AQA Chemistry A-level

Topic 3.13 - Amino Acids, Proteins and DNA

Flashcards

What are the two functional groups of amino acids?

What are the two functional groups of amino acids?

NH_2 and COOH (amine and carboxylic acid)

How many naturally occurring amino acids are there in the body?

How many naturally occurring amino acids are there in the body?

20

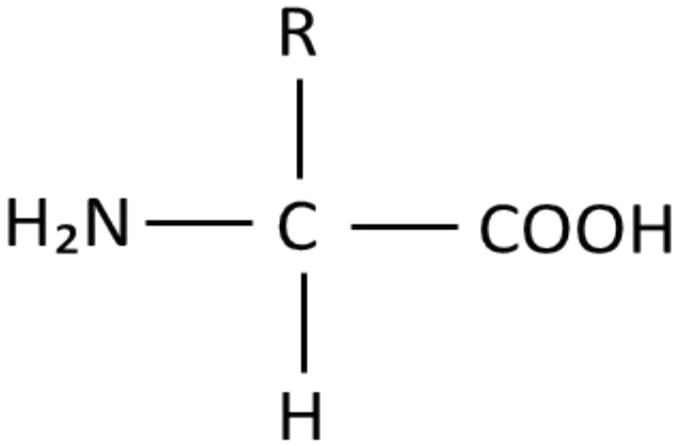
What type of amino acids are found in the body? What does this mean about their structure?

What type of amino acids are found in the body? What does this mean about their structure?

α-amino acids (alpha) It means that NH_2 is always on the carbon next to COOH

Draw a general formula for α-amino acids

Draw a general formula for α-amino acids



Are α-amino acids chiral? Why?

Are α-amino acids chiral? Why?

Yes, one carbon has 4 different substituents.

Except glycine, where R = H.

Which enantiomer do α-amino acids exist as in nature?

Which enantiomer do α-amino acids exist as in nature?

(-) enantiomer

How can amino acids be synthesised industrially?

How can amino acids be synthesised industrially?

$RCHO + NH_4CN \rightarrow RCH(NH_2)CN$ via nucleophilic addition.

$RCH(NH_2)CN + HCl + 2H_2O \rightarrow RCH(NH_2)COOH + NH_4Cl$

(hydrolysis, HCl is dilute) Need to reflux the reaction mixture

Is the product from amino acids being synthesised naturally optically active? Why?

Is the product from amino acids being synthesised naturally optically active? Why?

No, a racemic mixture is formed as the CN^- ion can attack from above or below the planar C=O bond with equal likelihood. An equal amount of each enantiomer is formed, so no net effect on plane polarised light.

In what form do amino acids exist as solids? What consequences does this have?

In what form do amino acids exist as solids? What consequences does this have?

Zwitterions (ionic lattice) - high melting and boiling points

What colour solids are most zwitterions at room temperature?

What colour solids are most zwitterions at room temperature?

White solids

Do zwitterions dissolve in water? Non-polar solvents? Why?

Do zwitterions dissolve in water? Non-polar solvents? Why?

Yes, but not in non-polar solvents. Due to ionic nature/polar bonds.

Define a zwitterion

Define a zwitterion

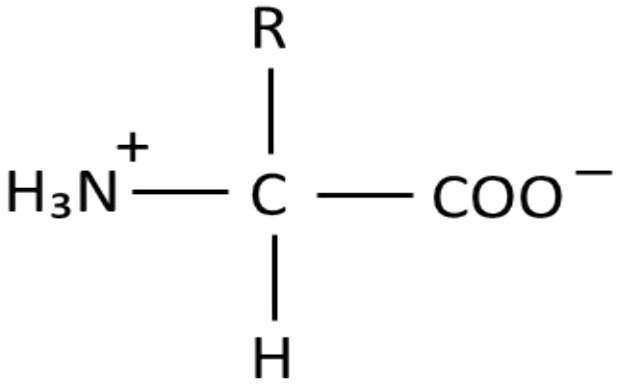
Ions which have both a permanent positive and negative charge, but are neutral overall.

