

7.3 Polymers

Name: _____ Class: _____ Date: _____

Total: 27 marks

KEY WORDS addition polymerisation

• condensation polymerisation

• monomer

Objective

Draw addition polymers and (HT) explain condensation polymerisation and natural polymers. Original questions for spec statements 4.7.3.1–4.7.3.4.

1 Key knowledge and worked examples

Addition polymerisation – alkene **monomers** join into a **polymer**; the **repeating unit keeps the monomer's atoms exactly** – no other product:

ethene ($\text{C}=\text{C}$) $\rightarrow$ poly(ethene) $-\text{C}-\text{C}-\text{C}-\text{C}-$; propene $\rightarrow$ poly(propene).

(HT) Condensation polymerisation – each monomer has **two functional groups**; joining expels a small molecule, usually **water**:

- ethanediol (two $-\text{OH}$) + hexanedioic acid (two $-\text{COOH}$) $\rightarrow$ **polyester**;
- **amino acids** ($-\text{NH}_2$ + $-\text{COOH}$) $\rightarrow$ **polypeptides**; mixed chains $\rightarrow$ **proteins** (glycine $\text{H}_2\text{NCH}_2\text{COOH}$).

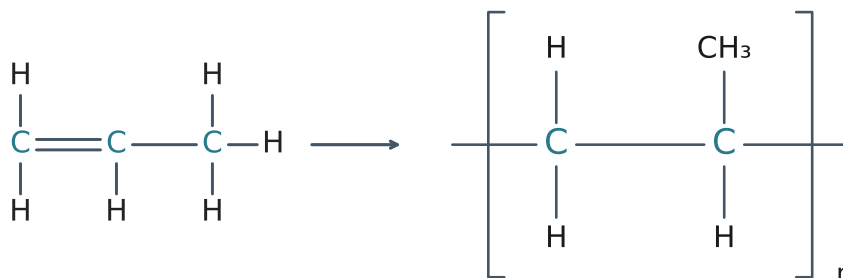
Natural polymers – **DNA**: two chains of four **nucleotides**, **double helix**; **proteins** from amino acids; **starch** and **cellulose** from glucose.

Worked example (2 marks). Why does addition polymerisation form no small by-product?

The double bond simply opens; every monomer atom is incorporated into the chain's repeating unit, so nothing is left over.

Propene monomer

Repeat: methyl side group retained



C_3H_6 per repeat · all atoms retained · no small by-product

HT worked link count. Two diols and two diacids join into one open chain: four molecules need three joining links, releasing three waters. Each molecule can join at both ends because it has two functional groups. A ring would need a different link count.

2 Practice

2.1 What functional group must a monomer have for addition polymerisation? [1]

2.2 Name the polymer formed from propene. [1]

2.3 (*HT*) Name the small molecule lost in condensation polymerisation. [1]

3 Exam-style questions

3.1 Draw the repeating unit of poly(butene), given butene $\text{CH}_2=\text{CH}-\text{CH}_2-\text{CH}_3$. [3]

3.2 (*HT*) Explain how a polyester forms from a diol and a dioic acid, naming the linkage formed. [4]

3.3 Describe DNA's structure and name the monomers of proteins, starch and cellulose. [4]

3.4 A supplied addition polymer has repeating interior $-\text{CH}_2-\text{CHCl}-$. Draw its fully displayed alkene monomer. Explain whether water is released in this polymerisation. [4]

3.5 (*HT*) Five diol and five diacid molecules join into one finite open chain without branches or rings. Count its joining links and water molecules. Explain why both monomers need two functional groups. [4]

3.6 (*HT*) Glycine has formula $\text{H}_2\text{N}-\text{CH}_2-\text{COOH}$. Identify its two different functional groups. Five glycine molecules form one open polypeptide chain, losing one water per link. Given relative masses 75 for glycine and 18 for water, calculate the chain's relative mass. [5]

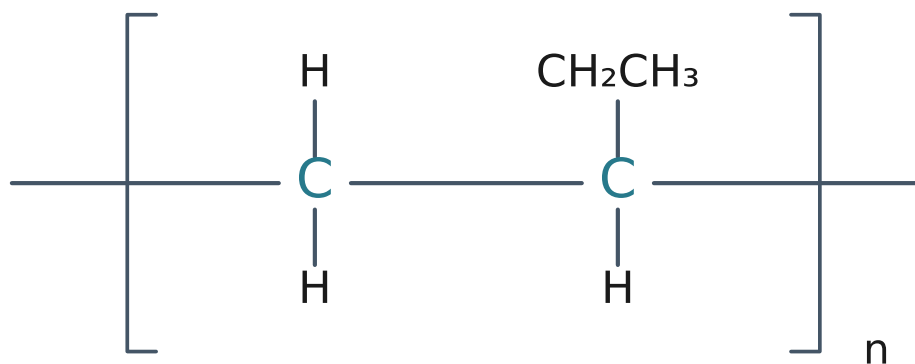
Solutions

2.1 $C=C$, a carbon-carbon double bond.

2.2 Poly(propene).

2.3 Water (usually).

3.1



C_4H_8 per repeat; continuation bonds cross both brackets

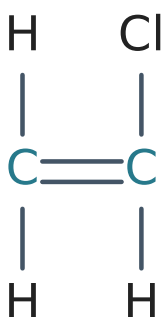
Two backbone carbons; correct H/ethyl side groups and valencies; brackets with continuation bonds and n.

3.2 Each diol molecule has two $-OH$ groups and each acid two $-COOH$ groups; ester links form between an $-OH$ of one monomer and a $-COOH$ of the other; releasing a molecule of water at each link; the alternating chain is a polyester with ester linkages.

3.3 DNA – two polymer chains made of four different nucleotides wound as a double helix; proteins from amino acids; starch and cellulose from glucose.

3.4

$CH_2=CHCl$: restore the double bond



Two $C=C$ carbons; two H on one carbon and one H/one Cl on the other with valid bonds. No water: all monomer atoms are retained by addition polymerisation.

3.5 Ten molecules joined in one open chain make nine links, hence nine water molecules. Two groups let each monomer join at both ends, so chain growth can continue rather than stopping at one isolated ester. The count assumes the stated open chain, not a ring.

3.6 Amino -NH_2 and carboxylic-acid -COOH groups. Five molecules make four links, hence lose four waters.

$$M_r(\text{chain}) = 5M_r(\text{glycine}) - 4M_r(\text{water})$$

$$M_r(\text{chain}) = 5 \times 75 - 4 \times 18 = 303$$

Correct mass subtraction; 303 with no mass unit because this is relative mass.