BIOMOLECULES

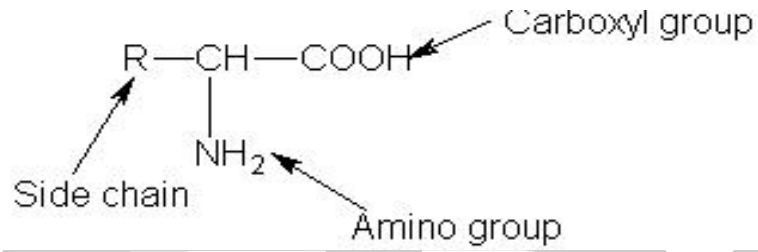
Topic: 2

AMINO ACIDS

VERY SHORT ANSWER QUESTIONS

1. **What are amino acids?**

Ans: Amino acids are organic compounds of both, an amino group & carboxylic group. They are represented by general formula:



2. **What is the importance of amino acids?**

Ans: These amino acids are very important because they are the building blocks of protein.

3. **Which among the following statements are true for glycine?**
   1. It exists in crystalline form 2. It is optically active
   3. It is soluble in water 4. It can form Zwitter ions
   (A) 1, 2 and 3 (B) 1, 2 and 4
   (C) 1, 3 and 4 (D) 2, 3 and 4

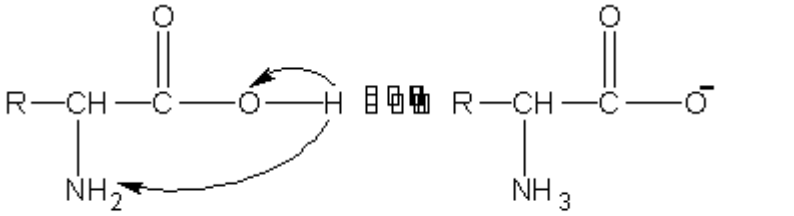
Ans: (C) It is ionic so it exists in crystalline form. Because it is ionic so it soluble in water. Because acidic and basic groups are present in the same molecule, so

4. **What is zwitter ion?**

Ans: ZWITTER ION

(i) Amino acids contain both acidic carboxyl group -(COOH) and basic amino group in the same molecules.

(ii) In aqueous solution, the acidic carboxyl group can lose a proton and basic amino group can gain a proton in a kind of internal acid – base reaction.



Dipolar ion or Zwitter ion

5. What are essential amino acids?

Ans: Essential amino acids: These must be supplied to our diet as are not synthesized in body.
Some of them are
(1) Valine (2) Leucine (3) Isoelucine (4) Phenylalanine (5) Arganine (5) Threonine (6) Tryptophan (7) Methionine (8) Lysine (9) Arginine (10) Histadine

Note: Histidine and arginine are essential i.e. can be synthesized but not in quantities sufficient to permit normal growth.

6. What are non-essential amino acids?

Ans: Non – Essential Amino acids: These amino acids are synthesized in body.
Some of them are
These are as follows:
(1) Glycine (2) Alanine (3) Tyrosine (4) Serine (5) Cystine (6) Proline (7) Hydroxyprocine (8) Cysteine (9) Aspartic acid (10) Glutonic acid

7. **What are the physical properties of amino acids?**

Ans: Physical properties of amino acid
(i) Amino acids are generally, crystalline substance having sweet taste.
(ii) They melt with decomposition at higher temperature (more than 200°C).
(iii) They are soluble in water but insoluble in organic solvents

8. **What is isoelectric point?**

Ans: <u>ISOELECTRIC POINT</u>
When ionized form of amino acid is placed in an electric field it will migrate towards the opposite electrode. Depending upon the pH of the medium following three thing may happen. In acidic medium, the cation move towards cathode. In basic medium, the anion move towards anode. The Zwitter ion does not move towards any of the electrodes. At a certain pH (i.e. H^+ concentration), the amino acid molecules show no tendency to migrate towards any of the electrodes and exists as a neutral dipolar ion, when placed in electric field is **known as isoelectric**

point. All amino acids do not have the same isoelectric point & it depends upon the nature of R – linked to α- carbon atom.