How do zwitterions occur in amino acids? Draw a general structure of one

How do zwitterions occur in amino acids? Draw a general structure of one

COOH is deprotonated → COO^-

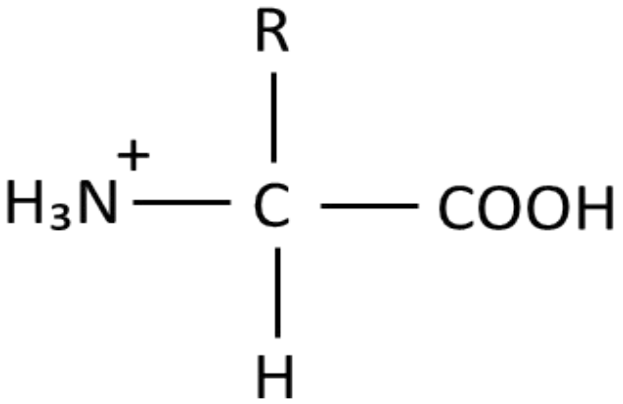
NH_2 is protonated → NH_3^+



What happens to amino acids in acidic conditions? Draw this.

What happens to amino acids in acidic conditions? Draw this.

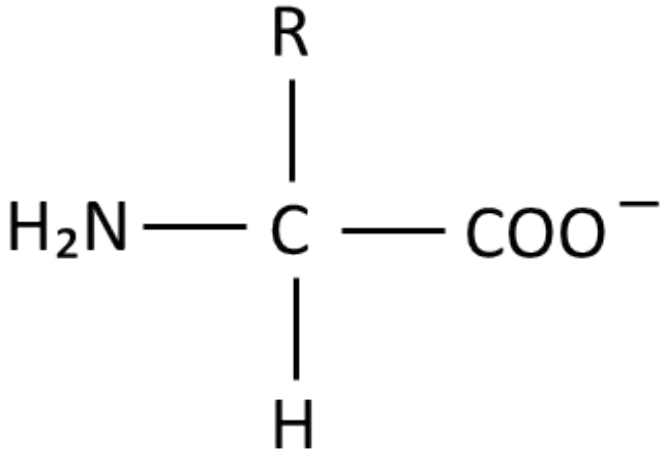
Gains a proton on NH_2 group



What happens to amino acids in alkaline conditions? Draw this.

What happens to amino acids in alkaline conditions? Draw this.

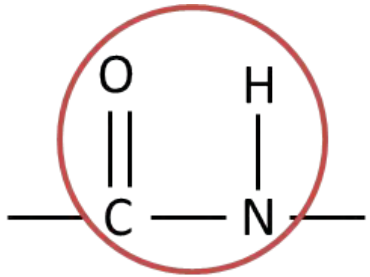
Loses a proton from COOH group



What is the peptide linkage?

What is the peptide linkage?

-CONH-

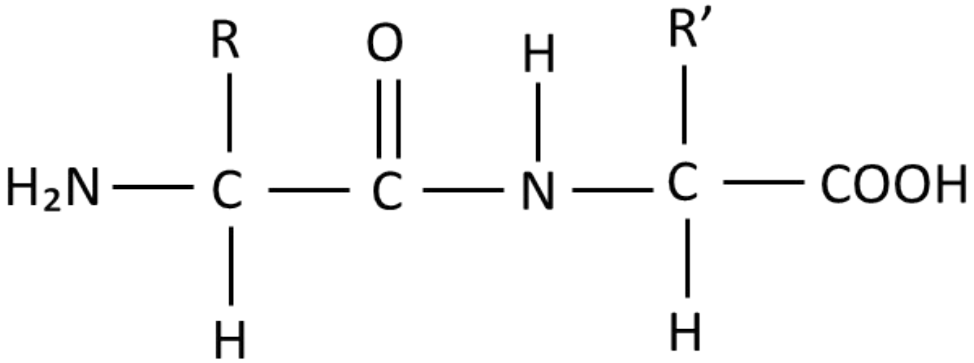


The peptide linkage

What is a dipeptide? Draw a general one for amino acids.

What is a dipeptide? Draw a general one for amino acids.

Two amino acids bonded together (a dimer)



What name is given to chains of amino acids up to 50 amino acids?

What name is given to chains of amino acids up to 50 amino acids?

Polypeptides

What name is given to chains of amino acids with more than 50?

What name is given to chains of amino acids with more than 50?

Proteins

What are polypeptides and proteins found in?

What are polypeptides and proteins found in?

Enzymes

Wool

Hair

Muscles

What is the process called by which polypeptides or proteins can be broken down into their constituent amino acids?

What is the process called by which polypeptides or proteins can be broken down into their constituent amino acids?

hydrolysis

What conditions are needed for hydrolysis to occur?

