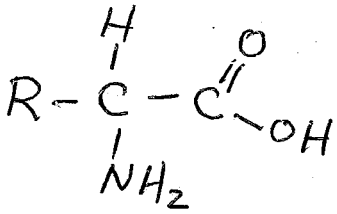
Amino acids

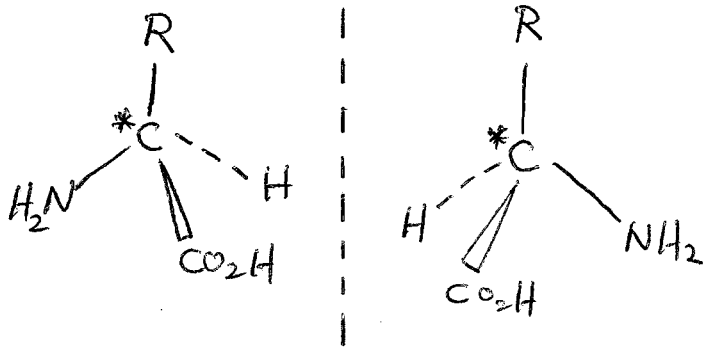
- compounds containing an amino group ($-NH_2$) and a carboxylic acid group ($-COOH$).
- biologically important amino acids have the amino group attached to the carbon next to the $-COOH$ group. They are known as 2-aminoacids.
- general formula:



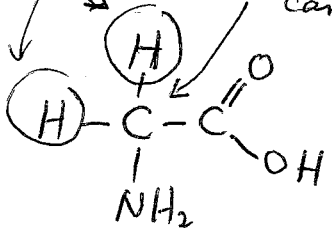
- where R can be a group containing other active groups like $-OH$, $-SH$, other amine or carboxylic acid groups etc.
- simple amino acids examples:

		traditional biochemical name
NH_2-CH_2-COOH	aminoethanoic acid	glycine (Gly)
$CH_3-CH(NH_2)-COOH$	2-aminopropanoic acid	alanine (Ala)

- All amino acids (except aminoethanoic acid) contain an asymmetric carbon atom and exhibits optical isomerism.



same group · non chiral carbon.



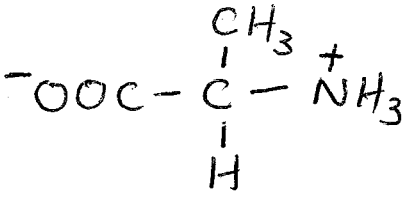
aminoethanoic acid

- Examples of enantiomers / optical isomers:

  (+) alanine (+) cysteine
  (−) alanine (−) cysteine

- amino acids exhibit both amines and carboxylic acid properties. They are amphoteric.
- amino acids can form zwitterions

Zwitterions

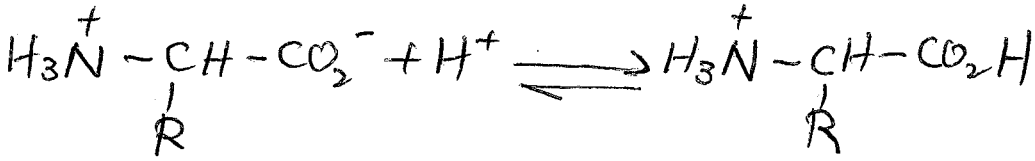


a zwitterion

- a zwitterion is a dipolar ion.
- it has a plus and a minus charge in its structure.
- a proton from the COOH group moves to NH_2
- amino acid exist as zwitterions at a certain pH.
- the pH value is called the isoelectric point.
- produces increased inter-molecular forces (strong electrostatic forces of attraction between the dipolar ions)
- melting and boiling points are higher.
- amino acids are soluble in water but insoluble in non-polar solvents.

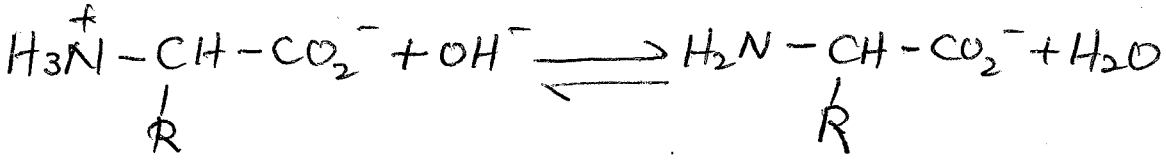
Acid / base properties of amino acids

- these allow amino acids behave as buffer solution, where pH remains almost unchanged when a small amount of H^+ or OH^- added.
- when acid is added,



