CIE Chemistry A-Level

Topic 21 - Polymerisation

(A level only)

Flashcards

What is condensation polymerisation?

What is condensation polymerisation?

The joining together of monomers to form a polymer with the release of a small molecule such as water or HCl.

What monomers can be reacted together to form a polyester?

What monomers can be reacted together to form a polyester?

Either:

- A monomer containing two carboxylic acid groups and a monomer containing two alcohol groups.
- A monomer containing both an alcohol and a carboxylic acid group.

Describe the formation of an ester link

Describe the formation of an ester link

A condensation reaction occurs. H^+ is lost from the -OH of an alcohol and OH^- is lost from the -COOH of the carboxylic acid. Water is formed when these ions combine. The organic molecules join.

During the formation of an ester bond, HCl may form instead of water. Why?

During the formation of an ester bond, HCl may form instead of water. Why?

An acyl chloride (-COCl) may be used instead of a carboxylic acid (-COOH) to form an ester bond. The chlorine is lost from an acyl chloride during a condensation reaction which bonds to a hydrogen atom to form hydrogen chloride.

What monomers can be reacted together to form a polyamide?

What monomers can be reacted together to form a polyamide?

Either:

- A monomer containing two carboxylic acid groups and a monomer containing two amine groups.
- Two monomer containing both a carboxylic acid and an amine group.

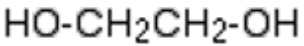
Describe the formation of an amide link

Describe the formation of an amide link

A condensation reaction occurs. H^+ is lost from the $-NH_2$ of an amine and OH^- is lost from the -COOH of the carboxylic acid. Water is formed when these ions combine. The organic molecules join.

The monomers below are used to form Terylene. Draw the structure of this polymer, labelling the type of link formed

benzene-1,4-dicarboxylic acid



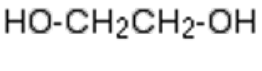
ethane-1,2-diol

Jim Clark, 'Polyesters', Chemguide

The monomers below are used to form Terylene. Draw the structure of this polymer, labelling the type of link formed

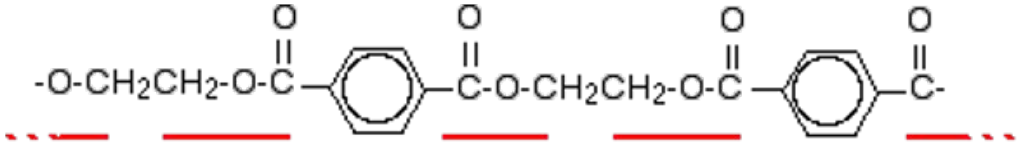
Monomers

benzene-1,4-dicarboxylic acid



ethane-1,2-diol

Polymer



ester linkages

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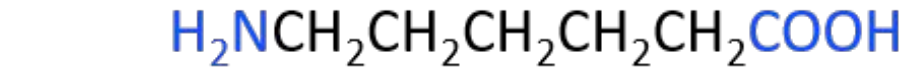
The monomer below is used to form Nylon 6. Draw the structure of the polymer formed

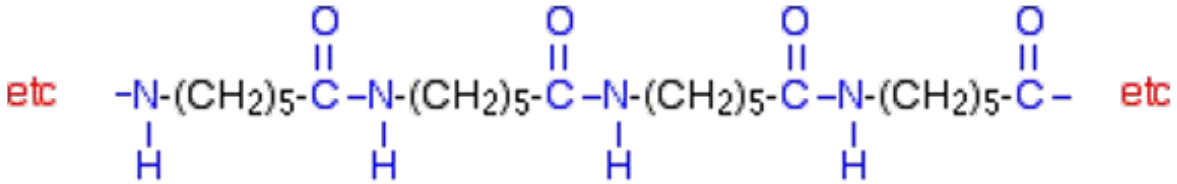
$$H_2NCH_2CH_2CH_2CH_2CH_2COOH$$

The monomer below is used to form Nylon 6. Draw the structure of the polymer formed

Monomer



Polymer



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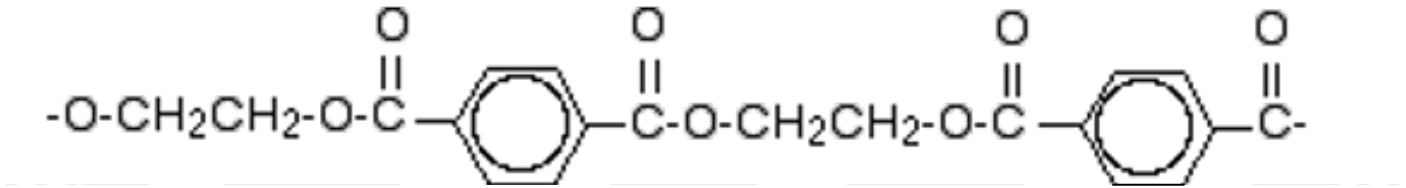
What is a repeat unit?

