WJEC Chemistry A-level

4.7: Amino Acids, Peptides and Proteins

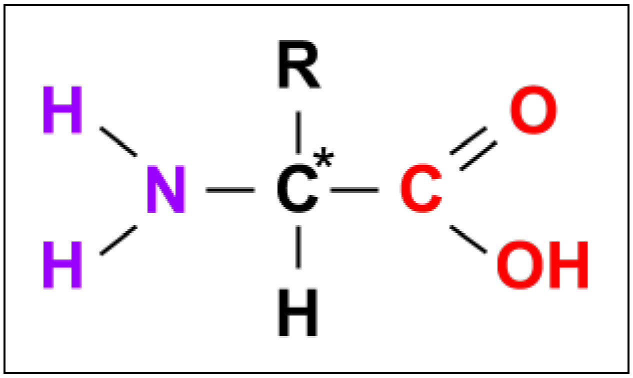
Detailed Notes

Welsh Specification

Amino Acids

An amino acid is a compound containing both an **amine group** and a **carboxylic acid group**. For **α-amino acids** the amine group is always on the **second carbon** in the chain.

Example:

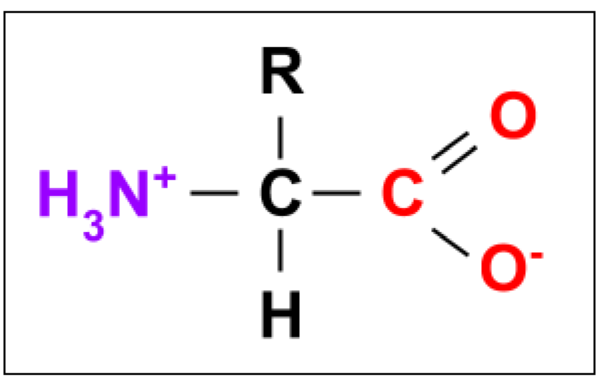


This second carbon is often **chiral** as it has four different groups bonded to it. Therefore, the majority of amino acids exist as **optical isomers**. In fact, the only **α-amino acid** which is not chiral is **aminoethanoic acid** since it has a hydrogen atom as the R group.

Zwitterions

The two functional groups within a single molecule means that amino acids can **react as both acids (carboxylic acid group) and bases (amine group)** depending on the conditions of the reaction. This means zwitterions are **amphoteric**.

A **zwitterion** of an amino acid forms when the average overall charge on the molecule is **zero**. This point is known as the **isoelectric point**. The molecule displays both **charged parts** of the molecule since both the **carboxyl group** and **amino group** are ionised:

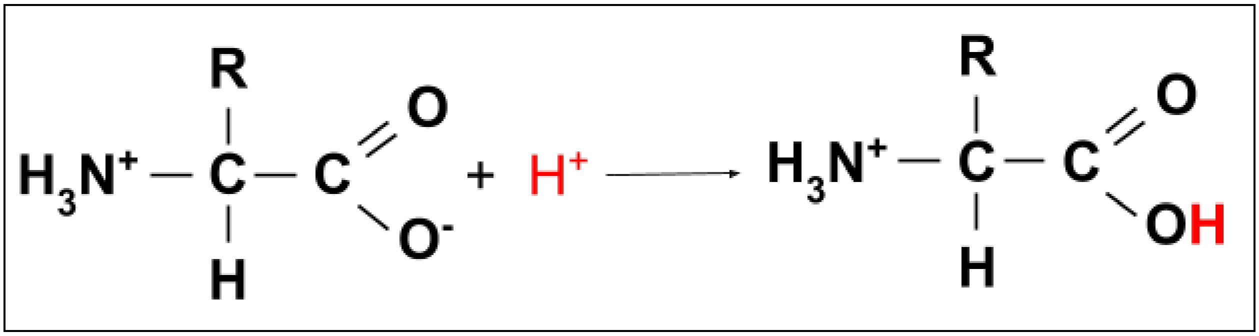


Amphoteric Nature

The ability of amino acids to act as both acids and bases is known as **amphoteric nature**. The **conditions** of a reaction can be changed to ensure the amino acid reacts in a certain way.

