Chapter
13

CARBOXYLIC ACIDS

INTRODUCTION

"The organic compounds containing —COOH as a functional group, are called carboxylic acids".

Carboxylic group —C(=O)—OH itself is made up of two groups:

Carbonyl and hydroxylic. The name carboxylic is derived from "Carbo" of carbony and "xylic" of hydroxylic group.

ALPHATIC CARBOXYLIC ACIDS

Carboxylic acid will be aliphatic if — COOH is attached with H or R (methyl, ethyl etc). Its general formula is R/H —C(=O)—OH. e.g.,

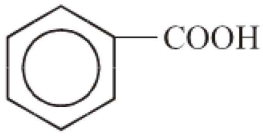
H—C(=O)—OH	CH_3—C(=O)—OH	CH_3—CH_2—C(=O)—OH
(Formic Acid)	(Acetic Acid)	(Propionic Acid)

Aromatic Carboxylic Acids:

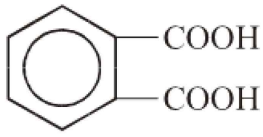
"If carboxylic group — COOH is attached with an aryl or phenyl group, it is called aromatic carboxylic acid".

Ar—C(=O)—OH

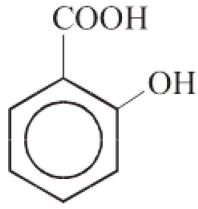
For Examples:



Benzoic acid



Benzene 1, 2, dicarboxylic acid
(Phthalic Acid)

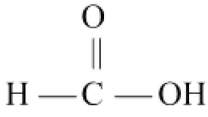


Salicylic acid

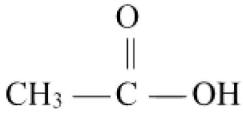
Carboxylic acids can also be classified on the basis of number of carboxylic group present in the acid i.e., mono, di tri or poly.

(1) Monocarboxylic Acids:

If one carboxylic group — COOH is present in an acid, it is called monocarboxylic acids; e.g.,



Methanoic acid (Formic acid)



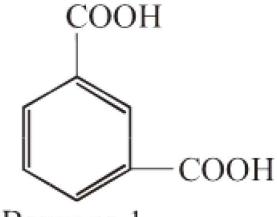
Ethanoic acid (Acetic acid)

(2) Dicarboxylic Acids:

"If two carboxylic groups —COOH are present in an acid molecule, it is called dicarboxylic acids." e.g.,



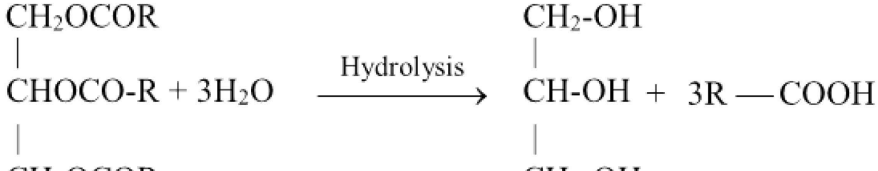
Ethanedioic acid
(oxalic acid)



Benzene 1,
3-dicarboxylic acid
(Iso-Phthalic acid)

Fatty Acids:

"The aliphatic monocarboxylic acids are also called aliphatic acids." These acids are usually obtained by the hydrolysis of fats and oils which are natural glycerides or ester of glycerol.



(ester) fats — glycerol — fatty acid

For example, palmitic acid $C_{15}H_{31}COOH$, is obtained by hydrolysis of palmitin (fat). Stearic acid $C_{17}H_{35}COOH$ is obtained by the hydrolysis of stearin (a fat).

NOMENCLATURE OF CARBOXYLIC ACIDS

(a) Common Names:

The common names of carboxylic were derived from the source from which they are isolated. The irritation caused by an ant bite is due to formic acid (Latin word formica, ant). It was first isofated by the distillation of red ants. Similarly acetic acid was fiorst isolated from vinegar and butyric acid was named after "butyrum" means butter.

Common names of some monocarboxylic acids are given in the next table.

(b) IUPAC Nomenclature:

The IUPAC names of saturated monocarboxylic acids is alkanoic acids. The following rules are obeyed to name the carboxylic acids.

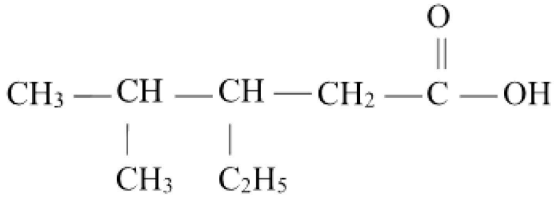
(1) Select longest continuous carbon chain including the carboxyl carbon atom.

(2) From the name of alkane having corresponding number of carbon atoms "–e" is replaced by "–oic, acid" which gives the name of carboxylic acid.

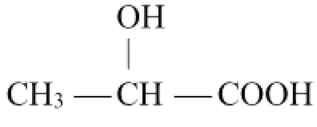
(3) Numbering always starts from the carboxyl carbon atom.

(4) The position and name of the bracnehs are written before the name of carboxylic acid.

(5) Since carboxyl group is always at one terminal of the chain, no prefix is necessary to locate the position of carboxylic group.



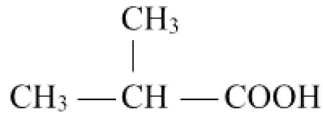
3-ethyl-4-methyl-pentanoic acid



α-hydroxyl propanoic acid (Latic acid)

Table – Some Common Names of Carboxylic Acids

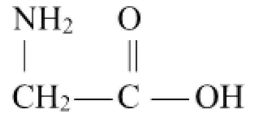
Formula	IUPAC Name	Common Name with Derivation
$H—COOH$	Methanoic acid	Formic acid (Formica, ant)
$CH_3—COOH$	Ethanoic acid	Acetic acid (acetum, vinegar)
$CH_3—CH_2—COOH$	Propanoic acid	Propionic acid (protos, first point, fat)
$CH_3—CH_2—CH_2—COOH$	Butanoic acid	n-Butyric acid (butyrum; butter)
$CH_3(CH_2)_3—COOH$	Pentanoic acid	n-Valeric acid (roots of valerian plant)
$CH_3(CH_2)_4—COOH$	Hexanoic acid	Caproic acid (Caper, goat)



2-Methyl propanoic acid

(Iso-butyric acid)

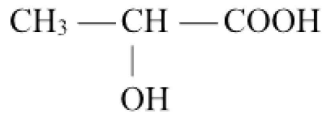
(α-methyl propionic acid)



2-amino ethanoic acid

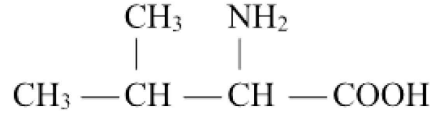
(α-amino acetic acid)

(Glycine)



Lactic acid

(α-hydroxy propanoic acid)

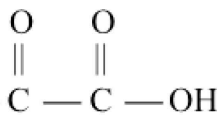
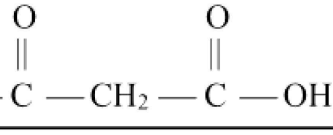