What is a repeat unit?

A structure that appears in a molecule many times. This may be made up of one monomer or several.

Draw the repeat unit of Terylene (structure shown below)



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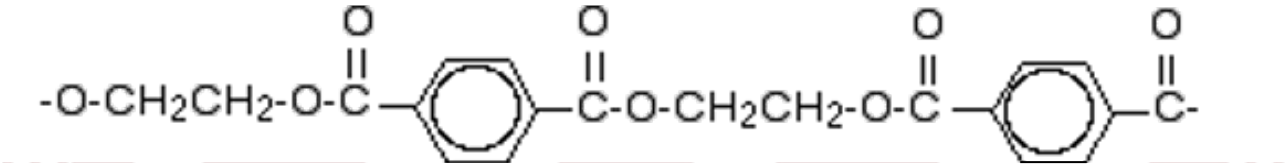
Draw the repeat unit of Terylene (structure shown below)



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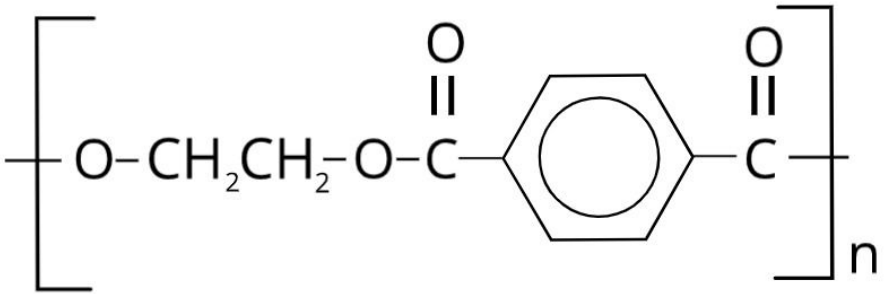
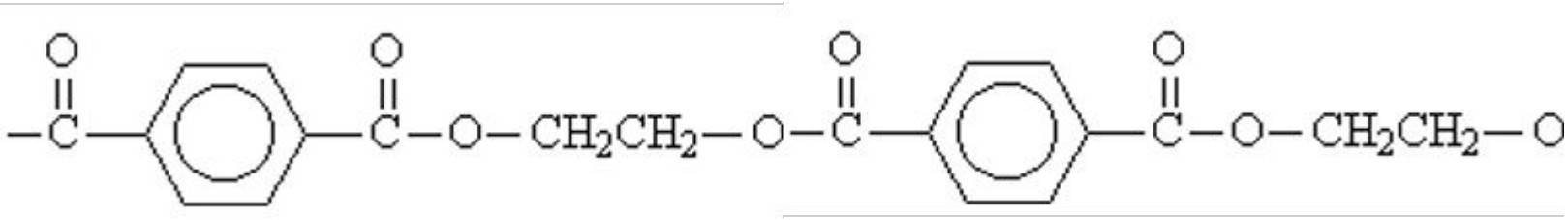


