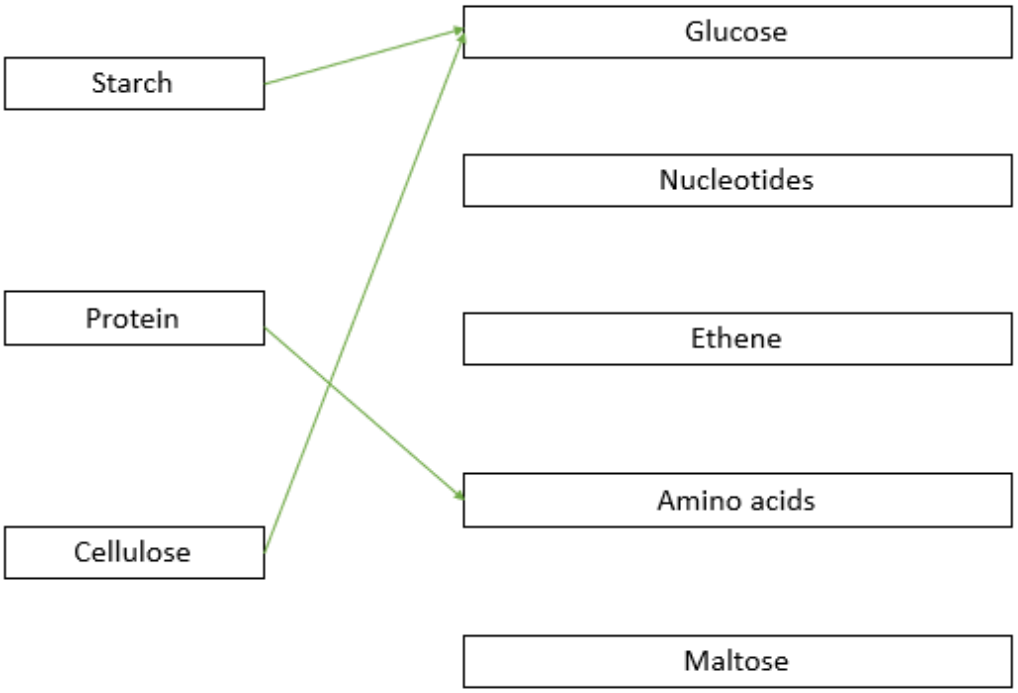
(b) Draw **one** line from each naturally occuring polymer to the monomer it is formed from.

You can use the monomer more than once.



Answer

The correct pairings are:



- Starch with glucose; [1 mark]
- Protein with amino acids; [1 mark]
- Cellulose with glucose; [1 mark]

[Total: 3 marks]

(3 marks)

(c) Which statements are correct about the structure of DNA?

Tick (✓) **two** boxes.

It consists of three polymer chains	
It has bases, A, C, G, and T	
It has a double helix structure	
It's formed from the monomer glucose	

Answer

The two correct statements are:

- It has bases A, C, G and T; [1 mark]
- It has a double helix structure; [1 mark]

[Total: 2 marks]

- DNA consists of two polymer chains
- The polymer chains consist of the monomer, nucleotides
- The nucleotides contain four different bases: A, G, C and T
- These bases pair up with each other from each chain to give the DNA a double helix structure

(2 marks)

(d) What type of polymerisation are proteins formed by?

Answer

Proteins are formed by:

- Condensation polymerisation; [1 mark]

[Total: 1 mark]

- Proteins are formed from the monomer, amino acids
- Amino acids contain two different functional groups
- Condensation polymers are formed from monomers with two different functional groups

(1 mark)

3 (a) This question is about addition and condensation polymerisation.

Place the statements about each type of polymerisation into the correct column in **Table 1.**

- Formed from a monomer with C=C double bond
- Can be formed from two monomer types with the same functional group
- A small molecule, usually water is released
- Only one product is formed
- Can be formed from one monomer type with two different functional groups

Table 1

Addition polymerisation	**Condensation polymerisation**

Answer

The correctly sorted statements are:

Addition polymerisation	Condensation polymerisation
Formed from a monomer with C=C double bond; [1 mark]	Can be formed from two monomer types with the same functional group; [1 mark]
Only one product is formed; [1 mark]	A small molecule, usually water is released; [1 mark]
	Can be formed from one monomer type with two different functional groups; [1 mark]

[Total: 5 marks]

- You need to be able to compare the types of polymerisation and know which polymers they form

(5 marks)

(b) Which polymers are made by condensation polymerisation?

Tick (✓) **two** box.

Polypeptides	
Poly(propene)	
Polyester	
Polystyrene	

Answer

Two polymers formed via condensation polymerisation are:

- Polyester; [1 mark]
- Polypeptides; [1 mark]

[Total: 2 marks]

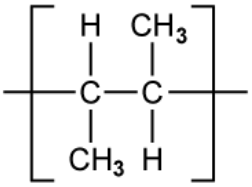
- A polyester is formed from two separate monomers that each contain two of the same function group
    - They are formed from a dicarboxylic acid and a diol
- A polypeptide is made from amino acids
    - Amino acids contain two different functional groups on them– NH_2 and –COOH

(2 marks)

(c) Poly(butene) can be formed from its monomer via addition polymerisation.

It's structure is shown in **Figure 1**.