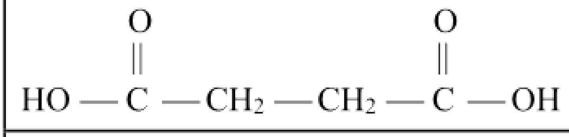
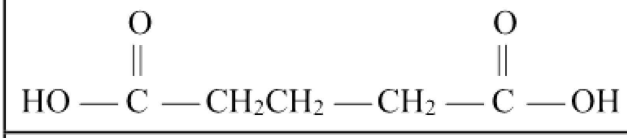
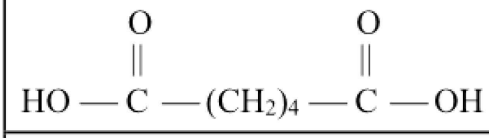
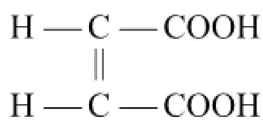
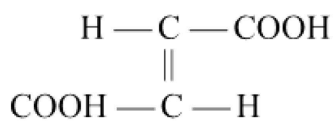
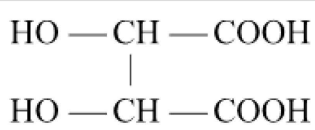
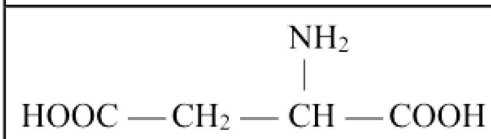
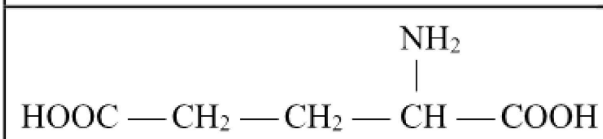
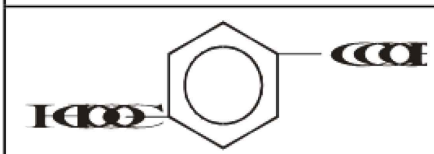
2-amino-3-methl butanoic acid

(Valine)

Dicarboxylic Acids:

Dicarboxylic acids are named by adding "dioic acid" at the end of the parent hydrocarbons e.g.,

Formula	IUPAC Name	Common Name
	Ethanedioic acid	Oxalic Acid
	Propanedioic acid	Malonic acid

	Butanedioic acid	Succinic acid
	Pentanedioic acid	Glutaric acid
	Hexdanedioic acid	Adipic acid
	Cis-2-batenedioic acid	Maleic acid
	Trans-2-butenedioic acid	Fumaric acid
	2, 3, dihydroxy butanedioic acid	Tartaric acid
	2-Amino butanedioic acid	Aspartic acid
	2-Amino pentanedioic acid	Glutamic acid
	Benzene –1, 4, dicarboxylic acid	Terephthalic acid

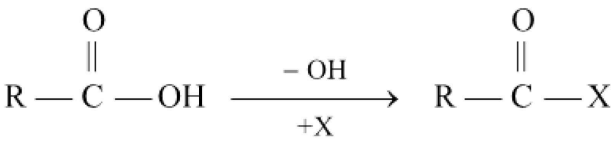
DERIVATIVES OF CARBOXYLIC ACIDS

Carboxylic Acid Derivatives:

The carboxylic acid derivatives may be regarded as compound in which — OH group of a carboxylic acid has been replaced by another functional group.

(1) Acid Halides:

"If hydroxyl group of carboxylic acids is replaced by halogen, the product is called acid halide."



Acid Acid Halide

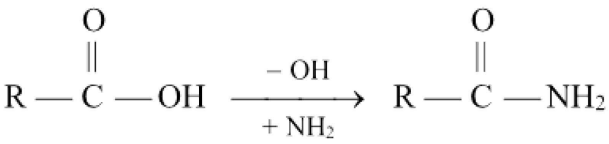
For Example:



Acetyl Chloride Formyl Bromide

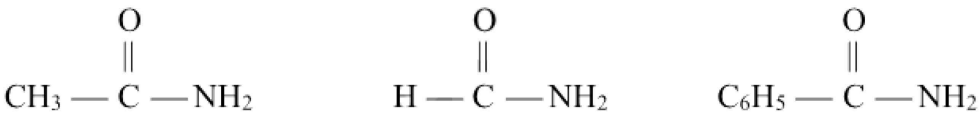
(2) Acid Amides:

"If hydroxyl group of carboxylic acid is replaced by —NH_2 group, the product is called acid amide."



Acid amide

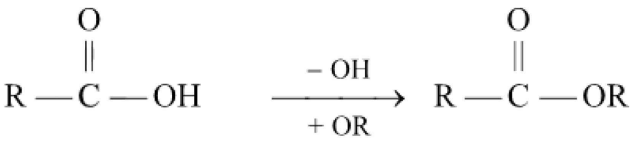
For Example:



Acetamide Formamide Benzamide

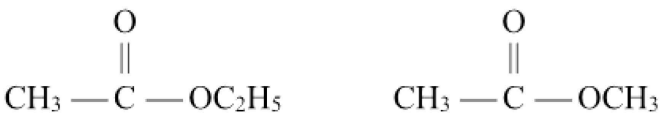
(3) Esters:

"If hydrogen of hydroxyl group of a carboxylic acid is replaced by alkyl group or aryl group, the product is called ester."



Ester

For Example:



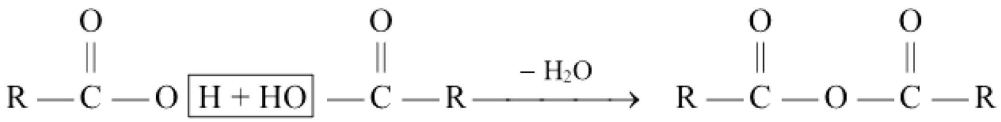
Ethyl Acetate Methyl Acetate



n-propyl formate Ethyl butyrate

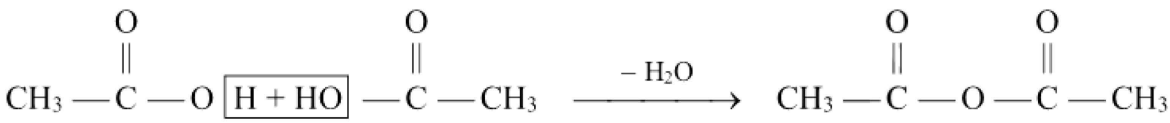
(4) Acid Anhydrides:

"When two molecules of organic acid lose a molecule of water between two OH groups, the derivative formed is called acid anhydride."

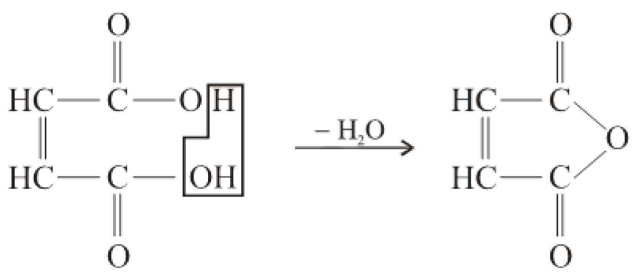


Acid Anhydride

For Example:



(Acetic acid-two molecules) Acetic anhydride

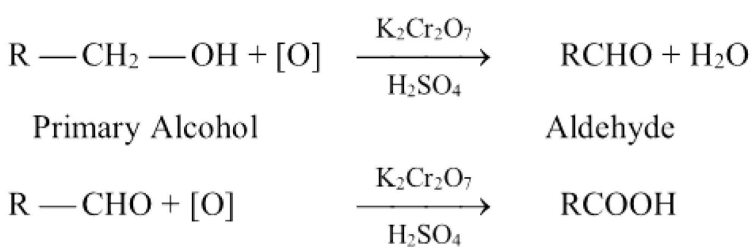


Maleic Acid Maleic Anhydricle

GENERAL METHODS OF PREPARATIONS

(1) From Alcohols and Aldehydes:

Primary alcohol on oxidation changes to aldehyde and, aldehydes on oxidation changes to carboxylic acids. Oxidation takjes place with the mixture of $K_2Cr_2O_7$ and conc. H_2SO_4.