Identify the monomers in the polymer below



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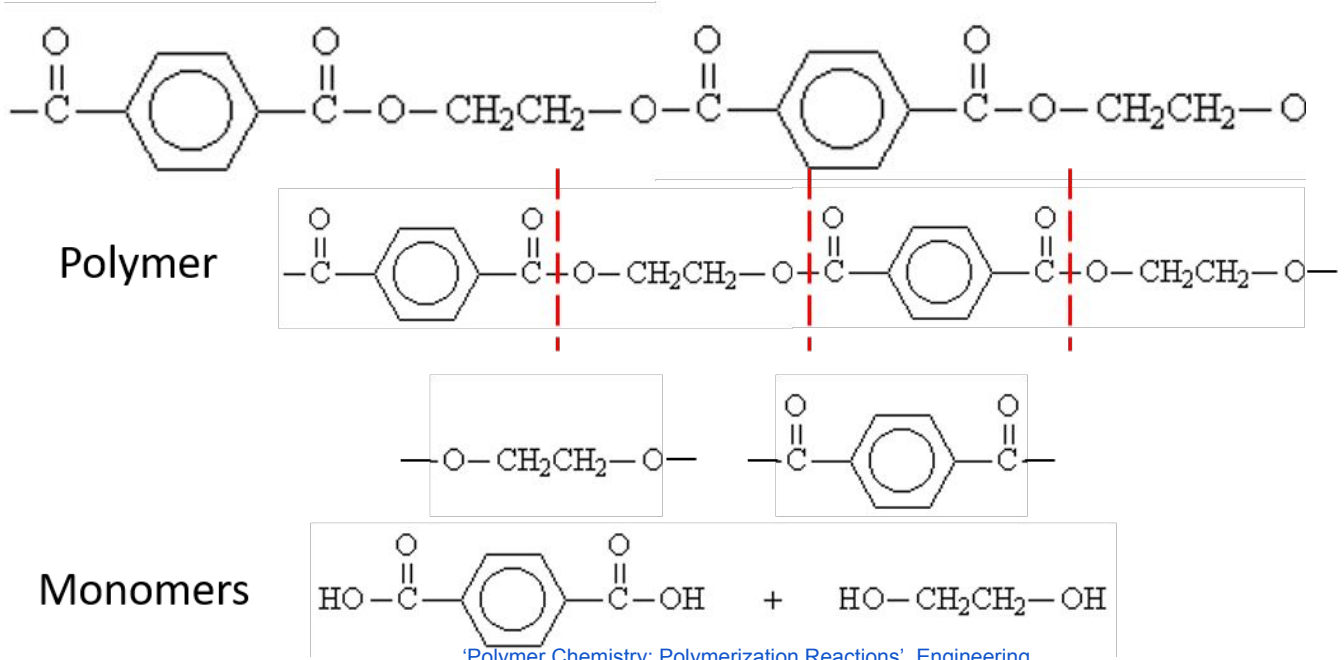

What are the differences between addition polymerisation and condensation polymerisation?

What are the differences between addition polymerisation and condensation polymerisation?

Addition polymerisation	Condensation polymerisation
Monomers contain C=C double bonds.	Monomers contain -OH and -COOH or -COCl for polyesters. Monomers contain -NH_2 and -COOH or -COCl for polyamides.
Main chain of the polymer only contains C-C single bonds.	Main chain contains nitrogen or oxygen atoms as well as carbon atoms.
The polymer is the only product of the reaction.	The polymer and a small molecule like water or HCl are formed during the reaction.

What does thermoplastic mean?

What does thermoplastic mean?

Upon heating, the polymer will soften and eventually melt. This means the polymer can be melted down and reshaped at the end of it its life.

Why are some polymers thermoplastic?

Why are some polymers thermoplastic?

When heated, enough energy is supplied to overcome the intermolecular forces of attraction between the molecules, meaning the chains can move.

What is meant by the term thermosetting?

What is meant by the term thermosetting?

These polymers remain solid when heated.

Why are some polymers thermosetting?

Why are some polymers thermosetting?

The covalent bonds between the polymer chains require a large amount of energy to overcome.

How does the presence of side chains affect the properties of a polymer?

How does the presence of side chains affect the properties of a polymer?

The chains are less able to pack together so the material has a low density. This also means that there are fewer points of contact between molecules so the van der Waals forces are weaker and less energy is needed to overcome them. As a result, the melting and boiling points of branched polymers are lower.

What are the types of intermolecular forces? List them in order from strongest to weakest

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- Hydrogen bonding.
- Permanent dipole-dipole.
- Van der Waals forces.

How do intermolecular forces affect the properties of Teflon (PTFE)?

How do intermolecular forces affect the properties of Teflon (PTFE)?

Although Teflon has relatively weak van der Waals forces, there are no side branches so the molecules pack closely together. As a result, more van der Waals forces form between the chains so the melting point is high as lots of energy is needed to overcome these forces.

How do intermolecular forces affect the properties of kevlar?

How do intermolecular forces affect the properties of kevlar?

Hydrogen bonds form between the strands (between the O in C=O and the H in N-H), causing the molecules to line up in a sheet. This makes the polymer very strong and means the melting point of kevlar is very high as a lot of energy is required to overcome hydrogen bonds.

What monomers make up DNA?

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Nucleotide monomers

What four bases make up the double stranded double helix of DNA?

What four bases make up the double stranded double helix of DNA?

A, C, G and T

What holds the two strands in DNA together?

What holds the two strands in DNA together?