Figure 1



Name the monomer that forms poly(butene)

Answer

The monomer that forms poly(butene) is:

- Butene; [1 mark]

[Total: 1 mark]

- **Tip:** When naming the polymer formed by an alkene during addition polymersation just add 'poly' in front of it and put the alkene name in brackets

- This works the other way as well: to deduce the name of the monomer used to make the polymer, just remove the 'poly' and brackets from the alkene name

(1 mark)

(d) Which type of bonding is present in poly(butene).

Circle **one** answer.

Ionic	Covalent	Metallic

Answer

The type of bonding present is:

- Covalent; [1 mark]

[Total: 1 mark]

- Poly(butene) consists of non-metal atoms so covalent bonding is present
- Ionic bonding forms between metals and non-metals
- Metallic bonding is found in metals and alloys

(1 mark)

4 (a) Alkenes form polymers via addition polymerisation reactions.

What is the functional group of an alkene?

Tick (✓) **one** box.

-OH		C=C		-COOH	

Answer

The functional group of an alkene is:

- C=C ; [1 mark]

[Total: 1 mark]

- –OH is the functional group of an alcohol
- –COOH is the functional group of a carboxylic acid

(1 mark)

(b) Give **two** conditions needed for addition polymerisation to take place.

Answer

Two conditions required for polymerisation are:

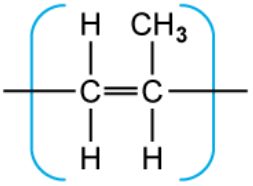
- High temperature; [1 mark]
- A catalyst; [1 mark]

[Total: 2 mark]

(2 marks)

(c) Propene can form the polymer, poly(propene).

A student drew this repeating unit for the polymer.



Identify **two** errors that the student has made.

Answer

Two errors that have been made are:

- There should be a single bond between the two carbon atoms; [1 mark]
- There should be an n at the bottom right hand side outside of the bracket; [1 mark]

[Total: 2 marks]

- When the propene monomers join together, the double bond will break so that the monomers can join up
- n represents a large number, it needs to be on the bottom right hand side outside of the bracket so that we know the unit is repeated a lot of times

(2 marks)

(d) Polystyrene is a common polymer often used in packaging.

What name can be given to this type of polymer?

Circle **one** answer.

Natural	Synthetic	Condensation

Answer

Polystyrene is a:

- Synthetic (polymer); [1 mark]

[Total: 1 mark]

- Synthetic polymers are manufactured by scientists, such as polystyrene and nylon
- Natural polymers are those that occur in nature such as protein and cellulose
- Condensation refers to the reaction that has happened to produce the polymer
- Polystyrene is produced via addition polymerisation, not condensation polymerisation

(1 mark)

5 (a) This question is about condensation polymerisation.

Condensation polymerisation produces a polymer and another small molecule.

Which small molecule is usually formed?

Tick (✓) **one** box.

carbon dioxide		water		oxygen		nitrogen

Answer

The substance usually released is:

- Water; [1 mark]

[Total: 1 mark]

(1 mark)

(b) Amino acids are formed by condensation polymerisation reactions.

Tick (✓) **two** correct statements about amino acids.

Amino acids form polypeptide chains	
An amino acid has two different functional groups	
Amino acids are saturated	
Amino acids contain an NH_3 functional group	

Answer

Two correct statements are:

- Amino acids form polypeptide chains; [1 mark]
- A single amino acid has two different functional groups; [1 mark]

[Total: 2 marks]

- Amino acids have two different functional groups: an NH_2 (amino) group and –COOH (carboxyl) group
- The carboxyl group has a double bond between the carbon and one of the oxygen atoms so is not saturated
- Amino acids form polypeptide chains and multiple chains will form proteins

(2 marks)

(c) A polyester can be formed from the two monomers shown in **Figure 1.**

Figure 1

$HO\text{-}CH_2\text{-}CH_2\text{-}OH$ ethane diol	$HOOC\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}COOH$ hexanedioic acid

Name the functional group for each monomer.

Ethane diol: _____

Hexanedioic acid: _____

Answer

The functional groups are:

- Ethane diol: alcohol; [1 mark]
- Hexanedioic acid: Carboxylic acid; [1 mark]

[Total: 2 marks]

- The –OH represents the functional group of the alcohol

- The –COOH represents the functional group of the carboxylic acid

(2 marks)

(d) Unlike condensation polymerisation, a small molecule is not released during addition polymerisation.

Give **one** other difference between condensation and addition polymerisation.

Answer

One difference between addition and condensation polymerisation is:

Any **one** from:

- Condensation polymerisation produces more than one product; [1 mark]
- Addition polymerisation only produces one product; [1 mark]
- Condensation polymerisation occurs with different monomers that have the same functional groups; [1 mark]
- Condensation polymerisation occurs with single monomers that have two different functional groups; [1 mark]
- Addition polymerisation occurs with one monomer type; [1 mark]

[Total: 1 mark]

(1 mark)

Medium Questions

1 (a) This question is about the chemistry and applications of polymers.

When two monomers with different functional groups join together, a polyester and another small molecule are formed.

Name the small molecule that is formed.

Answer

The molecule is:

- Water
  OR
  H_2O; [1 mark]

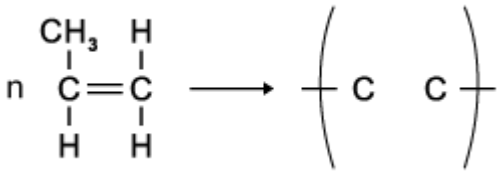
[Total: 1 mark]

(1 mark)

(b) Poly(propene) is produced from polymerising propene.