What conditions are needed for hydrolysis to occur?

6 mol dm^{-3} HCl, reflux for 24 hours

What is the primary structure of a protein? How is it bonded?

What is the primary structure of a protein? How is it bonded?

The sequence of amino acids along the protein chain. Bonded by covalent bonds

How is the primary structure represented?

How is the primary structure represented?

Sequence of 3 letter abbreviations of the amino acids

How can the primary structure of a protein be broken up?

How can the primary structure of a protein be broken up?

Hydrolysis, 6M HCl, 24 hour reflux

What is the secondary structure of a protein?

What is the secondary structure of a protein?

The shape of the protein chain

What are the two options for the secondary structure?

What are the two options for the secondary structure?

Alpha-helix shape or beta-pleated sheets

How is the secondary structure held together?

How is the secondary structure held together?

Hydrogen bonding, e.g. between C=O and N-H groups

What is the tertiary shape of a protein?

What is the tertiary shape of a protein?

Alpha-helix or beta-pleated sheet is folded into a complex 3D shape; this is the tertiary structure

How is the tertiary structure held together?

How is the tertiary structure held together?

Hydrogen bonding

ionic interactions between R groups

sulfur-sulfur bonding (disulfide bridges)

van der Waals forces of attraction

Why is the tertiary structure important?

Why is the tertiary structure important?

The shape of protein molecules is vital in their function - e.g. for enzymes

How can amino acids bond/be attracted to each other? (3 main ways)

How can amino acids bond/be attracted to each other? (3 main ways)

Hydrogen bonding

Ionic interactions between groups on side chains

Sulfur-sulfur bonds/disulfide bridges; 2 S atoms oxidised to form an S-S bond

What is wool? How is it held together?

What is wool? How is it held together?

Protein fibre with secondary alpha-helix structure; held together by hydrogen bonds

What does wool's structure and bonding mean for wool's properties?

What does wool's structure and bonding mean for wool's properties?

Can be stretched, H bonds extend.

Release it and it returns to its original shape

Wash too hot and H bonds permanently break so garment loses its shape.

What is a TLC plate made of?

What is a TLC plate made of?

Plastic sheet coated with silica, SiO_2. This is the stationary phase. (The solvent is the mobile phase)

Describe how you would carry out Thin Layer Chromatography

Describe how you would carry out Thin Layer Chromatography

Spot the samples onto a pencil line a few cm above the base of the TLC plate.

Place this in a beaker or tank, with solvent level below the pencil line. Ensure there is a lid on the beaker to keep the inside saturated with solvent vapour.

Wait until the solvent front is almost at the top of the TLC plate; then remove from the beaker and analyse.

Why does TLC separate amino acids (or other molecules)?

Why does TLC separate amino acids (or other molecules)?

Solvent carries amino acids up the TLC plate. The rate of movement depends on the balance between that amino acid's affinity for the solvent (solubility in it) and affinity for the stationary phase (attraction to the silicon with hydrogen bonding).

What do you often have to do to enable the amino acids to be seen on the chromatogram?

What do you often have to do to enable the amino acids to be seen on the chromatogram?

Spray with ninhydrin (amino acids are colourless, ninhydrin turns their spots purple)

Or shine UV light on them

How do you calculate an R_f value?

How do you calculate an R_f value?

Distance moved by that substance divided by the distance moved by the solvent front

How can R_f values verify which amino acid is which?

How can R_f values verify which amino acid is which?

Compare the experimental R_f values to known/accepted values in the same solvent.

Or run pure amino acids in the same solvent and compare results to identify amino acids

What is 2D TLC?

What is 2D TLC?

Uses a square TLC plate. Spot the amino acids in one corner, then run TLC in first solvent. Flip the plate through 90º and repeat TLC in a second, different solvent.

What are the benefits of 2D TLC (2 main ones)?

What are the benefits of 2D TLC (2 main ones)?

Separates the spots more - it is extremely unlikely that 2 amino acids will have identical R_f values in 2 solvents.

Gives you 2 R_f values for each amino acids; you can be more confident in verifying the identity of the amino acids when comparing to known values, as 2 R_f values can be verified

How do you find the primary structure of a protein?

How do you find the primary structure of a protein?

Reflux with 6M HCl and reflux for 24 hours

Carry out TLC to find the number and type of amino acids present.