SHORT ANSWER QUESTIONS

1. **Explain the classification of Amino acid.**

Ans: Amino acids are classified in to two categories.

1. **Essential amino acids**
These must be supplied to our diet as are not synthesized in body.
Some of them are
(1) Valine (2) Leucine (3) Isoelucine (4) Phenylalanine (5) Arganine (5) Threonine (6) Tryptophan (7) Methionine (8) Lysine (9) Arginine (10) Histadine

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These are as follows:
(1) Glycine (2) Alanine (3) Tyrosine (4) Serine (5) Cystine (6) Proline (7) Hydroxyprocine (8) Cysteine (9) Aspartic acid (10) Glutonic acid

2. **How amino acids are synthesized?**

Ans: Synthesis of α - amino acids
Protein can be hydrolyzed by refluxing with dilute hydrochloric acid to give a mixture of α - amino acids. The resulting mixture can be separated by
(a) fractional crystallization.
(b) Fractional distillation of their ester followed by hydrolysis (Fischer's method)
(c) Selective precipitation as salt with phosphotungstic and picric acid.
(d) Distribution of amino acid between n – butanol saturated with water (Dakin's method).
(e) Column, paper and gas chromatography.
(f) Electrophoresis.

By amination of α- halo acid

(i) $Cl-CH_2-COOH + 3NH_3 \xrightarrow[(-NH_4Cl)]{50^0C} H_2N-CH_2-COO^-NH_4^+ \xrightarrow{H^+/H_2O} H_2N-CH_2-COOH$

Chloro acetic acid (excess) Glycine

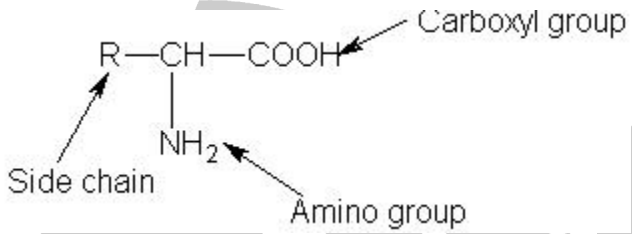
(ii) $H_3C-\underset{Br}{CH}-COOH + 3NH_3 \xrightarrow[(-NH_4Cl)]{50^0C} H_3C-\underset{NH_2}{CH}-COO\bar{N}H_4^+ \xrightarrow{H^+/H_2O} H_3C-\underset{NH_2}{CH}-COOH$

Alanine

LONG ANSWER QUESTIONS

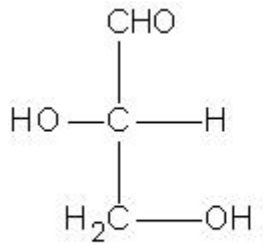
1. Explain the synthesis, physical and chemical properties of amino acids.

Ans: Amino acids are organic compounds of both, an amino group & carboxylic group. They are represented by general formula:

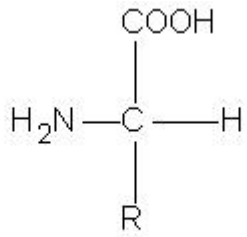


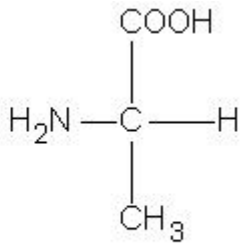
These amino acids are very important because they are the building blocks of protein.

(iv) Protein is the natural polymer moving α - amino acids as monomer. With the exceptions of glycine. All the other amino acids have chiral carbon & have two optically active isomers. All naturally occurring amino acids are in L – series in which $-NH_2$ group on the left and –OH group in the right as L – glyceraldehydes.