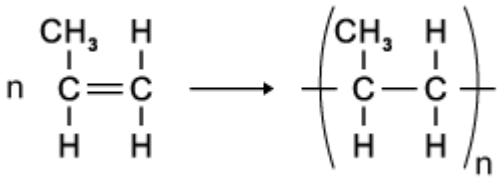
Complete the structure of poly(propene) in the equation shown in **Figure 1**.

Figure 1



Answer

The structure of poly(propene) is:



- Single C - C bond with nothing added to the trailing bonds; [1 mark]
- 3 x single C - H bonds and 1 x CH_3; [1 mark]
- Small n at bottom right hand side; [1 mark]

[Total: 3 marks]

- The bonds must be single bonds

(3 marks)

(c) Carpets are made from:

- wool
- poly(propene)
- a mixture of both

Wool is less durable than poly(propene).

A mixture of both substances to make carpets is more sustainable than using just wool or just poly(propene).

Suggest why.

Answer

A mixture is more sustainable as:

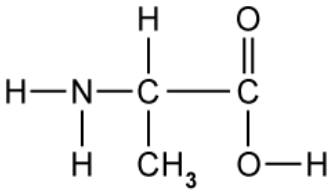
Any **three** from:

- Poly(propene) comes from a non-renewable source; [1 mark]
- Poly(propene) requires a lot of energy to make; **[1 mark]**
- Poly(propene) is not biodegradable; [1 mark]
- A wool carpet needs replacing more often (must refer to the carpet, not just the fibre); [1 mark]
- Wool requires the use of large areas of land (which could be used to grow food crops;) [1 mark]
  Ignore references to cost / pollution or landfill

[Total: 3 marks]

(3 marks)

(d) How many functional groups are present in the amino acid alanine?



A. 1

B. 2

C. 3

D. 4

Answer

The correct answer is B because:

- A functional group is a reactive part of a molecule
- Alanine contains an amino group, $-NH_2$, and a carboxylic acid group, -COOH
- Don't be fooled by the way organic molecules are drawn with groups of atoms at right angles. How they are joined is more important than where they are drawn in a displayed formula which can show functional groups above, below or side-on to the carbon chain.

(1 mark)

(e) Polymer fibres are used to make the fabric used to produce firefighter uniforms.

Table 1 below shows some properties of two types of polymer fibres, a poly(propene) and a polyester.

Table 1

	Polymer fibres	
Property	**Poly(propene)**	**Polyester**
Density in g/cm^3	0.88	1.40
Melting point in °C	162	263
Flame resistance	Poor	Good
Water absorption	Low	High

Evaluate the suitability of these polymers for firefighter uniforms.

Answer

Level 2 [3–4 marks]:

- Clear comparison mades, with at least one of the advantages of polyester over poly(propene) and vice versa given
- Justified conclusion as to which is best for making firefighter uniforms

Level 1 [1–2 marks]**:**

- Simple statements made about the suitability of the polymers
- Limited / no conclusion given

Polyester vs poly(propene) (advantages)

- Better flame resistance (so burns less easily)
- Higher melting point (so melts less easily)
- Absorbs water so less likely to ignite

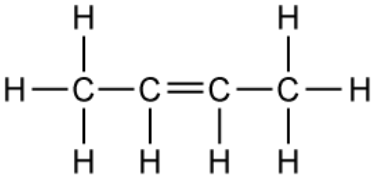
Poly(propene) vs polyester (disadvantages)

- High density so uniform is heavy
- Absorbs water so firefighter gets wet
- Absorbs water so uniform becomes heavy

[Total: 4 marks]

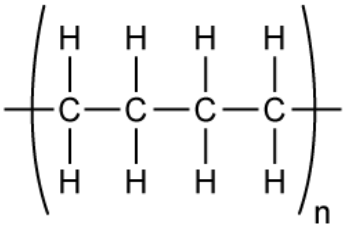
(4 marks)

2 The following molecule can undergo addition polymerisation.

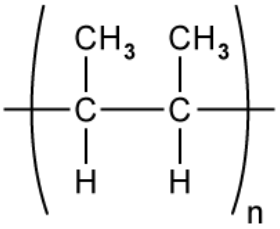


What it the correct repeat unit?

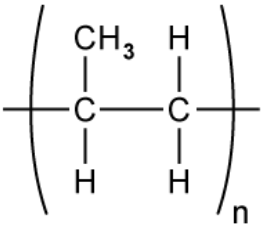
A



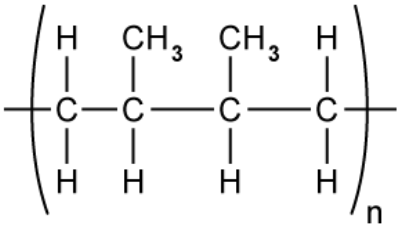
B



C



D



Answer

The correct answer is B because:

- In addition polymers the repeat unit always has two carbons in the chain and the other atoms are side groups drawn above or below the chain
- Each carbon across the double bond in the monomer has a -CH_3 group and -H attached, so the polymer must also have these as side groups

A is incorrect as the chain of the repeat unit is four carbons long instead of two

C is incorrect as one carbon in the chain has two Hs instead of a CH_3 and H

D is incorrect as the chain of the repeat unit is four carbons long instead of two

(1 mark)

3 (a) Poly(chloroethene) is an extremely versatile plastic with many different applications.

Give the monomer used to form poly(chloroethene).