Primary Alcohol Aldehyde

$$CH_3 — CH_2OH + [O] \xrightarrow[H_2SO_4]{K_2Cr_2O_7} CH_3CHO + H_2O$$

Ethanol Ethanal

$$CH_3CHO + [O] \xrightarrow[H_2SO_4]{K_2Cr_2O_7} CH_3COOH$$

Ethanal Ethanoic acid

(2) From Alkyl Nitriles:

Compounds having a cyanide (– C ≡ N) group are called nitriles. Hydrolysis of an alkyl nitrile on boiling with mineral acids or alkalis yields corresponding carboxylic acid.

$$R — C \equiv N + 2H_2O \xrightarrow{H^+ \text{ or } OH^-} RCOOH + NH_3$$

$$CH_3\,C \equiv N + 2H_2O + HCl \longrightarrow CH_3COOH + NH_4Cl$$

Alkyl nitriles can be prepared by treating alkyl halide with alocholic potassium cyanide.

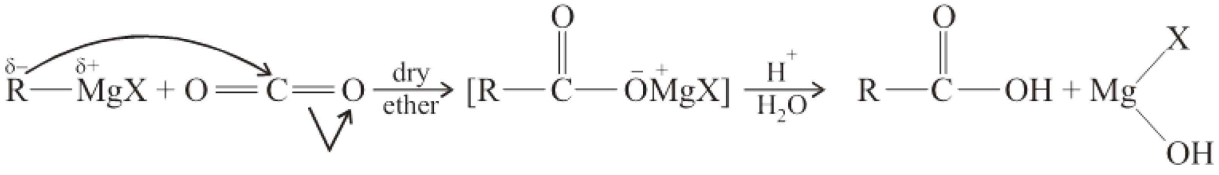
$$R — X + KCN \xrightarrow{\text{Alcohol}} R — CN + KX$$

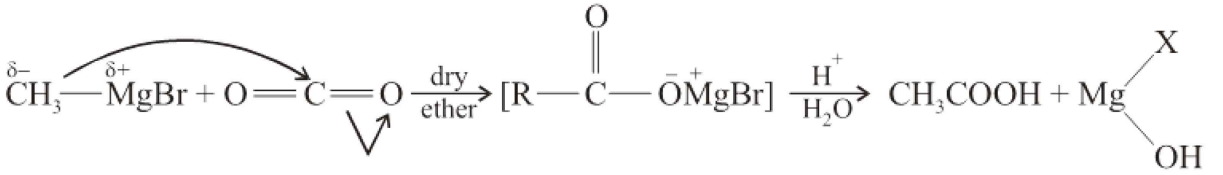
e.g; $CH_3Cl + KCN \longrightarrow CH_3 — CN + KCl$

It may be noted but acid produced has one carbon atom more than the original alkyl halide.

(3) From Grignard Reagent:

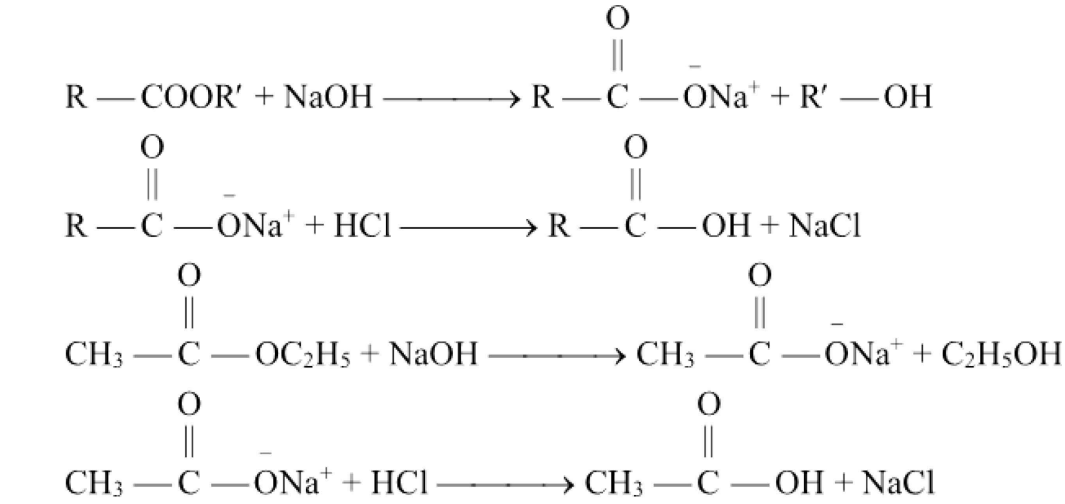
Carboxylic acids can be prepared by the action of Grignard reagent with carbon dioxide. This reaction is either carried out by passing carbon dioxide through the ethereal solution of corresponding Grignard reagent or by adding Grignard reagent to crushed dry ice suspended in ether. The addition product on reaction with a mineral acid produces carboxylic acid.





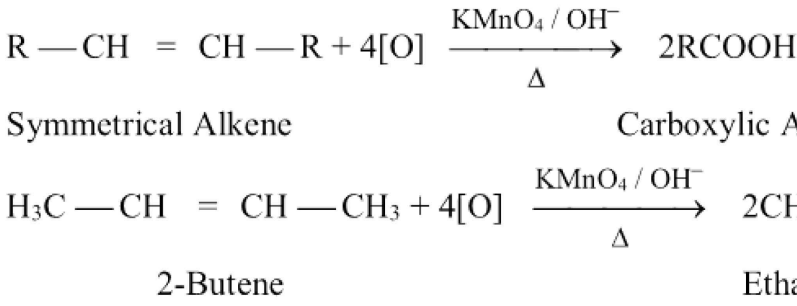
(4) By the hydrolysis of Esters:

The ester on boiling with concentrated sodium hydroxide yields sodium salt of the acid. This resulting salt when treated with dilute HCl gives the free carboxylic acid.



(5) By the Oxidative Cleavage of Alkenes:

Alkenes when heated with alkaline $KMnO_4$ are cleaved at the double bond to form carboxylic acids.



Symmetrical Alkene — Carboxylic Acid

2-Butene — Ethanoic Acid

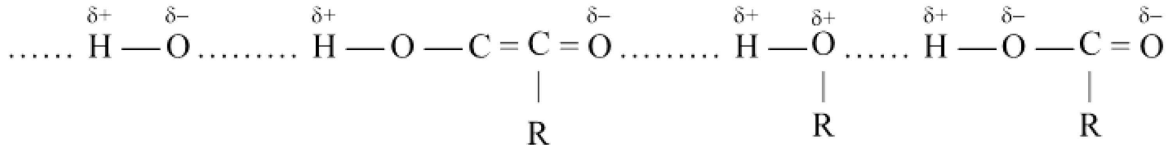
PHYSICAL PROPERTIES OF MONOCARBOXYLIC ACIDS

(i) Smell:

The first three aliphatic acids i.e., formic acid, acetic acid and propionic acid are colourless liquids and have pungent smell. The next three acids C_4 to C_6 are colourless liquids with somewhat upleasant smell.

(ii) Solubility:

Among the aliphatic acids, the first four members are very soluble in water due to hydrogen bonding.



The solubility of carboxylic acids in water gradually decreases with the increase in molecular mass.

(iii) Boiling Point:

The boiling points of carboxylic acids are relatively high due to intermolecular hydrogen bonding.

The molecular mass determination in non-polar solvent like benzene shows that carboxylic acids exist as cyclic dimers.