L - Glyceraldehyde



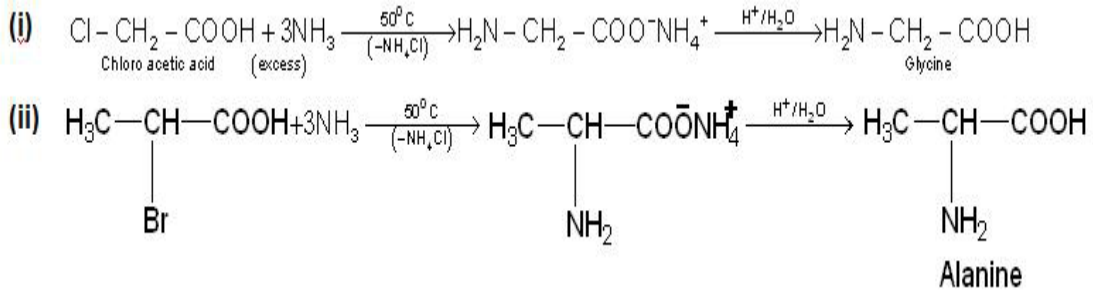


L - Alanine

I. Synthesis of α - amino acids

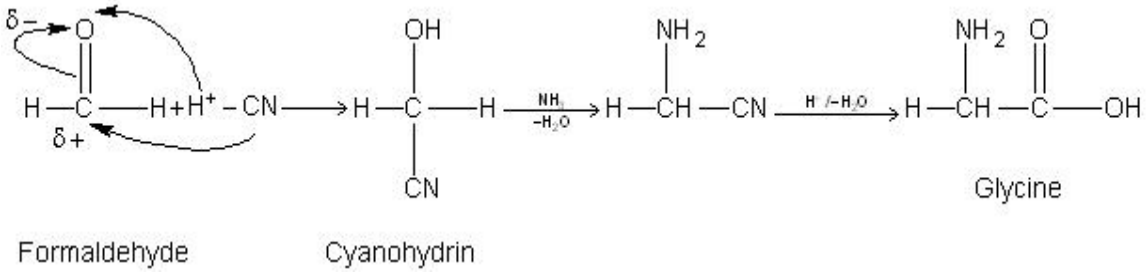
Protein can be hydrolyzed by refluxing with dilute hydrochloric acid to give a mixture of α - amino acids. The resulting mixture can be separated by fractional crystallization. Fractional distillation of their ester followed by hydrolysis (Fischer's method). Selective precipitation as salt with phosphotungstic and picric acid. Distribution of amino acid between n – butanol saturated with water (Dakin's method). Column, paper and gas chromatography and Electrophoresis.

By amination of α- halo acid



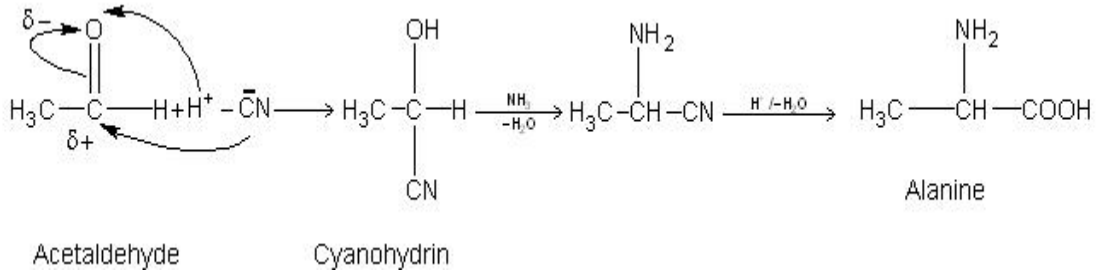
By Strecker Synthesis

(i)



Formaldehyde Cyanohydrin

(ii)

