Week 53

A-Level Chemistry

Homework bundle for this week
本周作业合集
exercises.lol

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A-Level Chemistry Name: ____________ Score: ______

1. In condensation polymerisation:
   - ☐ monomers join and a small molecule (e.g. water) is lost each time
   - ☐ a C=C opens and nothing is lost
   - ☐ no bonds form
   - ☐ only one monomer is used
2. A monomer with a C=C double bond, where nothing else is lost, undergoes:
   - ☐ addition polymerisation
   - ☐ condensation polymerisation
   - ☐ no polymerisation
   - ☐ hydrolysis
3. Poly(alkene)s are hard to biodegrade because they have:
   - ☐ only strong, non-polar C–C and C–H bonds
   - ☐ ester links
   - ☐ amide links
   - ☐ ionic bonds
4. A polyester can be made from:
   - ☐ a diol and a dicarboxylic acid
   - ☐ two alkenes
   - ☐ an alkane and a halogen
   - ☐ a single C=C monomer
5. Monomers with two functional groups that lose a small molecule give:
   - ☐ condensation polymerisation (with ester or amide links)
   - ☐ addition polymerisation
   - ☐ free-radical substitution
   - ☐ no polymer
6. Some polymers are made photodegradable so that light can break them down.

   ☐ True ☐ False

7. Polymers that can be broken down by microbes or hydrolysis are described as _________.

____

8. Polymers made by joining monomers with loss of a small molecule (e.g. water) form by _________ polymerisation.

____

9. Addition polymers form from monomers containing C=C double bonds.

☐ True ☐ False

10. Condensation polymers such as polyesters can be hydrolysed and so are more easily degraded than addition polymers.

☐ True ☐ False

35. Polymerisation

Answers · 答案

A-Level Chemistry

1. **monomers join and a small molecule (e.g. water) is lost each time**

   Each new link releases a small molecule; the monomers need two reactive groups.

2. **addition polymerisation**

   Addition polymerisation opens the C=C and joins monomers with no other product.

3. **only strong, non-polar C–C and C–H bonds**

   With no polar links to attack, microbes cannot easily break poly(alkene)s down.

4. **a diol and a dicarboxylic acid**

   A diol (two –OH) and a dicarboxylic acid (two –COOH) form ester links along the chain.

5. **condensation polymerisation (with ester or amide links)**

   Two-group monomers join with loss of a small molecule, forming ester/amide links — condensation.

6. **True**

   Photodegradable polymers are designed to be broken down by light.

7. **degradable**

   They reduce plastic waste.

8. **condensation**

   Polyesters and polyamides form this way.

9. **True**

   No small molecule is lost.

10. **True**

    The ester/amide links can be broken.

A-LEVEL CHEMISTRY • EXERCISE SHEET

35.1 Condensation polymerisation

Name: ____________ Class: ________ Date: __________ **Total: 9 marks**

KEY WORDS monomer 单体 • repeat unit 重复单元 • polyester 聚酯 • polyamide 聚酰胺 • condensation polymerisation 缩合聚合

Objective

Build the skills to answer exam questions on **condensation polymerisation 缩合聚合** — making **polyesters 聚酯** and **polyamides 聚酰胺**, and finding the **monomers 单体** or **repeat unit 重复单元**.

You must be able to:

- describe condensation polymerisation (two-group monomers, a small molecule lost)
- name the monomers for a polyester or polyamide
- deduce the monomers/repeat unit from a section of polymer

1 Worked examples

■ Links and monomers

polyester: $\text{-C(=O)-OH} + \text{H-O-} \rightarrow \text{-C(=O)-O-} + H_2O$

polyamide: $\text{-C(=O)-OH} + \text{H-N(H)-} \rightarrow \text{-C(=O)-NH-} + H_2O$

every new ester or amide link loses a small molecule (condensation)

A polyester forms ester links, a polyamide forms amide links; each new link releases a small molecule (e.g. water)

- **condensation:** each monomer has **two** reactive groups; a small molecule (water or HCl) is lost at each link.
- **polyester** = diol + dicarboxylic acid (or dioyl chloride); **polyamide** = diamine + dicarboxylic acid.

polyester (ester links)

$$\cdots\text{–CO–O–R–O–CO–R}'\text{–CO–O–}\cdots$$

$\downarrow$ break each link; add back –OH and –H

$$\underset{\text{diol}}{\text{HO–R–OH}} + \underset{\text{dicarboxylic acid}}{\text{HOOC–R}'\text{–COOH}}$$

To find the monomers, break the chain at each link and add back –OH and –H to the cut ends

2 Practice

2.1 Name the small molecule lost when a diol and a dicarboxylic acid form a polyester. [1]

2.2 Name the type of link in a polyamide. [1]

3 Exam-style questions

3.1 A polyamide is made from: [1]

- **A** an alkene only
- **B** a diol and a dicarboxylic acid
- **C** a diamine and a dicarboxylic acid
- **D** a single alcohol

3.2 When a section of polyester is hydrolysed, the monomers recovered are: [1]

- **A** two alkenes
- **B** a diol and a dicarboxylic acid
- **C** two diamines
- **D** an amino acid only

3.3 A polyester has the repeat unit $-O-CH_2CH_2-O-CO-C_6H_4-CO-$.

(a) Draw the two monomers. [2]

(b) Name the small molecule lost when they polymerise. [1]

3.4 Explain why each monomer in a condensation polymer must have **two** functional groups. [2]

Solutions

2.1 water.

