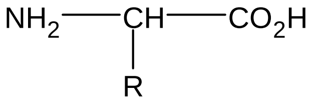
6.2.2 Amino Acids and Chirality

The simplest amino acid is glycine, where the R is an H $NH_2—CH_2—CO_2H$

General structure of an α amino acid

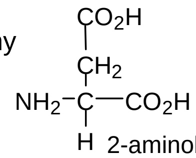


The R group can be a variety of different things depending on what amino acid it is.

The alpha in '**α**' amino acid means both NH_2 and COOH groups are joined to the same C.

Naming amino acids

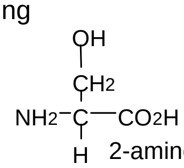
You do not need to know any common names for the 20 essential amino acids. We should, however, be able to name given amino acids using IUPAC organic naming



2-aminobutanedioic acid

$NH_2—CH_2—CO_2H$

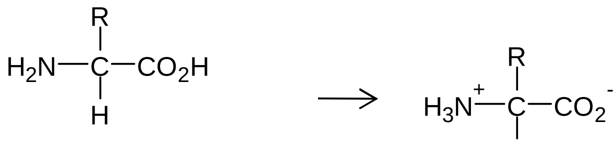
(2-)aminoethanoic acid



2-amino-3-hydroxypropanoic acid

Zwitterions

The no charge form of an amino acid never occurs. The amino acid exists as a dipolar zwitterion.



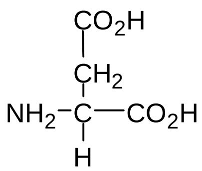
Zwitterion

Amino acids are often **solids**

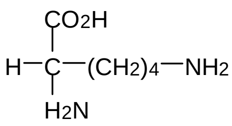
The **ionic interaction** between zwitterions explains the relatively high melting points of amino acids as opposed to the weaker hydrogen bonding that would occur in the no charge form.

An amino acid exists as a zwitterion at a pH value called the **isoelectric point**

Some amino acids have an extra carboxylic acid or an amine group on the R group. These are classed as acidic or basic (respectively) amino acids



Aspartic acid



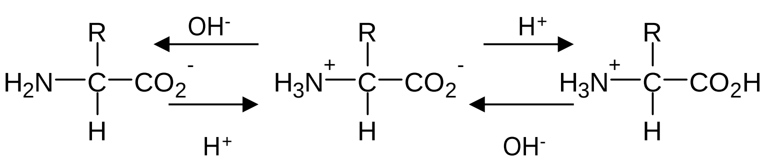
Lycine (basic)
2,6-diaminohexanoic acid

If the side R group of an amino acid contains an acidic of basic group then pH value of the **isoelectric point will be different**

An amine group on the R group may make the isoelectric point be pH > 10
An carboxylic acid group on the R group may make the isoelectric point be pH < 3

Acidity and Basicity

The amine group is basic and the carboxylic acid group is acidic.



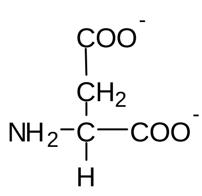
Species in alkaline solution High pH | **Species in neutral solution** | **Species in acidic solution Low pH**

Amino acids act as weak buffers and will only gradually change pH if small amounts of acid or alkali are added to the amino acids.

$^{+}NH_3\text{-}CH_2\text{-}CO_2^{-} + HCl \rightarrow Cl^{-}\ NH_3^{+}\text{-}CH_2\text{-}CO_2H$

$^{+}NH_3\text{-}CH_2\text{-}CO_2^{-} + NaOH \rightarrow NH_2\text{-}CH_2\text{-}CO_2^{-}Na^{+} + H_2O$

The extra carboxylic acid or amine groups on the R group will also react and change form in alkaline and acid conditions

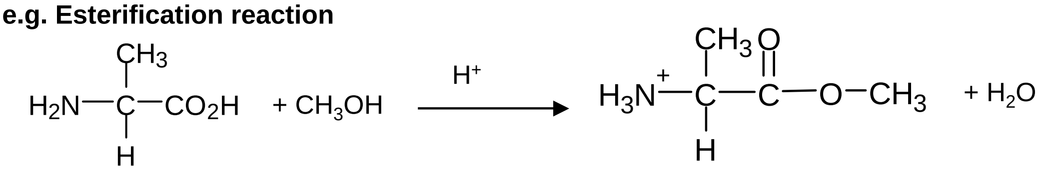


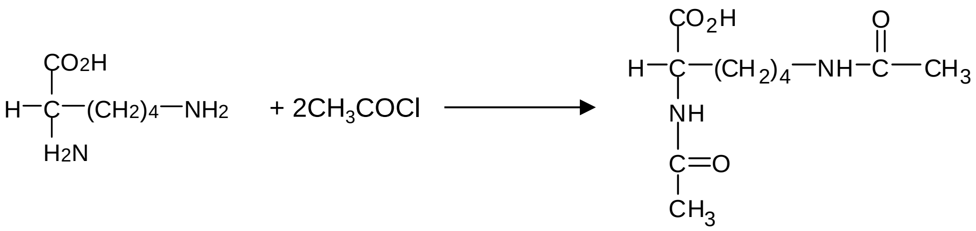
Aspartic acid in high pH

Other reactions of amino acids

The carboxylic acid group and amine group in amino acids can undergo the usual reactions of these functional groups met in earlier topics.