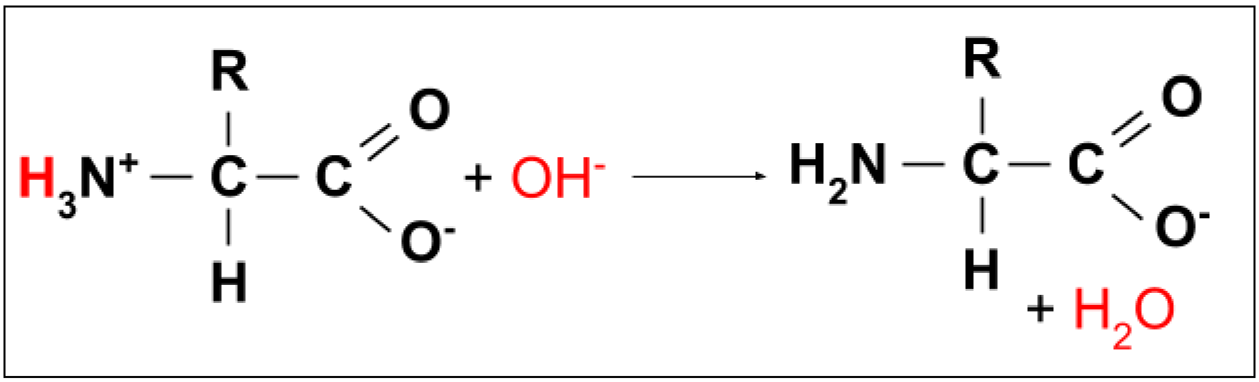
Acidic Conditions

In solutions with a **low pH**, the lone electron pair on oxygen is likely to **accept a hydrogen** atom, producing a molecule with a **positive** overall charge.



Basic Conditions

In solutions with a **high pH**, the hydrogen atom on the NH_3^+ group is likely to be **lost**, producing a molecule with a **negative** overall charge.



Properties of Amino Acids

Melting temperature

Amino acids have relatively **high melting temperatures**. This is because, in the solid state, the **zwitterion** is the usual form that an amino acid exists in. Due to the charges on the zwitterions, strong **ionic attractions** form between neighbouring zwitterions in the solid. Therefore, a **large amount of energy** is required to **break** the ionic attractions and melt the amino acid.

Solubility

Amino acids are generally **soluble in water** because **strong ionic attractions** form between the zwitterions and the **polar water** molecules.

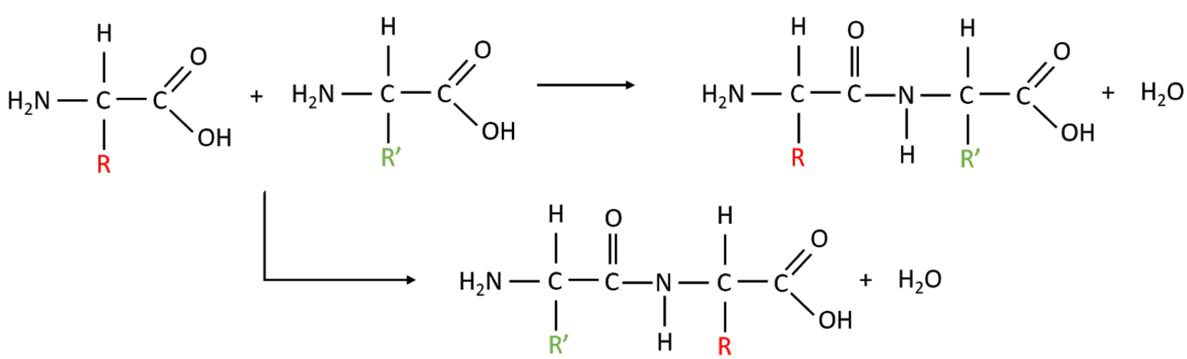
Amino acids are generally **not very soluble** in **non-polar organic solvents**. This is because there is a **lack of attraction** between the amino acid zwitterions and solvent molecules so there is **insufficient energy** to break the ionic lattice.

Peptides

Dipeptides

Dipeptides are formed when **two α-amino acids** react together in a **condensation** reaction. The link bond between the two amino acids is known as the **peptide linkage** or bond. The dipeptide will still have an **amine group** at one end of the molecule and a **carboxyl group** at the other end. In the following example, you can see that, depending on the order of how the two amino acids join, **two different dipeptides** can be produced.

Example:



Polypeptides

These molecules are just the same as dipeptides, however they are formed from more than two **amino acids**. Proteins are formed from polypeptides, once the polypeptide chain becomes **very long**.