How do you find the secondary and/or tertiary structure of a protein?

How do you find the secondary and/or tertiary structure of a protein?

Various techniques, e.g. X-Ray Diffraction

What is an enzyme?

What is an enzyme?

Protein based catalysts that speed up reactions in the body by factors of up to 10^{10}.

How many reactions is each enzyme designed to catalyse?

How many reactions is each enzyme designed to catalyse?

One reaction - they are very specialised

What is the structure of an enzyme?

What is the structure of an enzyme?

Globular protein with a creft/crevice in it, known as an “active site”. Very particular shape

How does its structure help the function of the enzyme? What is this hypothesis known as?

How does its structure help the function of the enzyme? What is this hypothesis known as?

The reacting molecules fit precisely into the active site and are held at exactly the right orientation to react. This is the lock and key hypothesis

How else do enzymes increase the rate of reaction?

How else do enzymes increase the rate of reaction?

Reacting molecules form temporary bonds (via intermolecular forces) to the enzyme. This weakens the bonds in the molecules, promotes electron movement and lowers E_A

What does the stereospecificity of enzymes mean?

What does the stereospecificity of enzymes mean?

Active sites are so selective of the shape of substrates that only reactions involving one enantiomer are catalysed.

What does stereospecificity mean for most naturally occurring molecules?

What does stereospecificity mean for most naturally occurring molecules?

Most naturally occurring molecules only occur as one enantiomer due to stereospecific enzymes

How are enzymes denatured?

How are enzymes denatured?

Change in temperature or pH

How does enzyme inhibition work?

How does enzyme inhibition work?

A molecule with a very similar shape and structure to the substrate is devised. Binds to the enzyme's active site. Blocks the active site (does not desorb easily). Substrate cannot adsorb to the active site, so reaction cannot be catalysed

An example of a drug that works through enzyme inhibition?

An example of a drug that works through enzyme inhibition?

Penicillin

What are the benefits of modelling new molecules on computers?

What are the benefits of modelling new molecules on computers?

Now we understand factors that affect the shapes of extremely complex proteins, we can model drugs that haven't even been synthesised, predict their properties and design drugs that will treat a range of medical conditions

What does DNA stand for?

What does DNA stand for?

Deoxyribonucleic acid

What does DNA do?

What does DNA do?

It is present in all cells and is a blueprint from which all organisms are made

What structure does DNA take?

What structure does DNA take?

A polymer with 4 monomers; they can be combined differently

What constitutes a nucleotide?

What constitutes a nucleotide?

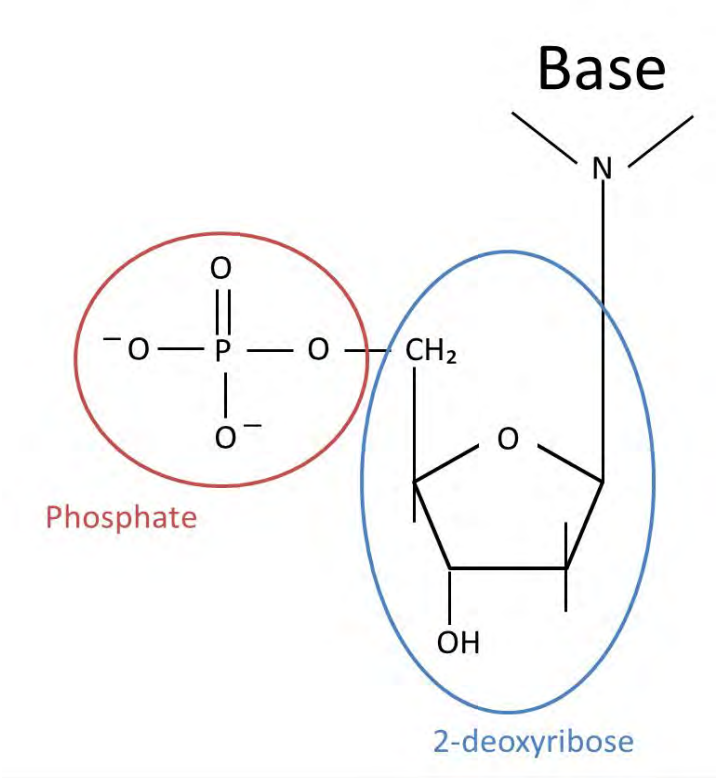
A phosphate ion

a sugar (2-deoxyribose)

a base (A (adenine), C (cytosine), G (guanine), T (thymine))

Draw a nucleotide.