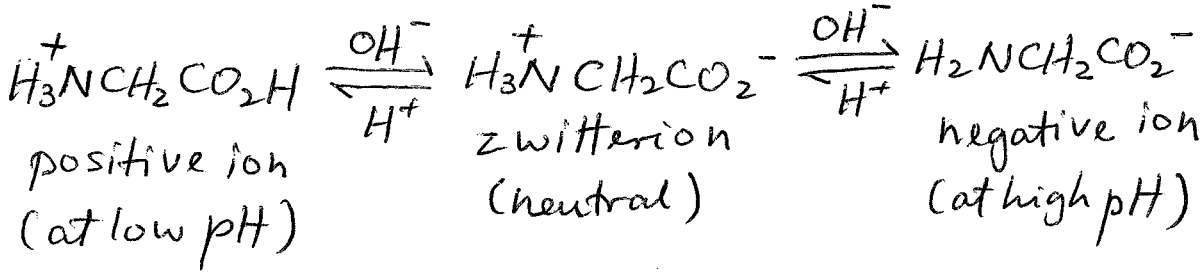
  - any H^+ added is removed
  - salt formed

- when alkaline is added,



  - any OH^- added is removed
  - salt formed

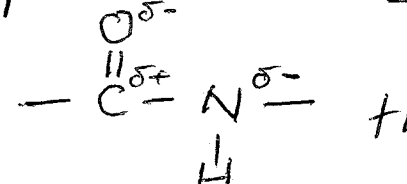
- Amino acids can exist in 3 forms depending on the pH of the solution.



- this principle is used to seperate amino acids in electrophoresis

Formation of peptides and polypeptides

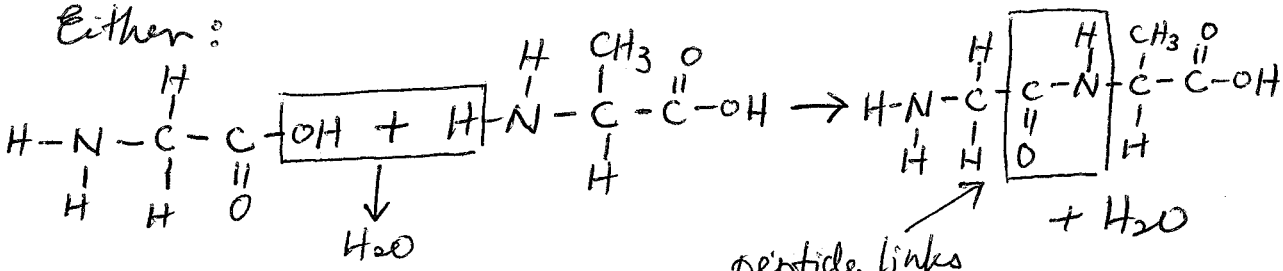
- amino acids can join up together to form peptides via an amide or peptide link



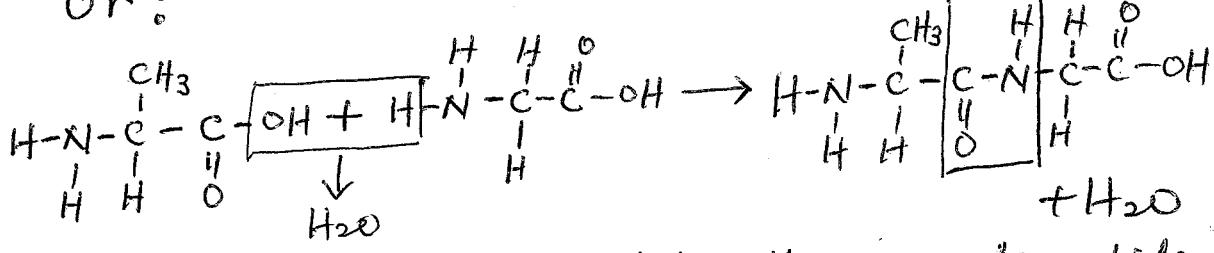
the peptide link.

- peptides are examples of polyamides
- more amino acids can join up to form peptide chains and these are the basis of protein.
- the condensation reaction happens where a water molecule is removed, when a peptide bond is formed between the $-CO_2H$ group of one amino acids and $-NH_2$ groups of another amino acid
- Example;

Either:



or:



- 2 amino acids are joined together → dipeptide
- 3 amino acids joined together → tripeptide
- many amino acids (>10) joined together - polypeptide.