Dimer of a Carboxylic Acid

Boiling Points of First Three Acids:

HCOOH	CH_3COOH	C_2H_5COOH
373K (100°C)	391K (118°C)	424K (151°C)

(iv) Melting Points:

The melting points of carboxylic acids increase irregularly with the increase in molecular mass. It has been observed that the melting points of carboxylic acids containing even number of carbon atoms is higher than the next lower and higher members containing odd number of carbon atoms. It is due to the different closer packing of molecules in solid state.

Melting points of some carboxylic acid are given below:

Acid Formula	Name	Melting Point
$CH_3 — CH_2COOH$	Propionic acid	251K (–22°C)
$CH_3 — CH_2 — CH_2 — COOH$	Butyric acid	267K (–6°C)
$CH_3 — (CH_2)_3\ COOH$	Valeric acid	237K (–36°C)

REACTIVITY OF CARBOXYLIC GROUP (COOH)

The carboxylic acid group consist of carboxyl and hydroxylic group. Although carboxylic acids have carbonyl group like aldehydes and ketones but they do not undergo addition or condensation like aldehydes or ketones. This is because carbon atom of the carbonyl group is less positive than that in aldehydes or ketones. However, carboxylic acids undergo following types of reactions.

(a) The reactions in which hydrogen atom of the carboxyl group is involved (salt formation).

(b) The reaction in which OH group is replaced by another group.

(c) The reactions involving carboxyl group as a whole.

(a) Reaction Involving H-Atom of Carboxylic Group:

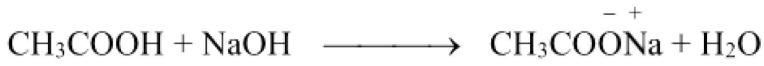
Carboxylic hydrogen in linked with oxygen which has greater electronegativity. Electrons of O — H bond are attracted toward oxygen and hydrogen can be removed as proton. Monocarboxylic acids are monobasic acids.



Some reactions regarding acidic nature of carboxylic acids are given below.

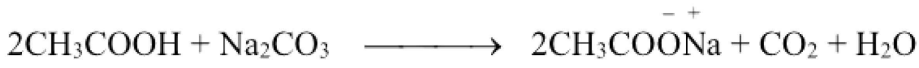
(1) Reactions with Bases:

Carboxylic acids react with bases (NaOH, KOH) to form salts.



(2) Reactions with Carbonates and Bicarbonates:

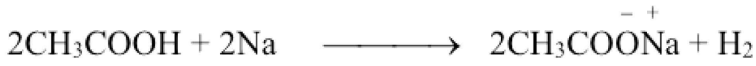
Carboxylic acids decompose carbonate and bicarbonates evolving carbon dioxide gas with effervescence.





(3) Reactions with Metals:

Carboxylic acids react with active metals like (Na, K, Ca, Mg etc.) to form their salts with the evolution of hydrogen gas.

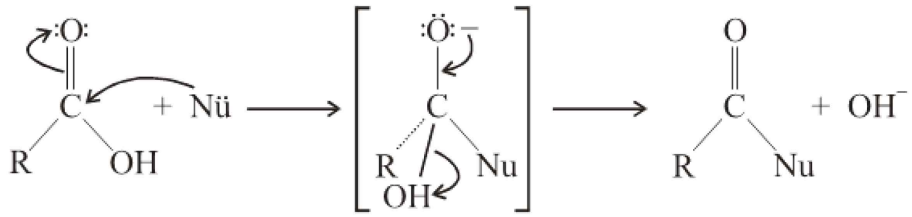


(b) Reaction Involving the — OH Group of the Carboxylic Acid:

The carboxylic group contain C = O in it just like aldehydes and ketones.

It is a polar group and a nucleophile can attack on the carboxyl carbon and form a tetrahedral intermediate. One substituent which is originally present is removed or called leaving group. In this way — OH group of carboxylic group can be replaced by X^-, OR^-, or NH_2^-.

In this way acid derivates like acid halides, acid amides or esters can be prepared.



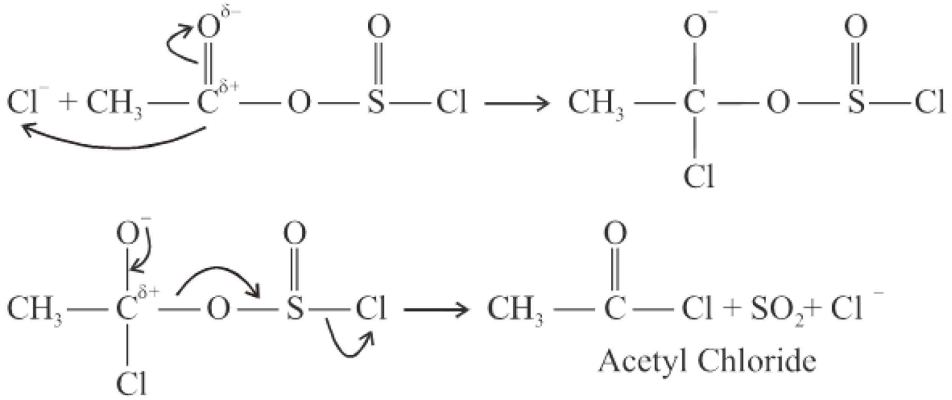
(1) Reaction of PCl_5 and $SOCl_2$:

(a) $CH_3COOH + PCl_5 \longrightarrow CH_3COCl + POCl_3 + HCl$

(b) $CH_3COOH + SOCl_2 \longrightarrow CH_3COCl + SO_2 + HCl$

Mechanism:

(i) $CH_3-C(=O)-OH + SOCl_2 \longrightarrow CH_3-C(=O)-O-S(=O)-Cl + H^+ + Cl^-$



Acetyl Chloride

(2) Formation of an Ester:

When carboxylic acids are heated with alcohols in the presence of concentrated H_2SO_4, esters are formed.

$$CH_3COOH + C_2H_5OH \underset{}{\overset{H_2SO_4}{\rightleftharpoons}} CH_3COOC_2H_5 + H_2O$$

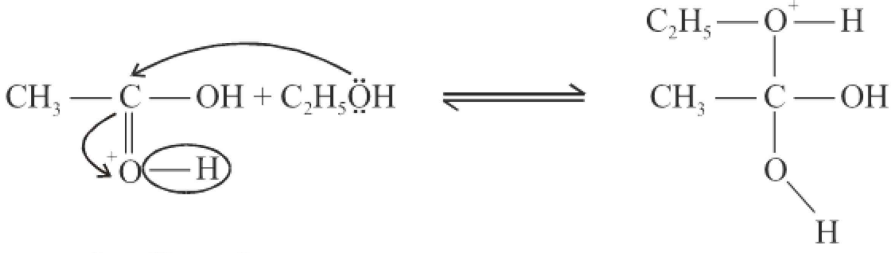
Mechanism:

The various steps of the above reactions are as follows:

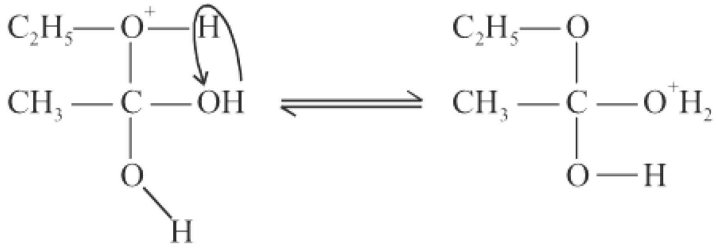
(i) Protonation of Carboxylic Acid:



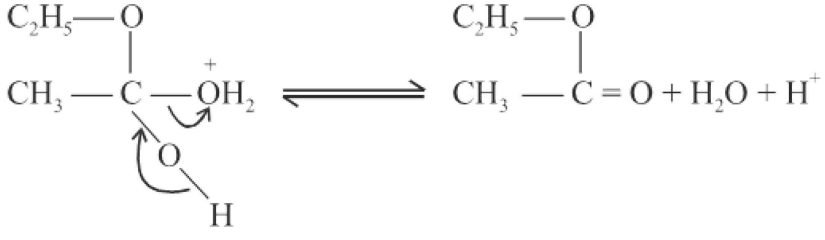
(ii) Attack of $CH_3—CH_2OH$:



(iii) Hydrogen Ion Transfer:



(iv) Elimination of Water and H^+



Esters have fruity smell and are used as artificial flavours. Flavours of some esters are listed below:

Ester	Flavour	Ester	Flavour
Amylacetate	Banana	Isobutyl formate	Raspberry
Benzylacetate	Jasmine	Ethyl butyrate	Pineapple
Amyl butyrate	Apricot	Octyl acetate	Orange
Methyl phenyl acetate	Honey	Methyl cinamate	Strawberry
Methyl acetate	Glue	Ethyl-isovalerate	Apple

(3) Formation of Amide (Reaction with Ammonia:

Carboxylic acids react with ammonia to form ammonium salts which on heating produce acid amides.

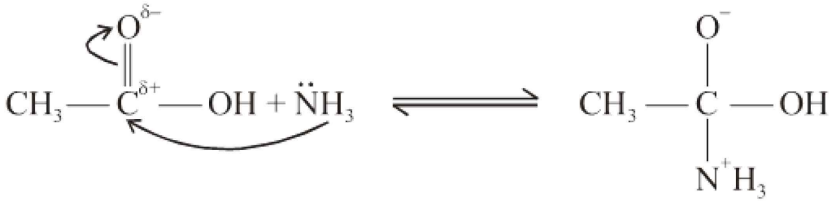
$$CH_3COOH + NH_3 \longrightarrow CH_3\overset{\overset{O}{\|}}{C}ONH_4$$

$$CH_3\overset{-\ +}{C}OONH_4 \longrightarrow CH_3CONH_2 + H_2O$$

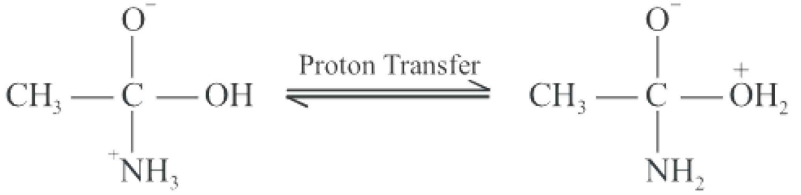
Acetamide

Mechanism:

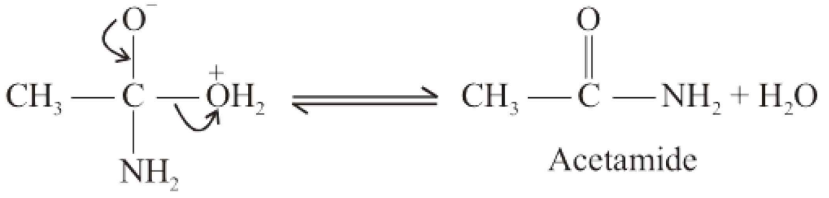
(i)



(ii)



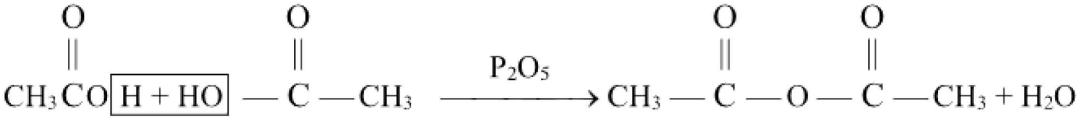
(iii)



Acetamide

(4) Formation of Acid Anhydride:

Carboxylic acids are dehydrated on heating strongly in the presence of phosphorus pentoxide.



Acetic Anthydride

(c) Reactions Involving Carboxyl Group (—C(=O)—OH)

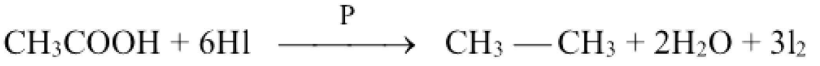
(1) Partial Reduction to Alcohols:

Carboxylic acids on reaction with lithium aluminum hydride ($LiAlH_4$) are reduced to alcohols.



(b) Complete Reduction to Alkanes:

Carboxylic acids on reduction with HI and red phosphorus give alkanes.



In this reaction —COOH group is reduced to a CH_3 group.

ACETIC ACID

It is the most important carboxylic acid. Its dilute solution is known as vinegar.

Acetic acid can be prepared by any of the general methods described earlier.

LABORATORY METHOD

(1) By the Oxidation of Ethyl Alcohol or Acetaldehyde:

When ethyl alcohol is oxidised with $K_2Cr_2O_7$ and dilute H_2SO_4, acetic acid is produced.

$$CH_3CH_2 — OH + [O] \xrightarrow[H_2SO_4]{K_2Cr_2O_7} CH_3CHO + H_2O$$

$$CH_3CHO + [O] \xrightarrow[H_2SO_4]{K_2Cr_2O_7} CH_3COOH$$

(2) By Hydrolysis of Nitriles:

Methyl nitrile (CH_3CN) on hydrolysis with dilute HCl, give acetic acid.

$$CH_3CN + 3H_2O \xrightarrow{H_3O^+} CH_3COOH + NH_4OH$$

Manufacture of Acetic Acid:

(1) From Acetylene:

Acetylene is treated with 20% H_2SO_4 and 1.0% $HgSO_4$ at 80°C to give ethanal (acetaldehyde) which is the oxidised using V_2O_5 to give acetic acid.

$$\underset{\text{(Acetylene)}}{HC \equiv CH} + H_2O \xrightarrow[1\%\ HgSO_4]{20\%\ H_2SO_4} CH_2 = CH — OH$$

$$CH_2 = CH — OH \xrightarrow{\text{Rearrangement}} CH_3CHO$$

$$CH_3 — CHO + [O] \xrightarrow{V_2O_5} CH_3COOH$$

(2) Oxidation of Ethanol:

Acetic acid is also prepared commercially by the oxidation of ethyl alcohol. It is oxidized by potassium dichromate in the presence of conc. sulphuric acid to give acetaldehyde which is further oxidized under the same conditions to give acetic acid.

$$CH_3—CH_2—OH + [O] \xrightarrow[H_2SO_4]{K_2Cr_2O_7} CH_3—\overset{\overset{O}{\|}}{C}—H + H_2O$$

$$CH_3—\overset{\overset{O}{\|}}{C}—H + [O] \xrightarrow[H_2SO_4]{K_2Cr_2O_7} CH_3—\overset{\overset{O}{\|}}{C}—OH$$

PHYSICAL CHARACTERISTICS

(1) Acetic acid is a colourless liquid with a boiling point 118°C.

(2) It has a strong vinegar odour and sour taste.

(3) The pure acid freezes to an ice like solid at 17°C. Therefore it is called glacial acetic acid.



(4) It exists as dimer.

(5) It is miscible with water, alcohol and ether in all proportions.

(6) Its specific gravity is 1.08 g cm^{-3} at 0°C.

USES OF ACETIC ACID

Acetic Acid is Used:

(i) As a coagulant for latex in rubber industry.

(ii) In the manufacture of plastic (polyvinyl acetate) rayon (cellulose acetate) and silk.

(iii) In medicine as a local irritant.

(iv) As a solvent in the laboratory for carrying out reactions.

(v) In the manufacture of many organic compounds like acetone, acetates and esters.