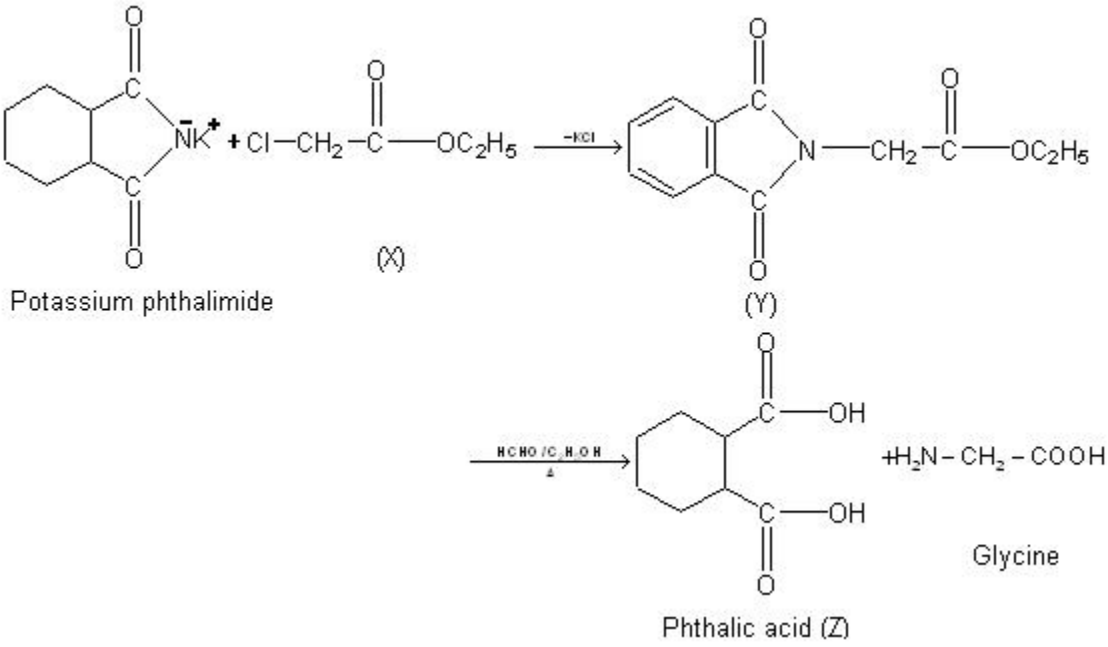


Acetaldehyde Cyanohydrin

Note: Generally the aldehyde is treated with a mixture of ammonium chloride and potassium cyanide in aqueous solution

$$NH_4Cl + KCN \xrightarrow{\text{Aqueous}} NH_4CN + KCl$$

$$NH_4CN \xrightarrow{\text{Aqueous}} NH_3 + HCN$$

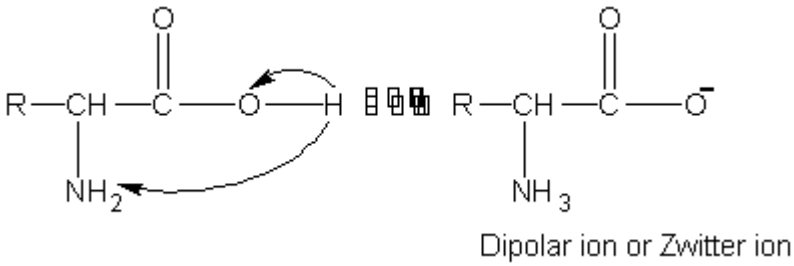


II. Physical properties of amino acid

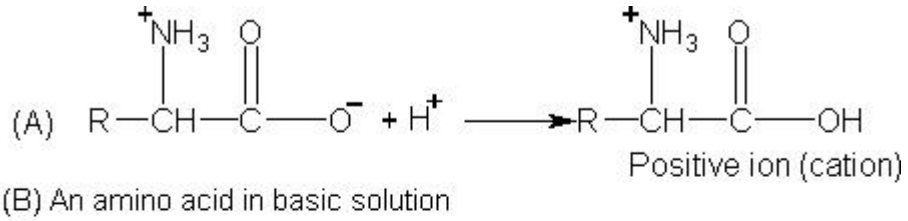
(i) Amino acids are generally, crystalline substance having sweet taste.
(ii) They melt with decomposition at higher temperature (more than 200°C).
(iii) They are soluble in water but insoluble in organic solvents