Hydrogen bonds

What is complementary base pairing in DNA?

What is complementary base pairing in DNA?

A always pairs with T and C always pairs with G.

Why does complementary base pairing occur during DNA replication?

Why does complementary base pairing occur during DNA replication?

Complementary base pairing occurs because of the hydrogen bonds that form between the base pairs.

What does complementary base pairing ensure in DNA replication?

What does complementary base pairing ensure in DNA replication?

It ensures that an identical strand of DNA is produced after replication.

Which monomers make up proteins? Draw the general structure of this monomer

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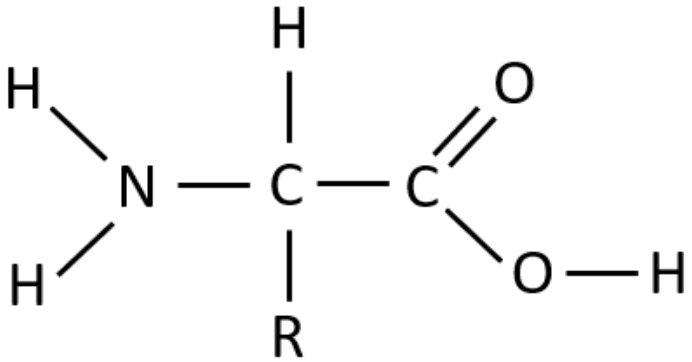
Amino acids



What groups do amino acids contain?

What groups do amino acids contain?

Amine ($-NH_2$) and carboxylic acid ($-COOH$)

Describe the primary, secondary and tertiary structure of a protein

Describe the primary, secondary and tertiary structure of a protein

Primary - sequence of amino acids.

Secondary - hydrogen bonding holds the amino acid chain in an α-helix or β-sheet.

Tertiary - final 3D shape of a protein (inc. primary and secondary), held by interactions between R groups.

What do hydrogen bonds form between as part of the secondary structure of a protein?

What do hydrogen bonds form between as part of the secondary structure of a protein?

Between the lone pair of electrons on oxygen in C=O and the hydrogen in N-H.

Describe an α-helix and a β-sheet

Describe an α-helix and a β-sheet

α-helix - loosely coiled spring.

β-sheet - zig-zag of parallel strands.

What types of interactions are found between R groups in the tertiary structure of a protein?

What types of interactions are found between R groups in the tertiary structure of a protein?

- Ionic bonds
- Hydrogen bonds
- Van der Waals forces (due to temporary dipoles)
- Disulfide bridges

When might disulfide bridges form between the R groups of amino acids in the tertiary structure of a protein?

When might disulfide bridges form between the R groups of amino acids in the tertiary structure of a protein?

The amino acid cysteine contains two -SH groups in its R group. If a hydrogen is lost from the -SH group, covalent bonds will form between the sulfur atoms in the R groups of adjacent cysteines.

How can polymers act as non-solvent based adhesives? Give two examples

How can polymers act as non-solvent based adhesives? Give two examples

Epoxy resins - a cross-linked thermosetting polymer sets into a shape that cannot be changed.

Super glues - water vapour in the air triggers the polymerisation of monomers in the glue.

How can polyacetylene act as a conducting polymer?

How can polyacetylene act as a conducting polymer?

Polyacetylene contains alternating double bonds and single bonds. When a double bond forms, p orbitals overlap sideways. This occurs along the whole chain meaning all the p orbitals overlap to create a delocalised system of electrons. This allows the polymer to conduct electricity.

Why are poly(alkenes) difficult to biodegrade?

Why are poly(alkenes) difficult to biodegrade?

Poly(alkenes) do not biodegrade easily because they are chemically inert.

What happens when certain polymers are exposed to light?

What happens when certain polymers are exposed to light?

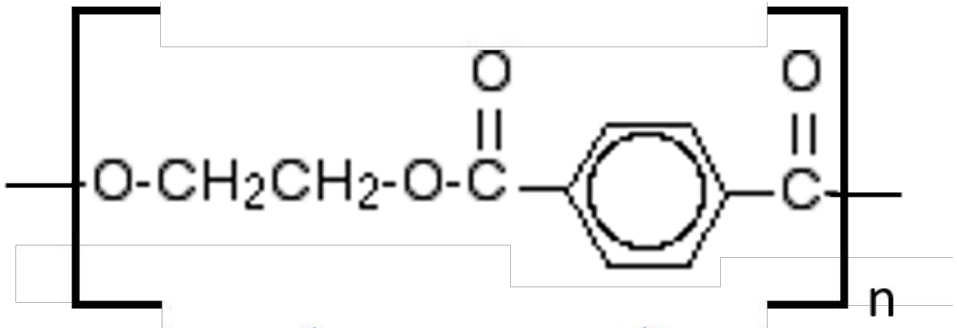
Certain polymers degrade/break down in the presence of light. UV light causes the chains to break so that the material crumbles.

