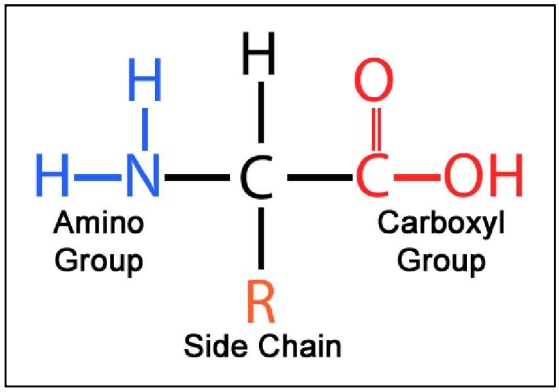
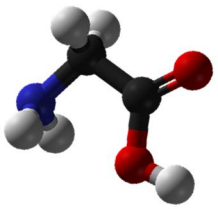
TC6 - Amino Acids

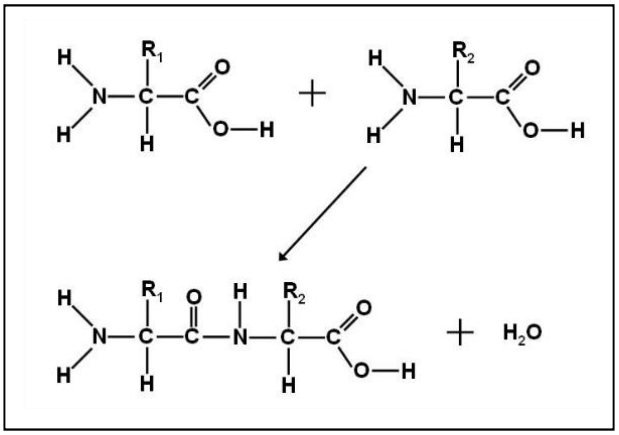


An amino acid is a compound that contains two functional groups; an **amino** group ($-NH_2$), a **carboxylic acid** group (-COOH) and a **side** chain (-R). The structure of each amino acid is the same except for the R group – it can be a variety of different things depending on which amino acid it is.

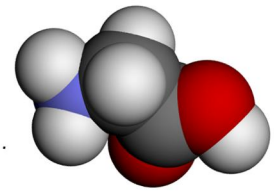


There are 20 different amino acids, the simplest one being **glycine** where the R group is a single hydrogen.

When amino acids react together, they form a **peptide bond** between the carbon atom in the carboxyl group on one amino acid and the nitrogen atom in the amino group on the other amino acid. This forms a **dipeptide molecule** (2 bonded amino acids) and a water molecule, in a **condensation reaction**. This reaction is **reversible**, and to break the peptide bond a **hydrolysis reaction** (the addition of water) must take place.



A long chain of amino acids is known as a **polypeptide**, or a **protein**. The sequence of amino acids is different for individual proteins, this is how we can tell them apart.



Amino acids are chiral molecules because they have a carbon atom with 4 different functional groups bound. This means they each have optical isomers and lack a plane of symmetry. Each isomer is a non-superimposable mirror image of the other. A solution of a single amino acid enantiomer will rotate plane polarised light.

The only amino acid which isn't chiral is glycine, because it has two H atoms bound to the central carbon.

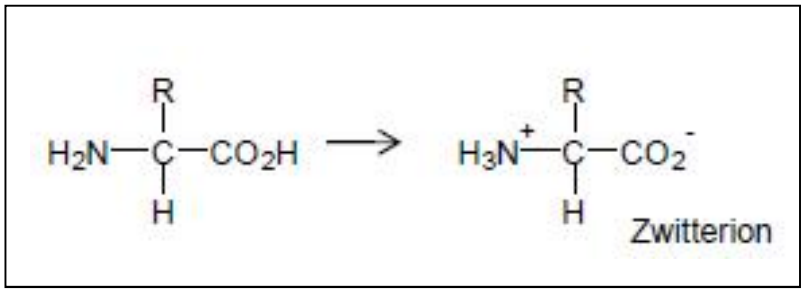
Produced by Olivia Turnbull at Newcastle University as part of a Nuffield Research Placement

Zwitterions:

Amino acids are **amphoteric** – meaning that they've got both acidic and basic chemical properties. The carboxyl group is **acidic**, allowing them to act as an acid, by donating a proton. Whereas, they can act as a base as the amino group is **basic**, so it can accept a proton.

An amino acid can exist as a **zwitterion**, a **dipolar ion**, consisting of both a positive and negative charge.

An amino acid can only become a zwitterion when its amino group is **protonated** and the carboxyl group is **deprotonated** so that the ion has both a positive and negative charge and an overall charge of zero. This is an amino acid's **isolectric point**, the pH where the overall charge on the ion is zero.



However, if the conditions are changed it will have an effect on the amino acid:

In conditions that are more acidic than the isoelectric point, the pH of the solution is lower. This means that there will be an excess of hydrogen ions, causing the negative carboxyl group of the zwitterion to pick up a hydrogen ion. The carboxyl group will no longer be negative and the amino acid will no longer be a zwitterion, it will be a **positive ion** as only the amino group is charged.

Increasing the pH of a solution of an amino acid to above the isoelectric point by adding hydroxide ions will create more alkaline conditions. The amino group of the amino acid will lose a hydrogen ion to bind with the hydroxide ion, forming a water molecule. By doing this, the carboxyl group will remain unchanged and the amino acid will no longer be a zwitterion, it will be a **negative ion**.

A zwitterion will only be formed if the conditions of a solution of an amino acid are at or near the isoelectric point. This is different for each amino acid as it all depends on the 'R' group of the amino acid.

Naming Amino Acids

Amino acids are named using the IUPAC organic naming system.

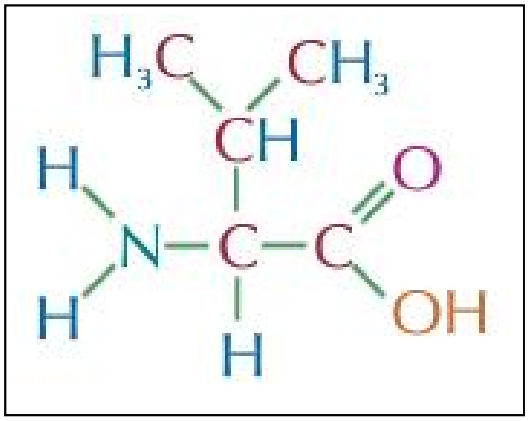
Steps to naming an amino acid:

1. Find the **longest** carbon chain, including the carboxyl carbon.
2. Starting with the carbon atom in the carboxyl group, number the carbon atoms in the chain.
3. Write down the **position** of any amino groups at the beginning of the name (e.g. 2-amino-…)
4. Write down the position and names of any **functional groups** in the compound.

Top Tip:

When working out the longest carbon chain in an amino acid, always count the carbon atom in the carboxyl group as your first carbon.

For example, the common name for this amino acid is valine. However, its systematic name is different.



The longest carbon chain is four carbon atoms long (…-butanoic acid)

The amino group is on the second carbon atom (2-amino-…)

There is also a methyl group on the third carbon atom (…-3-methyl-…)

The systematic name of this amino acid will be:

2-amino-3-methyl-butanoic acid

Recall Questions:

1. Which reaction is required to form a peptide bond?
2. Explain why amino acids are said to be amphoteric.
3. Name this amino acid.