2.2 an amide link / peptide bond.

3.1 C. A polyamide forms from a diamine and a dicarboxylic acid (or a dioyl chloride).

3.2 B. Hydrolysing a polyester recovers the diol and the dicarboxylic acid.

3.3 (a) the diol $HO-CH_2CH_2-OH$ (ethane-1,2-diol) and the diacid $HOOC-C_6H_4-COOH$ (benzene-1,4-dicarboxylic acid).
(b) water.

3.4 with two reactive groups, a monomer can bond at **both** ends; so the chain can keep growing in both directions to form a long polymer — with only one group it would stop after one link.

8 Asparagine and aspartic acid are two naturally occurring amino acids. Their structures and isoelectric points are shown in Table 8.1.

Table 8.1

amino acid	structure	isoelectric point
asparagine	$HOOCCH(NH_2)CH_2CONH_2$	5.41
aspartic acid	$HOOCCH(NH_2)CH_2COOH$	2.77

(a) Define isoelectric point.

....

.... [1]

(b) Draw the structures of asparagine and aspartic acid at pH 2.

asparagine at pH 2

aspartic acid at pH 2

[2]

(c) Asparagine and aspartic acid are treated separately with an excess of $LiAlH_4$.

Draw the structures of the organic products of these reactions.

product of asparagine treated with an excess of $LiAlH_4$

product of aspartic acid treated with an excess of $LiAlH_4$

[2]

(d) Propanedioic acid, $HOOCCH_2COOH$, is treated with an excess of thionyl chloride, $SOCl_2$. Propanedioyl chloride, $ClOCCH_2COCl$, is formed.

(i) Write an equation for this reaction.

.... [1]

(ii) Propanedioyl chloride reacts with an excess of asparagine to form compound **G** with molecular formula $C_{11}H_{16}N_4O_8$.

Each molecule of compound **G** has four amide groups.

Draw the structure of compound **G**.

Compound **G**, $C_{11}H_{16}N_4O_8$

[2]

(e) Asparagine is hydrolysed with an excess of hot NaOH(aq).

Draw the structure of the organic product of this reaction.

[2]

(f) A polymer can form from asparagine, $HOOCCH(NH_2)CH_2CONH_2$, as the only monomer.

Draw a length of the polymer chain containing **three** monomer residues.

Clearly label the repeat unit of the polymer on your diagram.

[3]

(g) Aspartic acid exists in two optically active forms.

(i) Plane polarised light is passed through pure samples of these two optically active forms in solutions of the same concentration.

Describe **two** similarities and **one** difference in their effect on the plane polarised light.

similarities ....

....

difference ....

....

[2]

(ii) Give the term used to describe a mixture of equal amounts of the two optically active forms.

.... [1]

[Total: 16]

Question 9 starts on page 20.

A-LEVEL CHEMISTRY • EXERCISE SHEET

35.2 Predicting the type of polymerisation

Name: ____________ Class: ________ Date: __________ **Total: 9 marks**

KEY WORDS addition polymerisation 加成聚合 • condensation polymerisation 缩合聚合 • monomer 单体 • repeat unit 重复单元 • polyester 聚酯

Objective

Build the skills to answer exam questions on **predicting the type of polymerisation** 判断聚合类型 — telling **addition** 加成聚合 from **condensation** 缩合聚合 from the monomer and the product.

You must be able to:

- use the monomer's structure to predict the polymerisation type
- recognise addition (C=C, nothing lost) vs condensation (two groups, small molecule lost)

1 Worked examples

■ **Which type?**

addition polymerisation
- monomer has a **C=C**
- the double bond opens and the monomers join
- **nothing else** is lost

e.g. ethene → poly(ethene)

condensation polymerisation
- each monomer has **two** functional groups
- a **small molecule** (H_2O or HCl) is lost
- ester or amide links form

e.g. a polyester or polyamide

Addition opens a C=C and loses nothing; condensation joins two-group monomers and loses a small molecule polyester (ester links)

$$\cdots\text{–CO–O–R–O–CO–R}'\text{–CO–O–}\cdots$$

$$\big\downarrow \text{ break each link; add back –OH and –H}$$

$$\underset{\text{diol}}{\text{HO–R–OH}} \quad + \quad \underset{\text{dicarboxylic acid}}{\text{HOOC–R}'\text{–COOH}}$$

