

WJEC Chemistry A-Level

OA3.2: Amino Acids, Peptides and Proteins

Detailed Notes English Specification

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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:



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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:







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.



(c)



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) Aejahnke / CC BY-SA 3.0

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.

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