ZWITTER ION

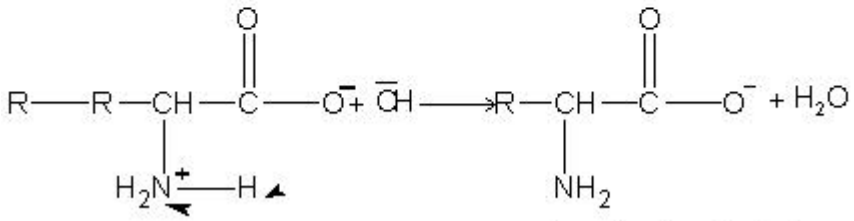
(i) Amino acids contain both acidic carboxyl group -(COOH) and basic amino group in the same molecules.
(ii) In aqueous solution, the acidic carboxyl group can lose a proton and basic amino group can gain a proton in a kind of internal acid – base reaction.



(iii) The product of this internal reaction is called a Dipolar or a Zwitter ion.
(iv) The Zwitter ion is dipolar, changed but overall electrically neutral and contain both a positive and negative charge.
(v) Amino acid in the dipolar ion form are amphoteric in nature.
(vi) Depending upon the pH of the solution, the amino acid can donate or accept proton.



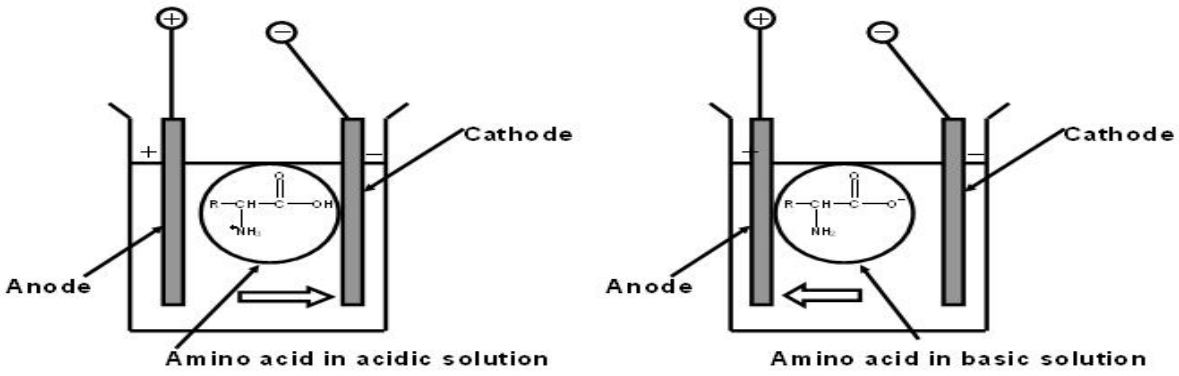
(B) An amino acid in basic solution



ISOELECTRIC POINT

(i) When ionized form of amino acid is placed in an electric field it will migrate towards the opposite electrode.
(ii) Depending upon the pH of the medium following three thing may happen.
   (a) In acidic medium, the cation move towards cathode.
   (b) In basic medium, the anion move towards anode.
   (c) The Zwitter ion does not move towards any of the electrodes.
(iii) At a certain pH (i.e. H^+ concentration), the amino acid molecules show no tendency to migrate towards any of the electrodes and exists as a neutral dipolar ion, when placed in electric field is known as isoelectric point.
(iv) All amino acids do not have the same isoelectric point & it depends upon the nature of R – linked to α- carbon atom.