Find the monomers to predict the polymerisation type

Clue	Type
monomer has a C=C, **nothing** else lost	**addition**
each monomer has **two** functional groups; a small molecule is lost; chain has ester/amide links	**condensation**

2 Practice

2.1 State the type of polymerisation when ethene forms poly(ethene). [1]

2.2 State the type of polymerisation when a small molecule is lost at each link. [1]

3 Exam-style questions

3.1 A monomer with **one** C=C and no other functional group will undergo: [1]

- **A** addition polymerisation
- **B** condensation polymerisation
- **C** neither
- **D** hydrolysis

3.2 Which observation shows that a polymer formed by **condensation**? [1]

- **A** the monomer had a C=C
- **B** no small molecule was lost
- **C** water (or HCl) was released and the chain has ester/amide links
- **D** the polymer is an alkene

3.3 For each monomer, predict the type of polymerisation and justify it: [3]

(a) CH_2=CHCl (chloroethene)

(b) $HOCH_2CH_2OH$ + $HOOC(CH_2)_4COOH$

(c) a single amino acid H_2NCH_2COOH

3.4 Explain how you could tell, from the **product** alone, whether a polymer was made by addition or condensation. [2]

Solutions

2.1 addition polymerisation.

2.2 condensation polymerisation.

3.1 **A**. One C=C and nothing lost → addition polymerisation.

3.2 **C**. Releasing a small molecule and having ester/amide links shows condensation.

3.3 (a) addition — it has a C=C and nothing is lost.
(b) condensation — two two-group monomers join, losing water → polyester.
(c) condensation — the amino acid has two groups (–NH_2 and –COOH), losing water → polyamide.

3.4 an addition polymer has a saturated C–C backbone with no links (the repeat unit is just the monomer); a condensation polymer has ester or amide links along the chain, which can be hydrolysed back to two monomers.

A-LEVEL CHEMISTRY • EXERCISE SHEET

35.3 Degradable polymers

Name: ____________ Class: ________ Date: __________ **Total: 8 marks**

KEY WORDS biodegradable 可生物降解 • hydrolysis 水解 • poly(alkene) 聚烯烃 • degradable polymers 可降解聚合物 • polyester 聚酯

Objective

Build the skills to answer exam questions on **degradable polymers** 可降解聚合物 — why poly(alkene)s last so long, and why polyesters and polyamides can be broken down.

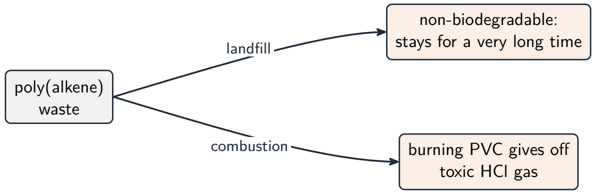
You must be able to:

- explain why poly(alkene)s are hard to biodegrade
- explain why polyesters and polyamides are biodegradable
- describe how hydrolysis breaks the links

1 Worked examples

■ Why some polymers degrade and others do not

PET bottles are a polyester — a condensation polymer whose ester links can be hydrolysed, so it can be broken down and recycled



Degradable polymers break down on disposal

- **poly(alkene)s** (e.g. poly(ethene)): only strong, non-polar C–C and C–H bonds → chemically inert → hard to **biodegrade**, last a long time.
- **polyesters / polyamides:** have **ester** or **amide** links → these can be broken by acidic or alkaline **hydrolysis** → biodegradable.
- some polymers are made **photodegradable** (light breaks them down).

2 Practice

2.1 State why poly(ethene) is hard to biodegrade. [1]

2.2 Name the reaction that breaks the links in a polyester. [1]

3 Exam-style questions

3.1 Poly(alkene)s are hard to biodegrade because they contain only: [1]

- **A** polar ester links
- **B** amide links
- **C** strong, non-polar C–C and C–H bonds
- **D** C=C double bonds

3.2 A polyester can be broken down by: [1]

- **A** addition
- **B** hydrolysis of the ester links
- **C** combustion only
- **D** none of these

3.3 Explain why a polyamide is biodegradable but poly(propene) is not. [3]

3.4 Suggest **one** environmental advantage of replacing a poly(alkene) packaging with a polyester. [1]

Solutions

2.1 it has only strong, non-polar C–C and C–H bonds, which are chemically inert.

2.2 hydrolysis.

3.1 **C**. Only strong, non-polar C–C and C–H bonds — chemically inert.

3.2 **B**. The ester links can be hydrolysed.

3.3 a polyamide has amide links that can be broken by acidic or alkaline hydrolysis; poly(propene) has only inert C–C and C–H bonds with no hydrolysable links; so the polyamide is biodegradable while poly(propene) is not.

3.4 the polyester can be hydrolysed/biodegraded, so it does not persist in the environment as waste.