e.g. Esterification reaction



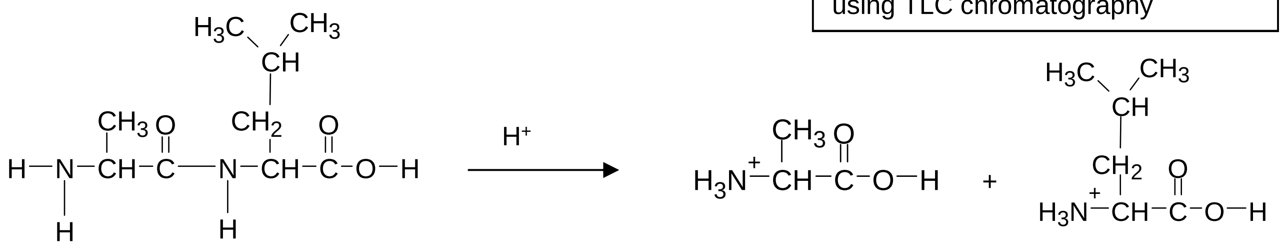


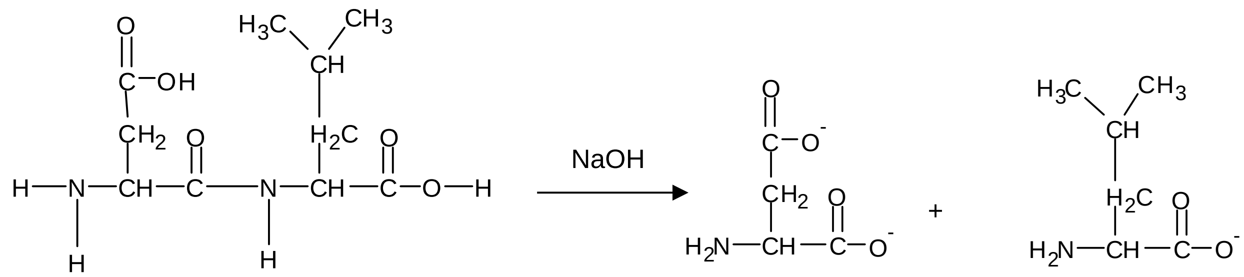
If the R group contains a amine or carboxylic acid then these will do the same reactions as the **α** amine and carboxylic groups

Hydrolysis of di-peptides/proteins

If proteins are heated with dilute acid or alkali they can be hydrolysed and split back in to their constituent amino acids.

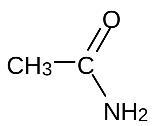
The composition of the protein molecule may then be deduced by using TLC chromatography





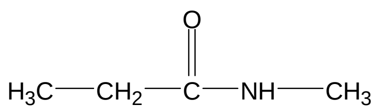
Amides

Add **–amide** to the stem name

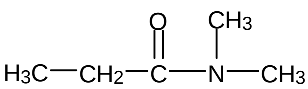


ethanamide

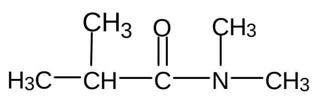
Secondary and tertiary amides are named differently to show the two (or three) carbon chains. The smaller alkyl group is preceded by an –N which plays the same role as a number in positioning a side alkyl chain



N-methylpropanamide



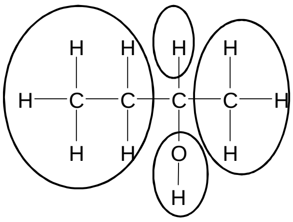
N,*N*-dimethylpropanamide



N,*N*,2-trimethylpropanamide

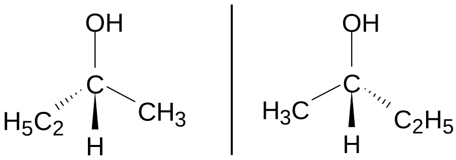
Optical Isomerism

Optical isomerism occurs in carbon compounds with 4 different groups of atoms attached to a carbon (called an **asymmetric carbon**).



A carbon atom that has four different groups attached is called a **chiral** (asymmetric) carbon atom

These four groups are arranged tetrahedrally around the carbon.

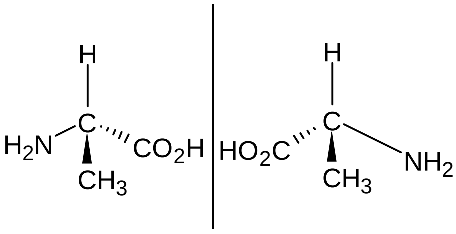


This causes two different isomers that are not superimposable to be formed. They are mirror images

Many naturally occurring molecules contain chiral C atoms, but are usually found in nature as a pure enantiomer

Optical Activity

All amino acids, except glycine, are chiral because there are four different groups around the C



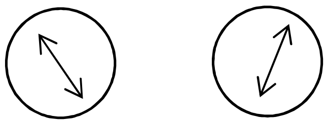
Two compounds that are optical isomers of each other are called **enantiomers**.

Optical isomers have similar physical and chemical properties, but they rotate plane polarised light in different directions.

One enantiomer rotates it in one direction and the other enantiomer rotates it by **the same amount in the opposite direction**.

One optical isomer will rotate light clockwise (+)(called dextrorotatory). The other will rotate it anticlockwise(-)(called laevorotatory).

Different systems of nomenclature are is existence for optical isomers. D/L or +/- are commonly used, but both have been superseded by the more useful and informative R/S system (this is not on the syllabus – for information only).



-ve enantiomer Anticlockwise rotation

+ve enantiomer clockwise rotation

Optical isomerism and *E/Z* isomerism are different types of stereoisomerism, which is defined as the same structural formula but a different spatial arrangement of atoms