(vi) As preservative for many edible material like pickle.

AMINO ACIDS

"The carboxylic groups which contain amino group — NH_2 at α-carbon are called amino acids or α-amino acids."

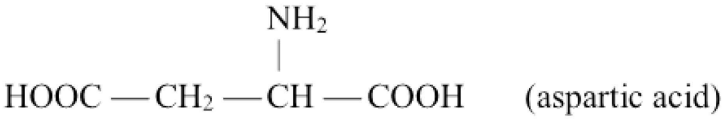
Different amino acids have, different structure of R or side chain. All naturally occurring amino acids are α-amino acids because -NH_2 group is present at a - carbon.

Amino acids are building block of proteins. Protein is a polymer made up of amino acids.

TYPES OF AMINO ACIDS

(i) Acidic Amino Acids:

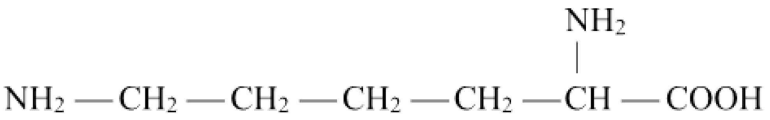
The amino acids which contain two carboxylic and one amino group are called acidic amino acids, e.g; aspartic acid, glutamic acid.



(aspartic acid)

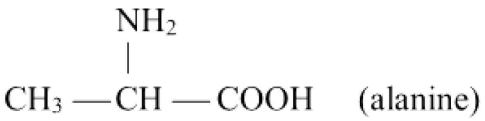
(ii) Basic Amino Acids:

The amino acids which contain two amino groups and one carboxylic group are called basic amino acids, e.g., lysine.



(iii) Neutral Amino Acids:

The amino acids which contain one amino and one carboxylic group in them are called neutral amino acids. Majority of natural amino acids are neutral, e.g., glycine, alanine. Up till now 20 amino acids have been identified in animals and plants proteins.



(alanine)

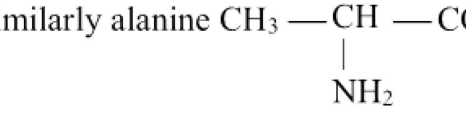
Essential and Non Essential Amino Acids:

The amino acids which our body can synthesize are called non essential amino acids. Out of 20 amino acids, 10 are non essential.

The amino acids which are not synthesize by our body are essential amino acids. These amino acids are taken in the body through diet. Essential amino acids are 10 in numbers.

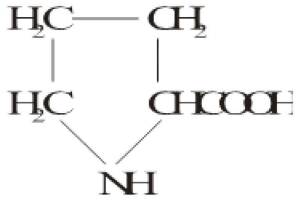
Deficiency of any essential amino acid may cause death.

NOMENCLATURE OF AMINO ACIDS

Although amino acids can be named according to IUPAC system, they are generally known by their trivial names. These trivial names usually reflect the origin or an obvious property of the compound. glycine, for example is so named, because it has a sweet taste (Greek glyky - sweet) and the tryosine was first isolated from cheese (from Greek tryos cheese). For the sake of simplicity, each amino acid has been given an abbreviation which generally consists of. the first three letters of the common name. For example the simplest (a amino acid is glycine H_2NCH_2COOH). It may be abbreviated as Gly. Similarly alanine  may be represented as Ala.

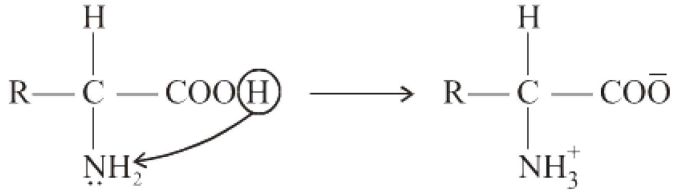
Names, structural formula and other features of some amino acids are given in table:

Table – Name, structural formulae and other features of amino acids

	Name	Nature	Abbreviation	Structural Formula
1.	Glycine	Neutral	Gly	$CH_2(NH_2)-COOH$
2.	Alanine	Neutral	Ala	$CH_3-CH(NH_2)-COOH$
3.	Valine	Neutral	Val	$CH_3-CH(CH_3)-CH(NH_2)-COOH$
4.	Proline	Neutral	Pro	
5.	Aspartic acid	Acidic	Asp	$HOOC-CH_2-CH(NH_2)-COOH$
6.	Glutamic acid	Acidic	Glu	$HOOC-CH_2-CH_2-CH(NH_2)-COOH$
8.	Histidine	Basic	His	

STRUCTURE OF AMINO ACIDS

The amino acids exist in the form of dipolar ion called zwitterion. This name is derived from a German word "Zwei" meaning two. Zwitterion has positive end and negative end within the same molecule. This ion is formed when —COOH group donate a proton to $—NH_2$ group.

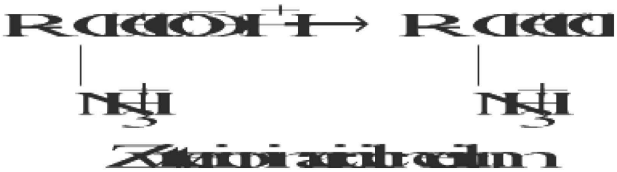


Zwitterion

The dipolar structure is also called internal salt and found only in neutral conditions. All α-amino acids exist largely in the dipolar ion form.

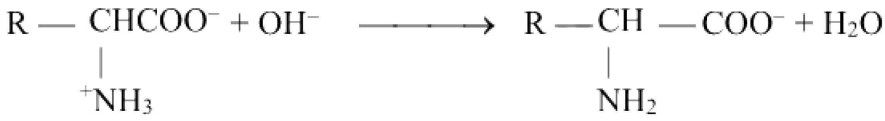
Zwitterion in Acidic Medium:

When an acids is added to an amino acid, the carboxylate ion accept the proton and, therefore, the basic character is due to this group.



Zwitterion in Basic Condition:

When an alkali is added to an amino acid, $-\overset{+}{N}H_3$ group releases the proton and therefore the acidic character is due to this group.



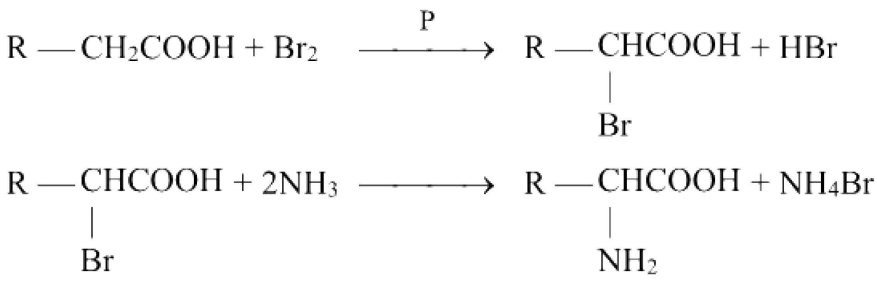
Zwitter ion in basic medium

SYNTHESIS OF AMINO ACIDS

Amino acids can be synthesized by the following reactions.

(1) By the Reaction of α-bromo Acid with Ammonia:

A carboxylic acid is changed to α-bromo carboxylic acid with reaction of Br_2 and acid in the presence of P or PBr_3. SN_2 substitution of α-bromoacid with NH_3 produce α-amino acid.