How can polyesters and polyamides be biodegraded?

How can polyesters and polyamides be biodegraded?

By undergoing hydrolysis

Draw the structures of the products that form when the polyester below undergoes acid and base hydrolysis



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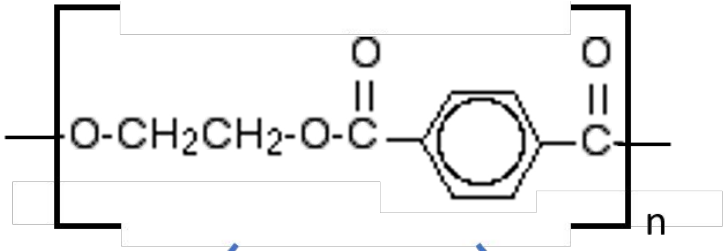
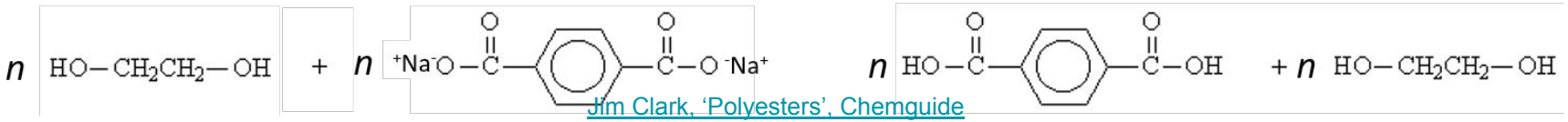


NaOH/ H_2O
Base hydrolysis

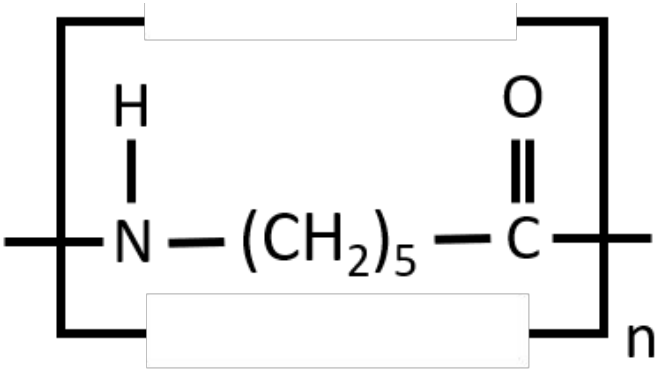
H^+/ H_2O
Acid hydrolysis



Jim Clark, 'Polyesters', Chemguide

'Polymer Chemistry: Polymerization Reactions', Engineering LibreTexts

Draw the structures of the products that form when the polyamide below undergoes acid and base hydrolysis



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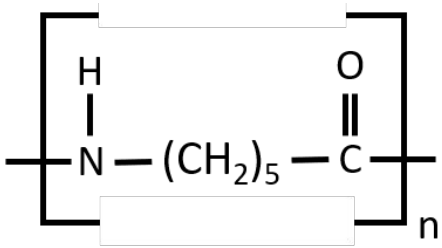

NaOH/ H_2O
Base hydrolysis

H^+/ H_2O
Acid hydrolysis

n $H_2NCH_2CH_2CH_2CH_2CH_2COO^-Na^+$

n $H_3\overset{+}{N}CH_2CH_2CH_2CH_2CH_2COOH$

Describe how proteins can be hydrolysed using acid

Describe how proteins can be hydrolysed using acid

Either:

- Heat the protein at 110°C with 6 mol dm^{-3} HCl for 8 hours (slow method).
- Place the protein in a sealed tube containing 6 mol dm^{-3} HCl and an atmosphere of nitrogen. Place in the microwave for 5-30 minutes (dependant on protein) using temperatures up to 200° C (fast method for small samples during analysis).

Draw the general structure of the product when a protein undergoes acid hydrolysis

Draw the general structure of the product when a protein undergoes acid hydrolysis

Amino acids are formed. As the amino acids are in an acidic solution, $-NH_2$ accepts a proton.