Answer

The monomer is

- Chloroethene; [1 mark]

[Total: 1 mark]

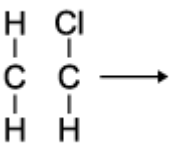
- To identify the monomer, just remove the poly- from the name

(1 mark)

(b) **Figure 6** shows part of the equation for the formation of poly(chloroethene).

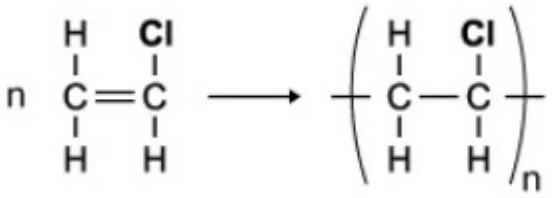
Complete **Figure 6** to show the product, correct notation and bonds in both the monomer and polymer.

Figure 6



Answer

The structures are:



- Double bond in the monomer between the carbon atoms; [1 mark]
- Small n in front of the monomer; [1 mark]
- 1 x C - C bond in the polymer; [1 mark]
- 2 x open ended bonds in the polymer; [1 mark]
- Large brackets and small n on bottom right hand side of the polymer; [1 mark]

[Total: 5 marks]

(5 marks)

(c) Poly(chloroethene) is the only product.

What type of polymer is poly(chloroethene)?

Answer

The type of polymer is:

- Addition; [1 mark]

[Total: 1 mark]

- Addition polymers only form one product whereas condensation polymers form two, a polymer and a small molecule, usually water

(1 mark)

4 (a) Proteins, starch and DNA are all naturally occurring polymers.

Give the names of the monomers from which proteins and starch are produced.

Answer

The monomers are:

- Proteins: amino acids; [1 mark]
- Starch: glucose; [1 mark]

[Total: 2 marks]

(2 marks)

(b) Describe the formation of polypeptides.

Answer

Polypeptides are formed because:

- Amino acids have two different functional groups; [1 mark]
- Which react by condensation polymerisation to form polypeptides [1 mark]

[Total: 2 marks]

(2 marks)

(c) Describe the structure of DNA.

Answer

DNA has the following structure

- Two polymer chains; [1 mark]
- A double helix; [1 mark]
- Each polymer chain is made from four different monomers **or** nucleotide; [1 mark]
  allow four (different) bases/ C G A T, or bases named

[Total: 3 marks]

(3 marks)

5 Which of the following is **not** true about DNA?

A. The structure is a double helix

B. DNA is made from nucleotides

C. DNA is made from two polymer chains

D. The monomers that form DNA are amino acids

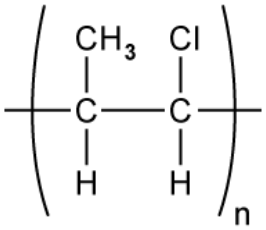
Answer

The correct answer is D because:

- The monomers that make up DNA are nucleotides not amino acids
- Amino acids are the monomers for making polypeptides or protein chains

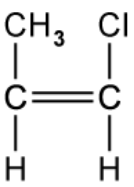
(1 mark)

6 The structure of a polymer is shown below.

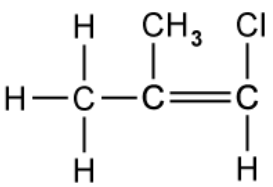


What is the correct monomer?

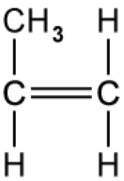
A



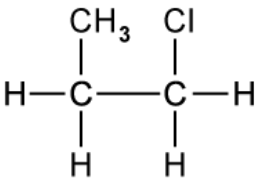
B



C



D



Answer

The correct answer is A because:

- Monomers that make addition polymers show a double bond and the side groups to the chain must correspond to the side groups on the monomer
- This polymer has a CH_3 and Cl on adjacent carbons so the monomer must be the same

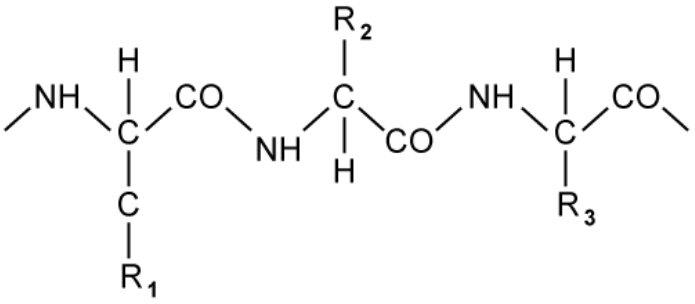
B is incorrect as three carbons are shown in the chain of the monomer instead of two

C is incorrect as the monomer is missing a Cl side group

D is incorrect as there is a missing double bond in the monomer

(1 mark)

7 Part of the chemical structure of a wool fibre is shown below.



What is true about the structure?

A. The structure is a carbohydrate

B. The structure is an addition polymer

C. The structure is a protein

D. Hydrogen has two covalent bonds in the chain

Answer

The correct answer is C because:

- The diagram shows the section of a chain containing the elements C, H, O and N
- The corresponds to the components of a protein

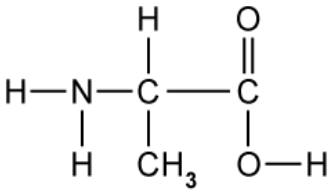
A is incorrect as the structure contains nitrogen so it cannot be a carbohydrate

B is incorrect as the structure is not a continuous carbon chain so it cannot be an addition polymer

D is incorrect as although it looks like the H has two covalent bonds in the chain, it is in fact a side group on the nitrogen. Hydrogen can only form one covalent bond

(1 mark)

8 How many functional groups are present in the amino acid alanine?



A. 1

B. 2

C. 3

D. 4

Answer

The correct answer is B because:

- A functional group is a reactive part of a molecule
- Alanine contains an amino group, -NH_2, and a carboxylic acid group, -COOH

Don't be fooled by the way organic molecules are drawn with groups of atoms at right angles. How they are joined is more important than where they are drawn in a displayed formula which can show functional groups above, below or side-on to the carbon chain.