(v) Amino acids have minimum aqueous solubility at isoelectric point.



Effect of electric field on an amino acid ion Acidic and Basic solution

IV. Chemical Properties

Amino acids show the following characteristic reactions.

1.Reaction of the carboxyl group.

2.Reaction of the amino group.

3.Reaction involving both the carboxyl and the amino group.

1. Reaction of the carboxyl group

a) **Reaction with base**

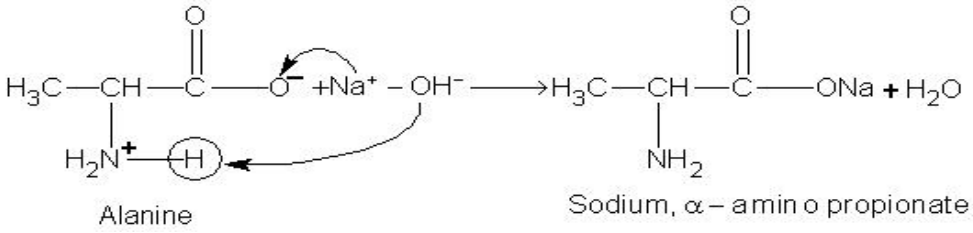
(i) $H_3N^+ - CH_2 - COO^- + NaOH \longrightarrow H_2N - CH_2 - COO^-Na^+ + H_2O$

Glycine — Sodium amino acetate

(ii) $H_3C-CH(NH_3^+)-COO^- + NaOH \longrightarrow H_3C-CH(NH_2)-COO^-Na^+ + H_2O$

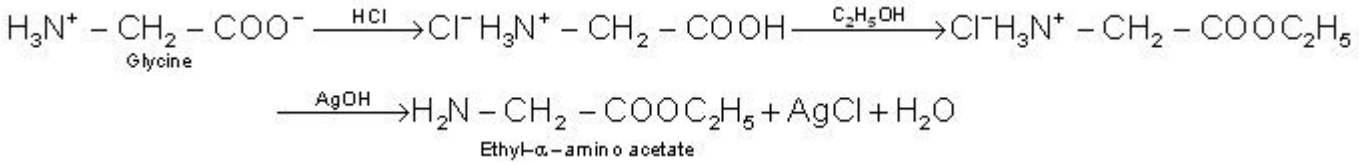
Alanine — Sodium, α– amino propionate

Mechanism:



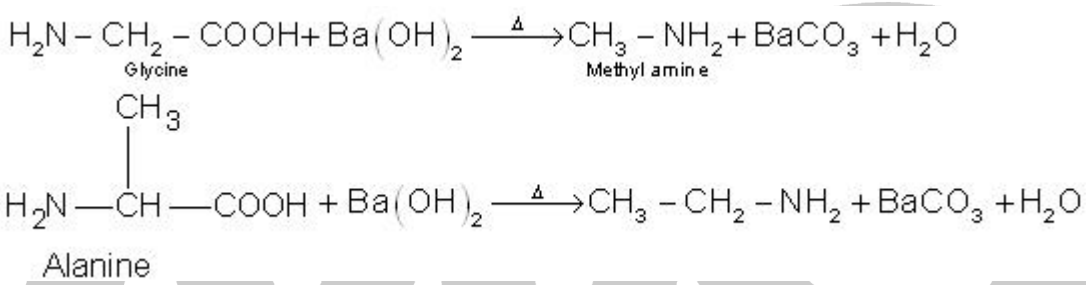
Alanine — Sodium, α – amino propionate

b) Esterification

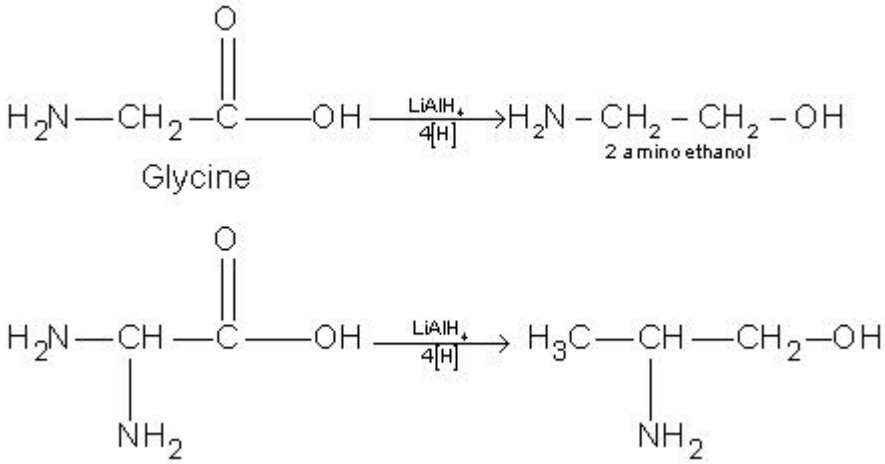


Note: HCl first converts the dipolar ion into an acid which is subsequently esterified.