Draw a nucleotide.



What forms between bases of adjacent nucleotides?

What forms between bases of adjacent nucleotides?

Hydrogen bonding

Which bases pair up between nucleotides?

Which bases pair up between nucleotides?

Adenine with Thymine (A and T)

Guanine with Cytosine (C and G)

How does DNA polymerise?

How does DNA polymerise?

OH on phosphate group and OH on number 3 carbon of 2-deoxyribose react to eliminate a molecule of H_2O

What kind of polymer does the polymerisation of DNA lead to?

What kind of polymer does the polymerisation of DNA lead to?

Condensation polymer chain → backbone of phosphate and sugar molecules, with bases attached

What defines the properties of the DNA molecule?

What defines the properties of the DNA molecule?

The order of the bases

Why does DNA have a double helix shape?

Why does DNA have a double helix shape?

Exists as 2 strands; these 2 strands are held together by hydrogen bonding (C and G and A and T). The complementary DNA molecule has bases that hydrogen bond in the same order to those on another molecule → double helix shape is formed

Why is it important that DNA is exactly copied when cells divide?

Why is it important that DNA is exactly copied when cells divide?

Because it codes for proteins and makes all cells

How is DNA is exactly copied when cells divide?

How is DNA is exactly copied when cells divide?

Hydrogen bonds between base pairs break. Covalent bonds in polymer chains remain intact. The sequence of bases is maintained. Separate nucleotide molecules that have been created move to hydrogen bond to their relevant bases. They polymerise. Thus, DNA is replicated exactly.

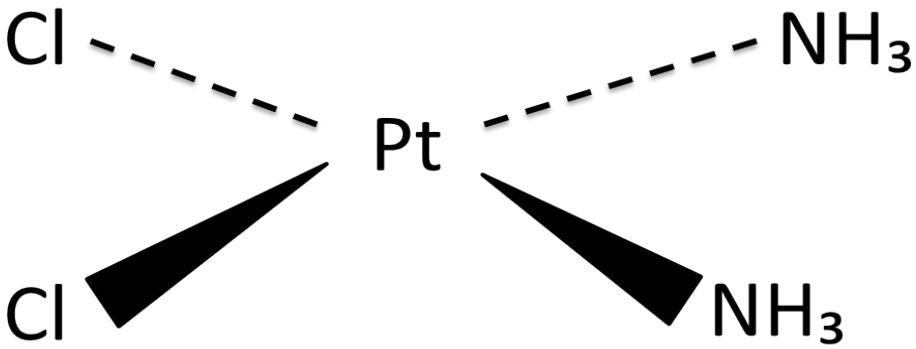
How does the body use information that is stored in DNA?

How does the body use information that is stored in DNA?

Template for arranging amino acids into protein chains → codes for proteins. “Recipe” for proteins that make up all living things; enzymes, flesh etc

Draw the structure of cisplatin

Draw the structure of cisplatin



What is cisplatin's function? How does it do this?

What is cisplatin's function? How does it do this?

Anti-cancer drug

Bonds to strands of DNA to distort shape and prevent cell replication. It bonds to the N (nitrogen) atoms on 2 adjacent G bases. The N atoms replace the Cl^- ligands in a ligand substitution reaction.

Why are Cl^- ions able to be replaced by N on the base?

Why are Cl^- ions able to be replaced by N on the base?

N atoms on the G base have lone pairs of electrons that can co-ordinately bond to the Pt ion; N atoms are better ligands than Cl^-, so replace them

What are the drawbacks of using cisplatin?

What are the drawbacks of using cisplatin?

Affects healthy cells that are replicating quickly, e.g. hair follicles → lose hair during chemotherapy

Thought to damage kidneys

What happens when excess bromomethane is added to an amino acid?

What happens when excess bromomethane is added to an amino acid?

CH_3Br is in excess, so every H on the N atom and the lone pair on the N atom is replaced by a CH_3 group → quaternary ammonium ion. (makes a salt with Br^-)

What happens if an amino acid is added to an excess of methanol in the presence of concentration sulfuric acid?

What happens if an amino acid is added to an excess of methanol in the presence of concentration sulfuric acid?

Methyl ester forms with COOH group → $COOCH_3$

NH_2 is protonated by the acid → NH_3^+