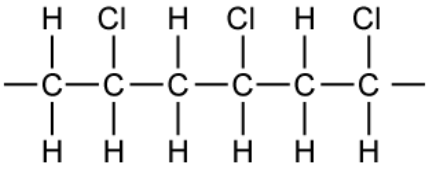
(1 mark)

Hard Questions

1 (a) This question is about polyvinyl chloride (PVC)

Figure 1 shows a short section of a PVC.

Figure 1

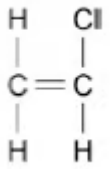


Draw the structure of the monomer from which it is made.

The monomer has two carbon atoms.

Answer

The monomer for PVC is:



- C=C double bond; [1 mark]
- 3 single bonds to hydrogen atoms and one single bond to a chlorine atom; [1 mark]

[Total: 2 marks]

- First you need to identify the repeating unit in the polymer
    - You can see that on every second carbon atom there is a chlorine atom and that this section is repeated along the chain
- Change the single bond in the repeat unit to a **double bond** in the monomer

- Remove the bond from each end of the repeat unit
- Ensure you only have four bonds from each carbon atom

(2 marks)

(b) Describe how the addition polymer PVC is formed from its monomer.

Answer

The polymer is formed from its monomer by:

Any **three** from:

- Many monomers / small molecules / vinyl chloride molecules; [1 mark]
  *do **not** accept many particles*
- Join / bond / link / combine / attach; [1 mark]
- To form one large molecule
  OR
  To form a long chain; [1 mark]
- No other substances are produced / only one substance is formed; [1 mark]
- The double bond breaks so that the monomer can join to another monomer; [1 mark]

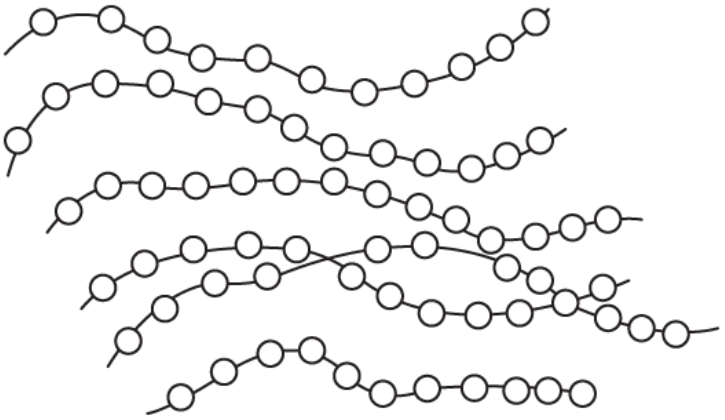
[Total: 3 marks]

- This question is checking your understanding of what happens during polymerisation (use **Figure 1** to help you)

(3 marks)

(c) PVC molecules are shown in **Figure 2.**

Figure 2



When PVC is heated, it melts.

Explain why.

Answer

c) PVC melts when heated because:

- It has intermolecular forces between the chains; [1 mark]
- Which are weak; [1 mark]
  allow weak forces between layers for 1 mark
- Which needs little energy to overcome
  OR
  Which are easily overcome (by heat)
  OR
  The chains slide over each other (when heated); [1 mark]
  if any reference to breaking covalent bonds only the third marking point is available.

[Total: 3 marks]

- Use the diagram to help you with this answer, which shows you the structure of a thermosoftening polymer
- There are no bonds shown between the polymer chains and they are tangled so only weak forces must be holding them together

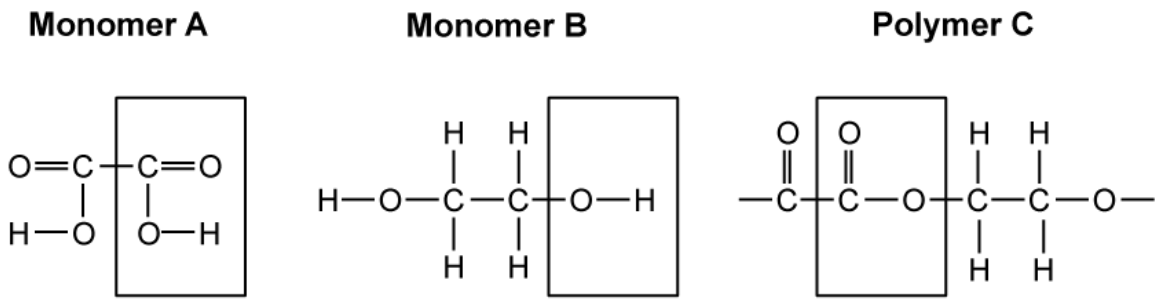
- If there were stronger bonds, the structure would be more rigid, like that of a thermosetting polymer
- **Remember:** For any question where you asked to explain melting/ boiling point always reference the energy required to overcome the bonds/ forces you have discussed in your answer as your last marking point

(3 marks)

(d) Polymer **C** can be formed from monomer **A** and monomer **B**.