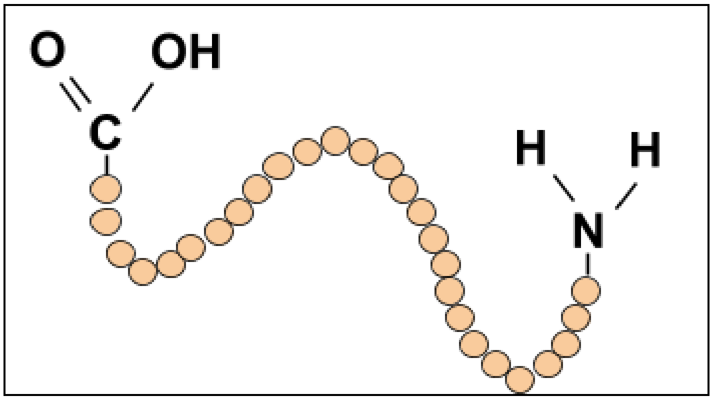
Proteins

Proteins are **sequences of amino acids** connected by **peptide links**.
Proteins have **complex structures** which are often broken down into the **primary** structure, **secondary** structure and **tertiary** structure.

Primary Structures

The primary structure of a protein is the **sequence of amino acids** which make up the protein chain. This is the simplest protein structure, consisting of a **single polypeptide chain** of amino acids joined together with **peptide links**.

Example:



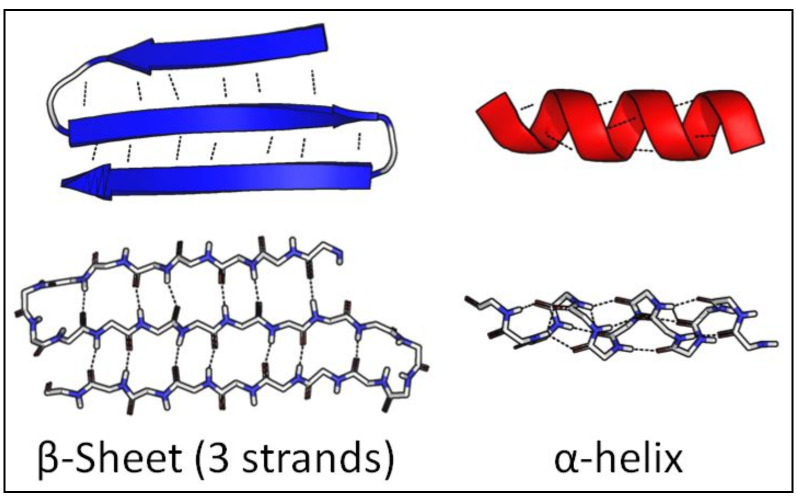
Secondary Structures

The secondary structure relates to how the protein chain has peptide links which can form **hydrogen bonds** with each other. This leads to two possible shapes of the chain:

- **α-helix spiral**, held in place by hydrogen bonds
- **β-pleated sheet** where the amino acids form a shape which is stabilised by hydrogen bonds between amino acids in different polypeptide chains

The secondary structure starts to give proteins a more **3D** structure.

Example:



(https://commons.wikimedia.org/wiki/File:Alpha_beta_structure_(full).png)

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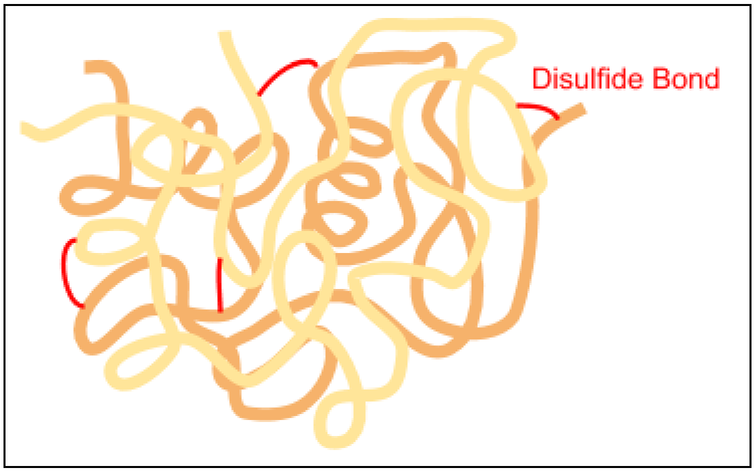
Tertiary Structures

The tertiary structure relates to the **extra bonds** which can form between different parts of the polypeptide chain, determining how the **α-coils** or **β-pleated sheets** of the protein **fold** with respect to each other. The types of extra bonds include **ionic** and **hydrogen bonds** and **disulphide bridges**.