Protein

- Proteins are polypeptides. The protein molecules may contain over 10^5 amino acids.
- They have very high molecular mass (>10,000) and are more complex in structure than polypeptides.
- In a protein chain, the end of the peptide chain with the $-NH_2$ group (written at the left-hand end) is known as the N-terminal, and the end with the $-COOH$ group (written at the right-hand end) is known as the C-terminal.

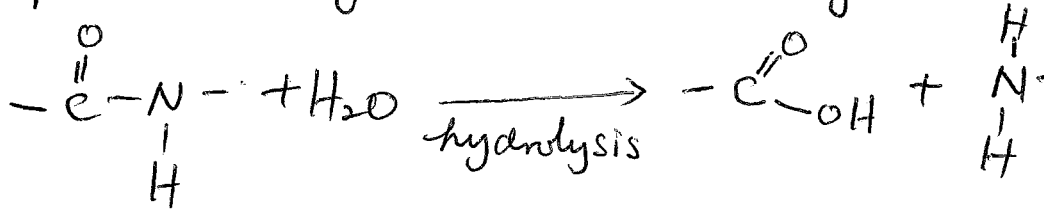
N-terminal (always at the left-hand end)

C-terminal (always at the right-hand end)

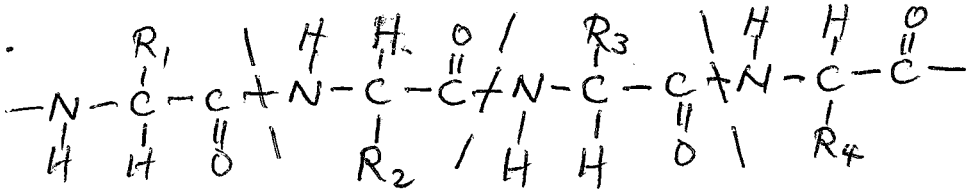
- hydrogen bonding exists between chains in the protein.

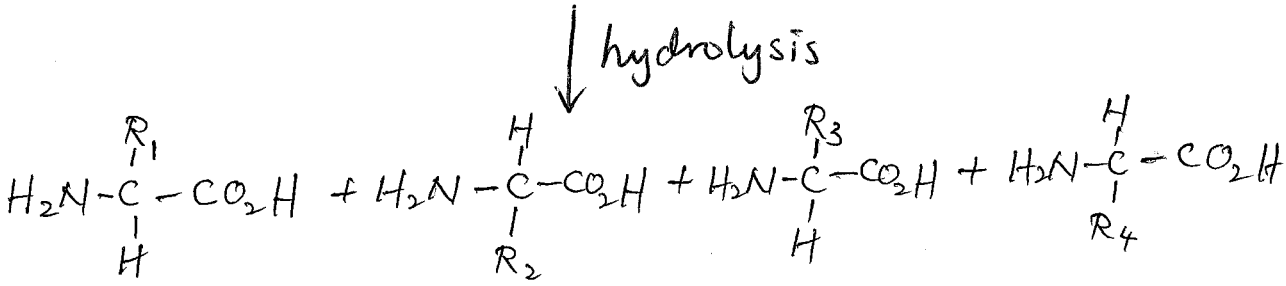
Hydrolysis of Protein

- by either alkaline hydrolysis or acid hydrolysis. to give amino acids.
- Reagents and Conditions:
  1. heat with mineral acid (dilute)
  2. heat with $NaOH_{(aq)}$
  3. use enzymes.
- peptide linkage is broken during reaction.

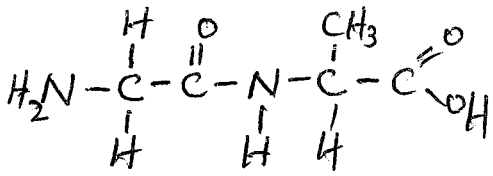


- eg.



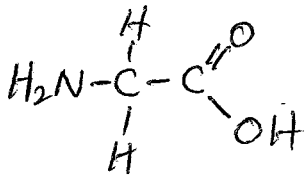


Alkaline hydrolysis of a dipeptide

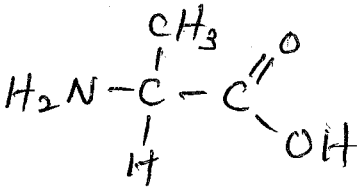


+ H_2O

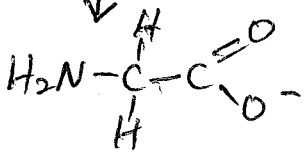
(OH^-)