The displayed structures monomer **A** and **B** are shown in **Figure 2** with the functional group highlighted in the box.

Figure 2



Name the functional group in:

Monomer **A**: _____

Monomer **B**: _____

Polymer **C**: _____

Answer

The monomers shown in **Figure 2** are:

- A - carboxylic acid; [1 mark]
- B - alcohol; [1 mark]
- C- ester; [1 mark]

[Total: 3 marks]

- You should be able to identify functional groups from displayed formulae for alkenes, alcohols, carboxylic acids and esters

(3 marks)

2 (a) This question is about photosynthesis and naturally occurring polymers.

Plants photosynthesise to produce oxygen and glucose, $C_6H_{12}O_6$, from carbon dioxide and water.

Write the balanced symbol equation for photosynthesis.

Answer

The balanced symbol equation for photosynthesis is:

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

- All formulae correct; [1 mark]
- Correctly balanced LHS; [1 mark]
- Correctly balanced RHS; [1 mark]

[Total: 3 marks]

- Although you should know the photosynthesis equation from the biology course, there is enough information in the question to work out what the products and reactants are
- The question says oxygen and glucose are formed from carbon dioxide and water
    - You are given the formula of glucose and should know the other formulae

$$CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$$

- Start by balancing the carbon atoms, there are six on the right hand side so should be six on the left

$$\mathbf{6}\,CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$$

- Now balance the hydrogen atoms – there are 12 on the right so there needs to be another six on the left as there are already 2 hydrogen atoms in water

$$\mathbf{6}\,CO_2 + \mathbf{6}\,H_2O \rightarrow C_6H_{12}O_6 + O_2$$

- Finally balance the oxygen atoms, there are now 18 on the left hand side, and 8 on the right hand side.

- A 6 is placed in front of the oxygen which then totals 18

$$\mathbf{6}\,CO_2 + \mathbf{6}\,H_2O \rightarrow C_6H_{12}O_6 + \mathbf{6}\,O_2$$

(3 marks)

(b) Describe a test that could be done to identify the gas produced during this reaction.

Give the result of the test.

Answer

To test for the gas product of the reaction:

- Use a glowing splint; [1 mark]
  *do **not** accept burning splint*

- (The splint) relights; [1 mark]
  Dependent on the correct test in MP1

[Total: 2 marks]

- There are only two products made during photosynthesis: glucose and oxygen
- The gas is oxygen so this is the test that should be described
- Don't get this test confused with testing for hydrogen
  - A burning splint is used for hydrogen
  - A glowing splint is used for oxygen
- Also be careful not to describe the test for carbon dioxide, this is a reactant not a product

(2 marks)

(c) Plants contain cellulose in their cell walls.

Name the monomer that forms cellulose.

Answer

The monomer that forms cellulose is:

- Glucose; [1 mark]
  accept glycogen

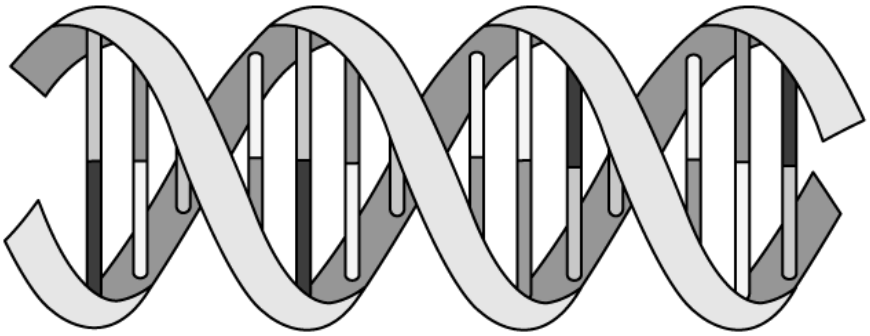
[Total: 1 mark]

- Cellulose strengthens the cell walls of plants and is a complex carbohydrate
- Starch is also made from the monomer glucose and is utilised by plants to store energy

(1 mark)

(d) A naturally occuring polymer found in all plants is shown in **Figure 1.**

Figure 1



Describe the shape and structure of this polymer.

Answer

The shape and structure of this polymer can be described as:

- Two polymer chains; [1 mark]
  allow two polymer strands
  ignore reference to compounds

- Four (different) monomers/nucleotides; [1 mark]
  allow four (different) bases
  allow C G A T
  allow cytosine, guanine, adenine and thymine

- (Double) helix; [1 mark]
  allow spiral
  *if no other mark, allow **1** mark for DNA*

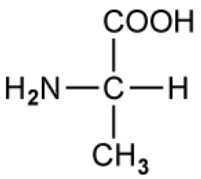
[Total: 3 marks]

- Another question that overlaps with the biology specification so make sure you learn it!

(3 marks)

(e) **Figure 2** shows the amino acid alanine.

Figure 2



How many functional groups are there in this amino acid?

Circle **one** box.

1 2 3 4

Answer

The number of functional groups in alanine is:

- 2; [1 mark]

[Total: 1 mark]

- Amino acids, such as alanine, consist of the following functional groups:

- NH_2– the amine group
- COOH– the carboxylic acid group

- **Careful**: don't count the CH_3 as a functional group, this is just an extension of the carbon chain

(1 mark)

(f) Alanine will react with other amino acids to form a polypeptide and water.

Name the type of polymerisation reaction that occurs.