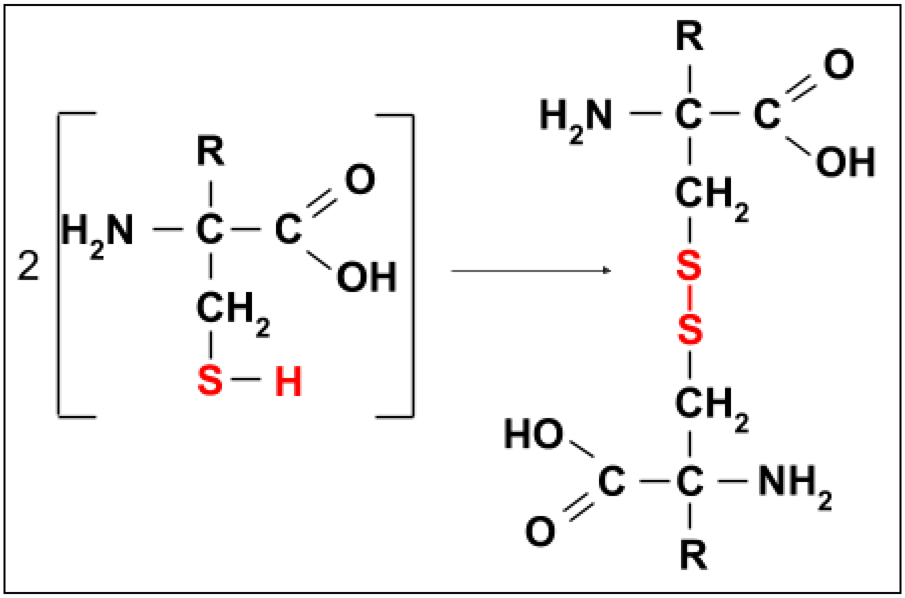
Example:



Disulfide Bonding

The **sulfur-sulfur bonds** that hold together **tertiary structures** are known as a **disulfide bridge**. They keep the protein structure stable by **losing two hydrogen ions**, producing a bond between the sulfide ions.

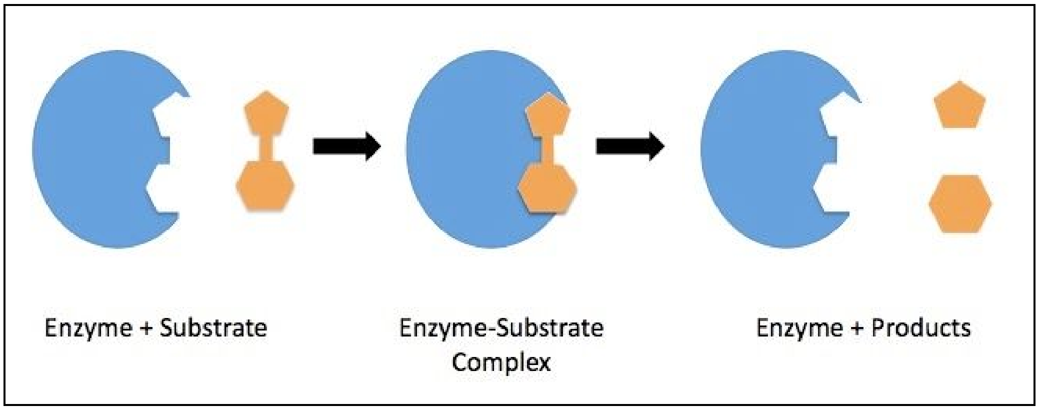
Example: This shows how disulfide bridges can form between two amino acids. The same idea can be transferred to proteins.



Enzymes

Enzymes are proteins that act as **biological catalysts**. Their **3D structure** contains **active sites** which are specific to a certain molecule that they break down, called a **substrate**.

Example:



(https://commons.wikimedia.org/wiki/File:Enzyme_mechanism_1.jpg)
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Enzymes are **stereospecific**, meaning they can only break down a **single enantiomer** of a substrate and will have no effect on the other optical isomer.