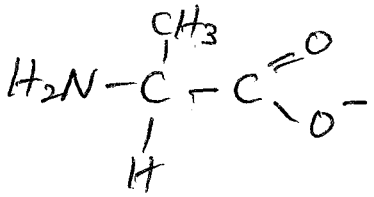
+

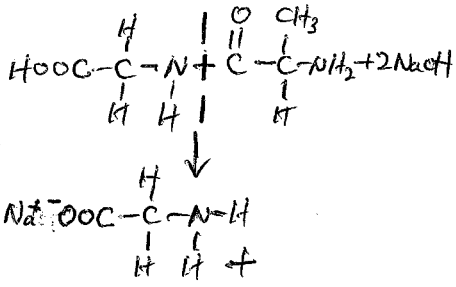


(OH^-)



(OH^-)

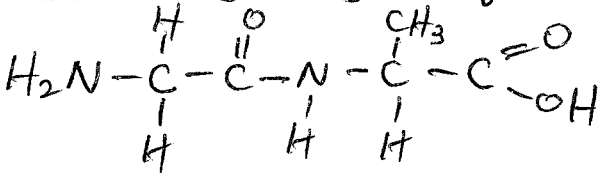




$Na^+ \bar{O}OCCH(CH_3)NH_2$

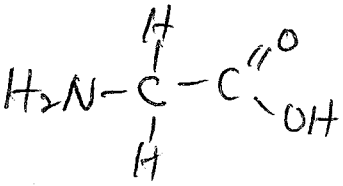
The acid groups become sodium salts & the amine groups remain

Acid hydrolysis of a dipeptide

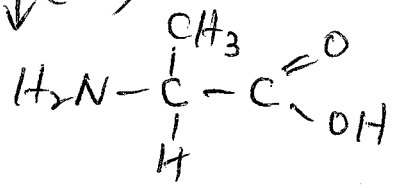


+ H_2O

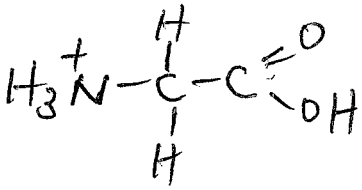
(H^+)



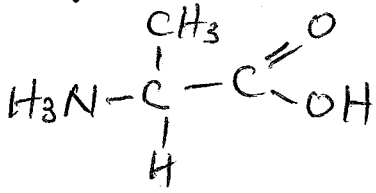
+



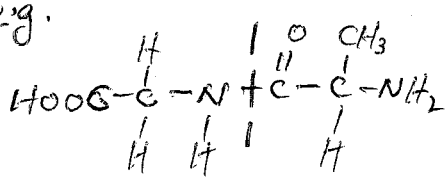
(H^+)



(H^+)



e.g.



$+ 2HCl \longrightarrow HOOCCH_2NH_3^+Cl^-$

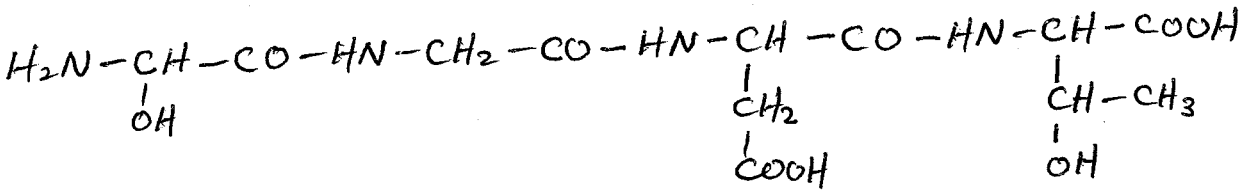
+

$HOOCCH(CH_3)NH_3^+Cl^-$

The amine groups are protonated and the acid groups remain

Exercise 1

A short polypeptide has the formula



The polypeptide was completely hydrolysed by boiling it with reagent X for some hours.

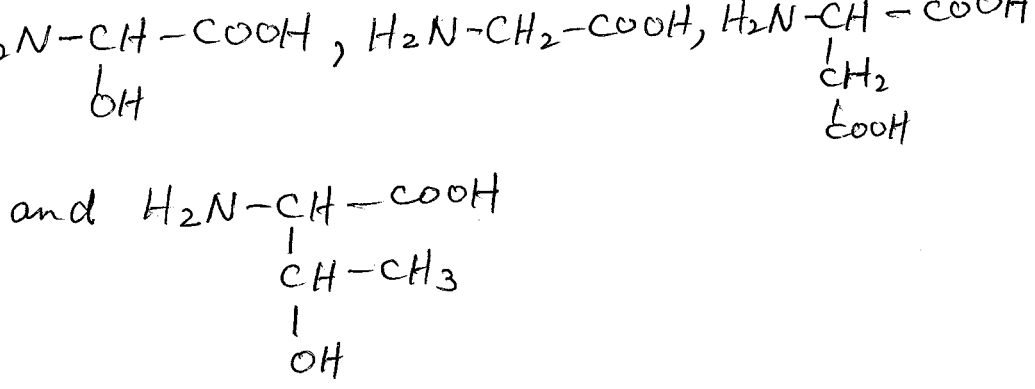
a) Name one substance that could be reagent X.