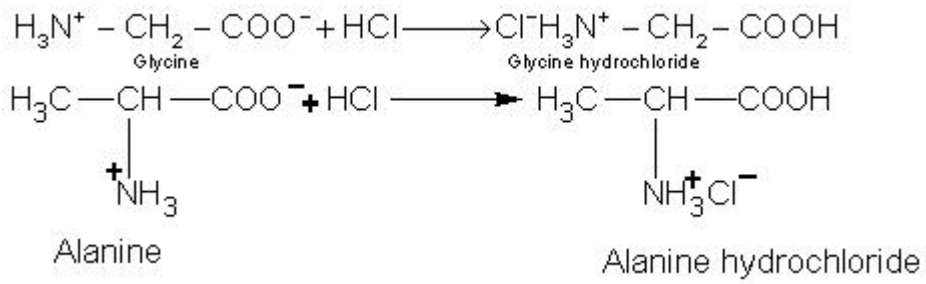
c) **Decarboxylation**



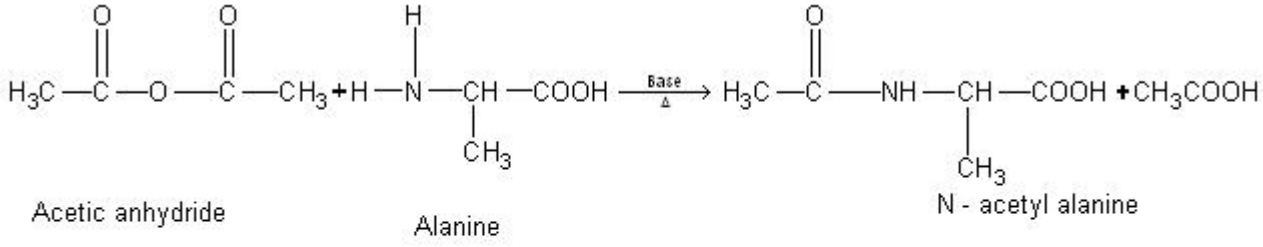
d) Reduction

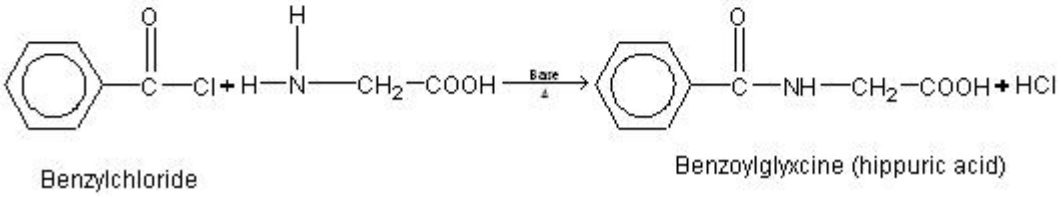


e) Reaction with strong acid

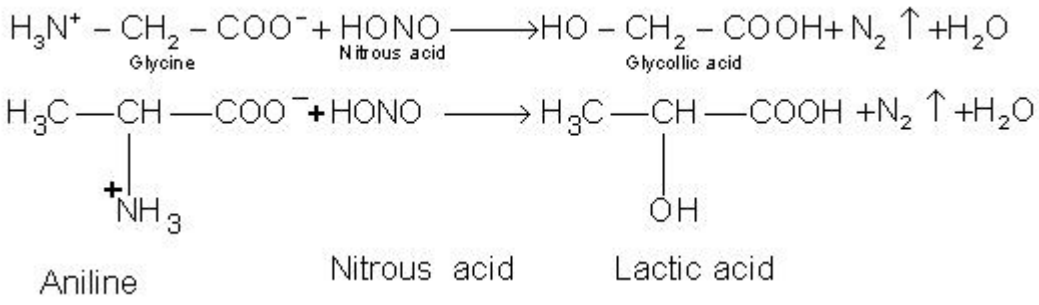


f) Acetylation





g) Reaction with Nitrous acid



Note: (i) This reaction forms the basis of the "van slyke method" for the estimation of amino acids.

(ii) The nitrogen is evolved (one half comes from the amino acid) quantitatively and its volume measured.

Reaction with Nitrosyl halide

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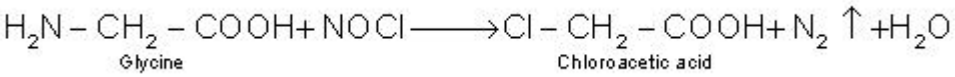
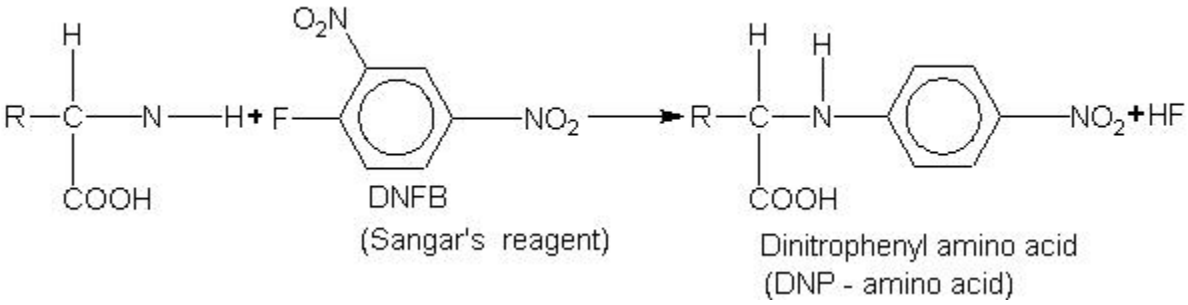
h) Reaction with Nitrosyl halide



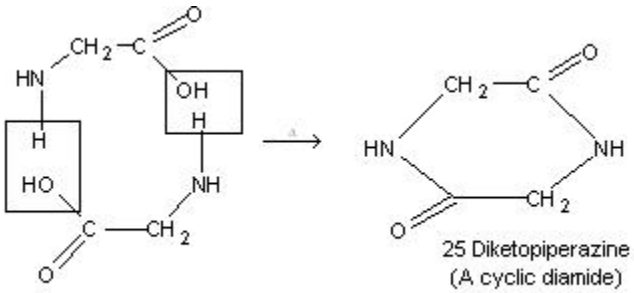
Reaction with 2, 4 – Dintrofluorobenzene (DNFB)



2.Reaction involving both the carboxyl & the amino group

Effect of heat

α - amino acids undergo dehydration on heating (200°C) to give diketo piperazines



Glycine (2 moles)

25 Diketopiperazine
(A cyclic diamide)