Answer

The polymerisation reaction which occurs is:

- Condensation (polymerisation); [1 mark]

[Total: 1 mark]

- Condensation polymerisation results in the formation of a polymer and another small molecule, usually water
- You are told this in the question so can deduce it is condensation polymerisation
- It cannot be addition polymerisation as the monomer, alanine, does not contain a double bond

(1 mark)

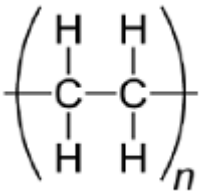
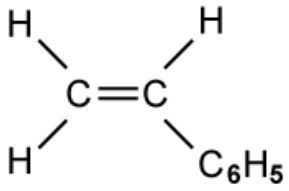
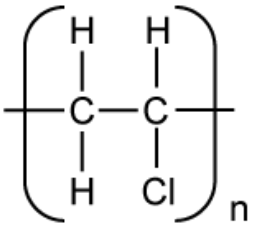
3 (a) This question is about polymerisation.

Table 1 shows information about polymers and the monomers they are made from.

Complete the table.

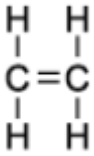
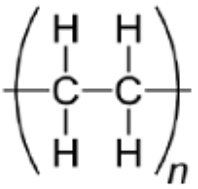
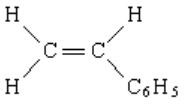
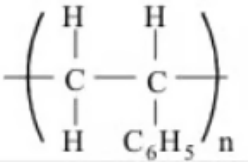
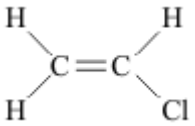
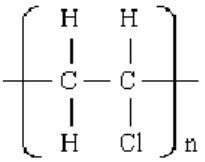
Table 1

Monomer	**Polymer**

Name	**Formula**	**Name**	**Formula**
ethene		poly(ethene)	
styrene		polystyrene	
		poly(chloroethene)	

Answer

The completed table is:

Monomer		Polymer	
ethene	 ; [1 mark]	poly(ethene)	
styrene		polystyrene	; [1 mark] 
chloroethene;[1 mark]		poly(chloroethene)	; [1 mark] 

- Correct displayed formula of ethene; [1 mark]
- Correct displayed formula of polystyrene; [1 mark]
- Correct name of monomer chloroethene; [1 mark]
- Correct displayed formula of poly(chloroethene); [1 mark]

[Total: 4 marks]

- This question tests your all round knowledge of addition polymers:
  - Drawing monomers from polymers
    - Remove the brackets, extended bonds from the carbon atoms and the n
    - Add a double bond between the two carbon atoms
  - Drawing polymers from monomers
    - Remove a double bond between the carbon atoms
    - Add an extended bond through the brackets for each carbon
    - Add an n in the bottom right hand corner outside of the bracket
  - Naming monomers
    - Remove the poly from the name of the polymer
  - Naming polymers
    - Add poly to the front of the monomer name and put the monomer name in brackets

(4 marks)

(b) State whether ethene is saturated or unsaturated.

Give **one** reason for your answer.

Answer

Ethene is:

- Unsaturated; [1 mark]
- (Because) it has a double bond; [1 mark]
  accept it has no single bonds

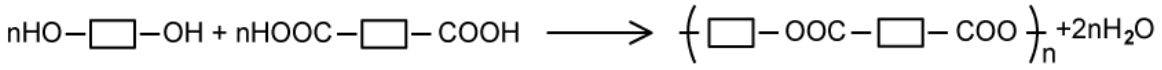
[Total: 2 marks]

- **Remember: S**aturated compounds have **S**ingle bonds only and **U**nsaturated contain do**U**ble bonds

(2 marks)

(c) Polyesters are not made from the same method of polymerisation as those in **Table 1.**

The equation demonstrates how a polyester is made:



Compare the polymerisation reaction used to make poly(ethene) to the reaction used to make polyester.

Answer

Comparisons of the two types of polymerisation include:

Any **four** from:

- Poly(ethene) produced by addition polymerisation whereas polyester by condensation polymerisation; [1 mark]
- Poly(ethene) produced from one monomer whereas polyester produced from two different monomers; [1 mark]

- Poly(ethene) produced from ethene / alkene whereas polyester from a (di)carboxylic acid and a diol / alcohol; [1 mark]

- Poly(ethene) is the only product formed whereas polyester water also produced; [1 mark]

- Poly(ethene) repeating unit is a hydrocarbon whereas polyester has an ester linkage; [1 mark]

[Total: 4 marks]

- Notice here that within the same marking point you need to reference both types of polymer

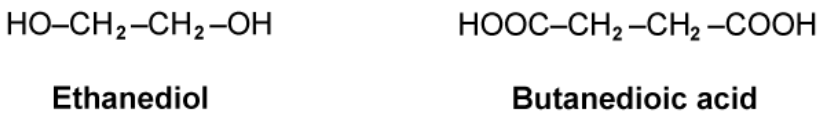
- You cannot achieve the mark if you just state, for example, that poly(ethene) is made from one monomer, you **must** then comment on the other polymer

(4 marks)

4 (a) This question is about polyesters.

A polyester is made from the monomers shown in **Figure 1.**

Figure 1



Ethanediol **Butanedioic acid**

Which homologous series does ethanediol belong to?

Answer

Ethanediol belongs to the homologous series:

- Alcohols; [1 mark]

[Total: 1 mark]

- You can either use the name or the displayed formula to work out this answer
- Alcohols always end in -ol and there is also the -OH functional group present in the formula

(1 mark)

(b) Give the formula that represents the functional group of butanedioic acid.