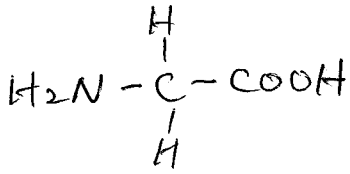
b) Write the formulae of the amino acid products when the polypeptide was completely hydrolysed.

c) One of the amino acid products is not optically active. Name this amino acid.

Answers.

a) dilute hydrochloric acid.

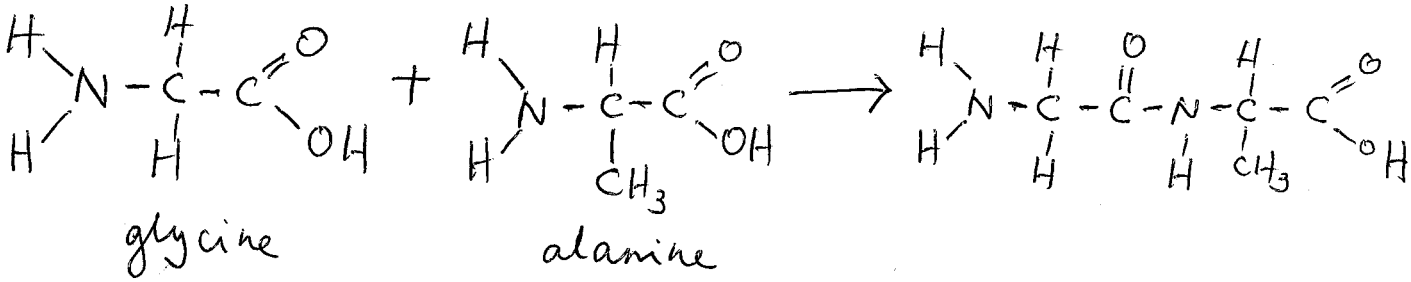
b) 

c)  aminoethanoic acid.

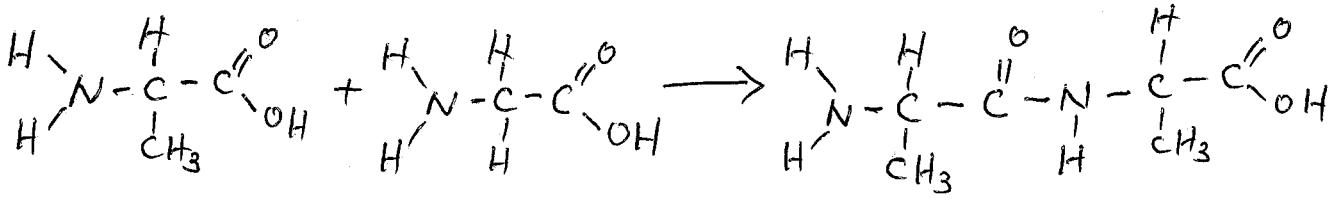
Exercise 2.

Look up the structures of alanine and glycine.
Draw the structure of the dipeptide formed when they react together.

Answers

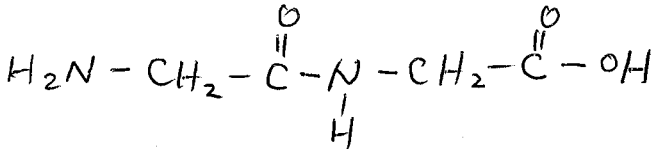


glycine alanine



Exercise 3

Look at the structure of the following dipeptide.



a) How many different amino acids formed the dipeptide?

b) Draw their structure(s).

c) Give the formulae of the organic products formed when the dipeptide is hydrolyed using

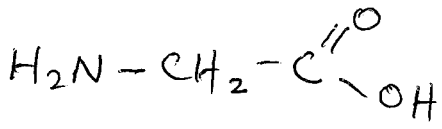
i) NaOH(aq)

ii) HCl(aq)

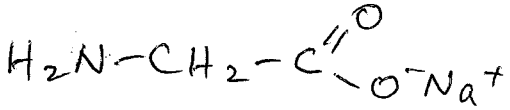
Answers

a) only one amino acid.

b)



c) i)



ii)