Answer

The formula that represents the functional group of butanedioic acid is:

- -COOH; [1 mark]

[Total: 1 mark]

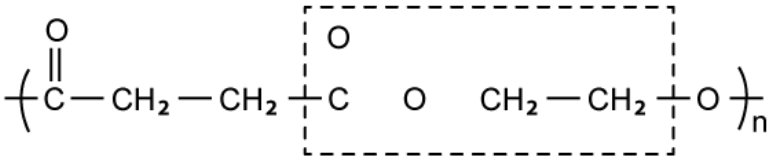
- You should be able to identify from **Figure 1** that there is a carboxylic acid functional group
- Make sure you write the formula for the functional group instead of naming it

(1 mark)

(c) Part of the structure formed by the polyester is shown in **Figure 2.**

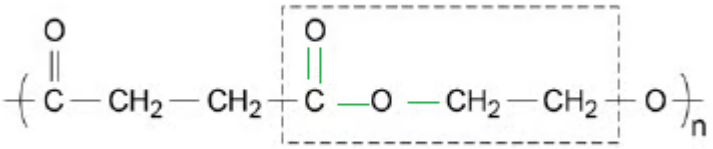
Draw the remaining bonds to complete the diagram.

Figure 2



Answer

The completed structure for this segment of a polyester is:



- C=O bond; [1 mark]
- 2 x C-O bonds; [1 mark]

[Total: 2 marks]

- This part of the polymer contains the ester link: –COO, that forms when the two monomers join

(2 marks)

(d) A small molecule is also produced during the formation of this polyester.

Name the small molecule.

Answer

The small molecule also produced when this polyester is made is:

- Water; [1 mark]

[Total: 1 mark]

- Each time an ester linkage forms between butanedioic acid and ethanediol, a water molecule is released
- This is formed from the OH^- ion from the butanedioic acid and the H^+ ion from the ethanediol

(1 mark)

(e) Why does this polyester melt when it is heated?

Answer

This polyester melts when it is heated because:

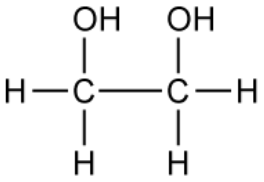
- It is a thermosoftening polymer; [1 mark]
  allow it is a thermoplastic
- It has no cross links; [1 mark]
  allow it has weak intermolecular forces

[Total: 2 marks]

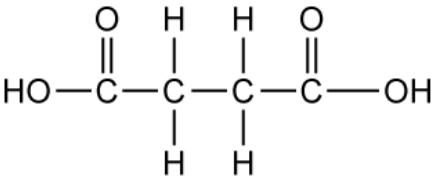
- The question does not use the command word explain which means a less detailed answer is required
- The question also doesn't tell you that polyester is a thermosoftening polymer so that should be your first making point with reference to the bonding/structure of the polyester as the second marking point

(2 marks)

5 Polyesters can be made by condensation polymerisation. Ethanediol can react with butanedioic acid (a carboxylic acid containing two -COOH groups) to make a polymer.



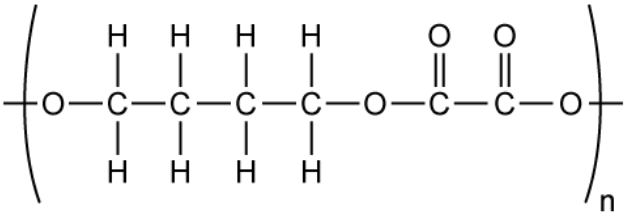
Ethanediol



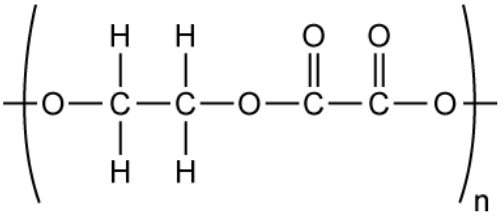
Butanedioic acid

Which of the following is a correct repeat unit for this polymer?

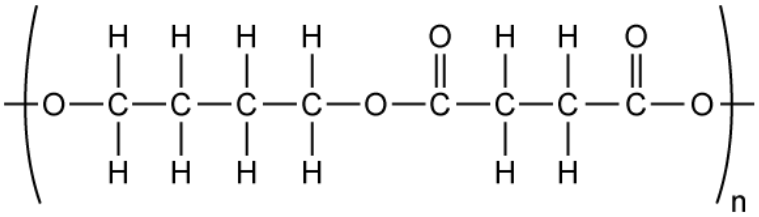
A.



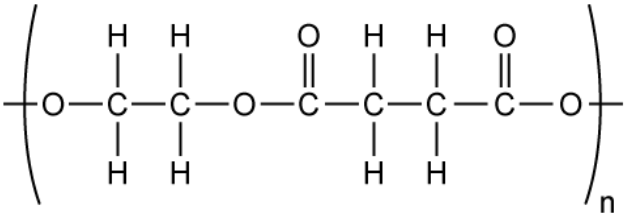
B.



C.



D.



Answer

The correct answer is D because:

- The monomers link together using an ester link
- The diol and dioic acid monomers have two carbons and four carbons respectively, so the polymer must have the same sections
- The carboxylic acid unit is four carbons long, so there must be four carbons between the ester links (including the ester carbon)

A is incorrect as the ester links are only two carbons long instead of four and the diol section is four carbons long instead of two

B is incorrect as each section is only two carbons long, instead of two and four

C is incorrect as each section is four carbons long instead of two and four

(1 mark)