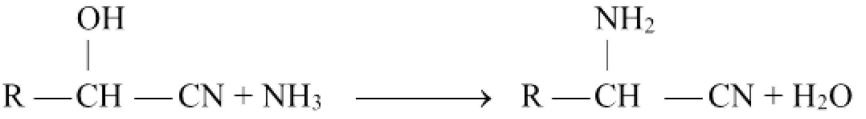


(2) The Strecker Synthesis:

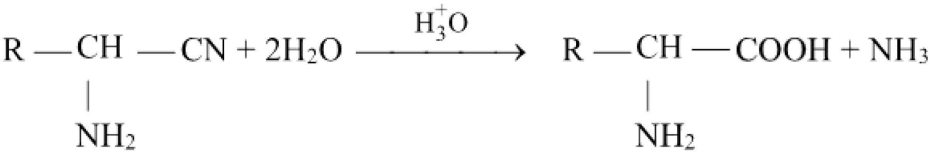
When hydrogen cyanide is added to an aldehyde in the presence of ammonia, α-amino acid is obtained.



Cyanohydrin



α-amino nitrile upon acidic hydrolysis yields an α-amino acid

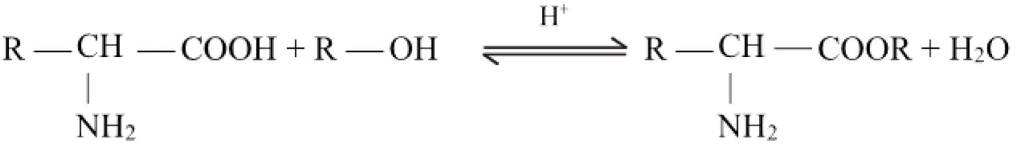


REACTIONS OF AMINO ACIDS

Amino acids undergo many chemical reactions characteristics of either amino group or carboxylic group.

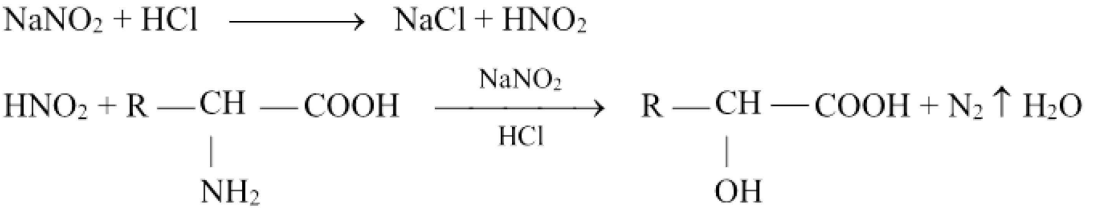
(i) Esterification:

Amino acids form aminoester when treated with an alcohol in the presence of catalytic amount of a strong acid.



(ii) Reaction with Nitrous Acid:

Amino acids react with nitrous acid to produce α-hydroxy carboxylic acid and nitrogen gas.



Test for Amino Acids:

Ninhydrin reacts with amino acids to form intense bluish-violet colour, Ninhydrin is also used to "visualize" amino acids separated by paper chromatography. Ninhydrin is used as locating agent in paper chromatography and thin layer chromatography.

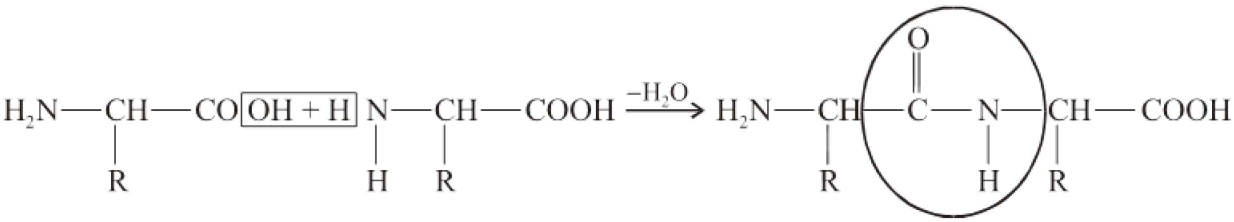
SYNTHESIS OF PEPTIDES AND PROTEINS

Peptide:

The compound which is formed by the combination of two more similar or dissimilar amino acids with the elimination of H_2O molecules.

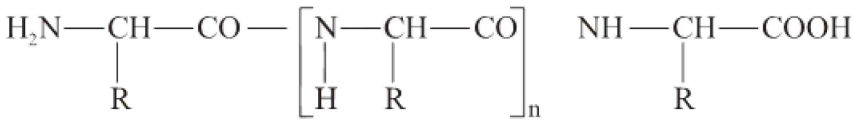
In this case, the carboxyl group of one amino acid and amino group of another amino acid gets condensed with elimination of water. The resulting — CO — NH — linkage is called a peptide linkage.

The formation of peptide is shown below:



Peptide Linkage (Dipeptide)

A dipeptide contains two amino acids, a tripeptide contains three amino acids and polypeptide contains several amino acids in it.



(Tripeptide)

EXERCISE

Q.1 Fill in the blanks:

(i) Formula of malonic acid is ————.

(ii) Methyl nitrile upon acidic hydrolysis produces ————.

(iii) Melting points of carboxylic acids containing even number of carbon atoms are ———— than the next lower and higher members containing odd number of carbon atoms.

(iv) Acetic acid on heating with ———— produces acetic anhydride.

(v) Acid chloride and acid anhydride are called ———— of acid.

(vi) Pure acetic acid is called ————.

(vii) Formula of alanine is ————.

(viii) Proline is a ———— amino acid.

(ix) A peptide having a molecular mass more than 10,000 is called ————.

ANSWERS

(i)	$HOOC\text{-}CH_2\text{-}COOH$	**(ii)**	acetic acid	**(iii)**	higher
(iv)	P_2O_5	**(v)**	derivative	**(vi)**	glacial acetic acid
(vii)	$CH_3\text{-}\underset{\displaystyle NH_2}{\underset{\vert}{CH}}\text{-}COOH$	**(viii)**	neutral	**(ix)**	protein

Q.2 Indicate True or False:

(i) Acetic acid exists as a dimer in benzene.

(ii) First three aliphatic acids have fruity smells.

(iii) Carboxylic acids on reduction with $LiAlH_4$ produce alkenes.

(iv) Acetic acid on dehydration produces CO and H_2.

(v) Sodium formate on heating with soda lime produces $NaHCO_3$ and hydrogen.

(vi) Amino acids exist as Zwitter ion.

(vii) Histidine is an acidic amino acid.

(viii) A peptide having molecular mass upto 10000 is called protein.

(ix) Phthalic acid is a monocarboxylic acid.

(x) Formula of glycine is CH_2COOH.

ANSWERS

(i)	True	**(ii)**	False	**(iii)**	False	**(iv)**	False	**(v)**	False
(vi)	True	**(vii)**	False	**(viii)**	False	**(ix)**	False	**(x)**	False

Q.3 Multiple choice questions. Encircle the correct answer:

(i) Acetic acid is manufactured by:

(a) Distillation **(b)** Fermentation

(c) Ozonolysis **(d)** Esterification

(ii) A carboxylic acid contains:

(a) A hydroxyl group **(b)** A carboxyl group

(c) A hydroxyl and carboxyl group **(d)** A carboxyl and an aldehydic group

(iii) Which acid is used in the manufacture of synthetic fibre:

(a) Formic acid **(b)** Oxalic acid

(c) Carbonic acid **(d)** Acetic acid

(iv) Which of the following derivative cannot be prepared directly from acetic acid:

(a) Acetamide **(b)** Acetyl chloride

(c) Carbonic acid **(d)** Acetic acid

(v) Which reagent is used to reduce a carboxylic group to an alcohol:

(a) H_2/Ni **(b)** H_2/Pt

(c) $NaBH_4$ **(d)** $LiAlH_4$

(vi) The solution of which acid is used for seasoning of food:

(a) Formic acid **(b)** Acetic acid

(c) Benzoic acid **(d)** Butanoic acid

(vii) Organic compounds X and Y react together to form organic compound Z. What type of compounds can X, Y and Z be:

	X	Y	Z
(a)	alcohol	ester	acid
(b)	acid	ester	alcohol
(c)	ester	alcohol	acid
(d)	alcohol	acid	ester

(viii) An aqueous solution of an organic compound reacts with sodium carbonate to produce carbon dioxide gas. Which one of the following could be the organic compound:

(a) $CH_2 = CH - CH_3$ **(b)** $CH_3 - CHO$

(c) $CH_3COOC_2H_5$ **(d)** $CH_3 - CH_2 - COOH$

(ix) Which of the following is not a fatty acid:

(a) Propanoic acid **(b)** Acetic acid

(c) Phthalic acid **(d)** Butanoic acid

(x) Acetamide is prepared by:

(a) Heating ammonium acetate **(b)** Heating methyl cyanide

(c) Heating ethyl acetate **(d)** The hydrolysis of methyl cyanide

ANSWERS

(i)	(b)	**(ii)**	(b)	**(iii)**	(d)	**(iv)**	(a)	**(v)**	(d)
(vi)	(b)	**(vii)**	(d)	**(viii)**	(d)	**(ix)**	(c)	**(x)**	(a)

Q.4 Write down the structural formulae of the following:

(i) Valeric acid **(ii) Propionic acid** **(iii) Oxalic acid**

(iv) Benzoic acid **(v) Acetic anhydride** **(vi) Acetyl chloride**

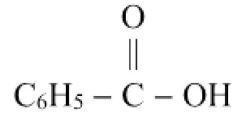
Ans.

Name	**Structural Formula**
Valeric acid	$H_3C - CH_2 - CH_2 - CH_2 - COOH$
Propionic acid	$H_3C-CH_2-\overset{\overset{O}{\|\|}}{C}-OH$

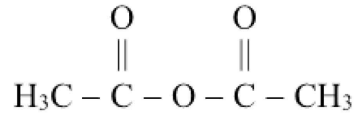
Oxalic acid



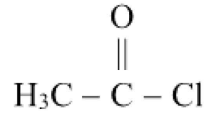
Benzoic acid



Acetic anhydride

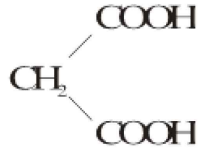


Acetyl chloride

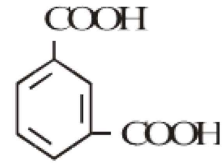


Q.5 Write down the names of the following compounds by IUPAC system:

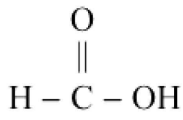
(i)



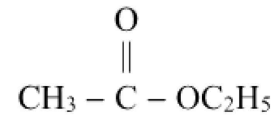
(ii)



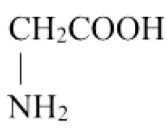
(iii)



(iv)

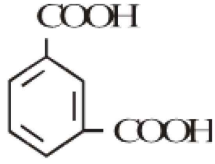
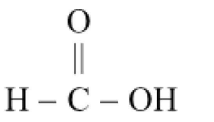


(v)



(vi) $HCOOC_3H_7$

Ans.

Structure	IUPAC Name
$HOOC - CH_2 - COOH$	1, 3-propane dioci acid.
	1, 3-benzene dicarboxylic acid
	Methanoic acid
$CH_3 - COOC_2H_5$	Ethyl acetate
$NH_2 - CH_2 - COOH$	2-aminoethanoic acid
$HCOOC_3H_7$	n-propyl formate

Q.6 How would you convert acetic acid into?

Ans.

(a) Methane:

$$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$$

$$CH_3COONa + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$$

(b) Acetyl chloride:

$$CH_3COOH + SOCl_2 \xrightarrow{\text{Pyridine}} CH_3 - \overset{\overset{O}{\|}}{C} - Cl + SO_2 + HCl$$

(c) Acetamide:

$$CH_3 - \overset{\overset{O}{\|}}{C} - OH + NH_3 \longrightarrow CH_3 - COO^-NH_4^+$$

$$CH_3 - COONH_4^+ \xrightarrow{\text{Heat}} CH_3 - \overset{\overset{O}{\|}}{C} - NH_2 + H_2O$$

(d) Acetic anhydride:

$$2CH_3 - \overset{\overset{O}{\|}}{C} - OH \xrightarrow[-H_2O]{P_2O_5} CH_3 - \overset{\overset{O}{\|}}{C} - O - \overset{\overset{O}{\|}}{C} - CH_3$$

Q.7 (a) What are fatty acids?

(b) What is vinegar? Describe how is vinegar prepared from ethanol?

Ans.

(a) Fatty Acids: Long chain aliphatic carboxylic acids are called fatty acids especially the higher members of carboxylic acids which are obtained by the hydrolysis of fats and oils are called fatty acids. e.g.,

(i) Palamatic acid ($C_{15}H_{31}COOH$)

(ii) Stearic acid ($C_{17}H_{35}COOH$)

(b) Vinegar: A liquid containing 3-6% acetic acid is called vinegar. It is prepared from ethanol which is obtained by the fermentation of sugar, starch etc. Ethanol is oxidized to vinegar by bacteria. It may also be oxidized by using $K_2Cr_2O_7$ + conic. H_2SO_4 as follow:

$$H_3C - CH_2 - OH + [O] \xrightarrow{K_2Cr_2O_7,\ H_2SO_4} H_3C - \overset{\overset{O}{\|}}{C} - H + H_2O$$

$$H_3C - \overset{\overset{O}{\|}}{C} - H + [O] \xrightarrow{K_2Cr_2O_7,\ H_2SO_4} H_3C - \overset{\overset{O}{\|}}{C} - OH$$

Q.8 How would you carry out the following conversions:

(i) Acetic acid into acetamide (ii) Acetic acid into acetone

Ans.

(i) Steps Involved:

(a) $CH_3COOH + NH_3 \longrightarrow CH_3COO^-N^+H_4$

(b) $CH_3COOH^-N^+H_4 \longrightarrow CH_3 - \overset{\overset{O}{\|}}{C} - NH_2 + H_2O$

Acetamide

(ii) Steps Involved:

(a) $2CH_3 - \overset{\overset{O}{\|}}{C} - OH + Ca(HO)_2 \longrightarrow CH_3 - \overset{\overset{O}{\|}}{C} - O - Ca - O - \overset{\overset{O}{\|}}{C} - CH_3 + 2H_2O$

(b) $CH_3 - \overset{\overset{O}{\|}}{C} - O - Ca - O - \overset{\overset{O}{\|}}{C} - CH_3 \xrightarrow{\text{Dry distillation}} CH_3 - \overset{\overset{O}{\|}}{C} - CH_3 + CaCO_3$

Acetone

Q.10 What happens when the following compounds are heated:

(i) Calcium acetate (ii) Sodium formate and soda lime

(iii) Ammonium acetate

Ans.

(i) Calcium acetate on heating produce acetone. The reaction is:

$$CH_3 - \overset{\overset{O}{\|}}{C} - O - Ca - O - \overset{\overset{O}{\|}}{C} - CH_3 \xrightarrow{\text{Heating}} CH_3 - \overset{\overset{O}{\|}}{C} - CH_3 + CaCO_3$$

(ii) Sodium formate on heating with soda lime produces sodium carbonate and hydrogen. The reaction is:

$$H-\overset{\overset{O}{\|}}{C}-ONa + NaOH \xrightarrow[CaO]{Heat} Na_2CO_3 + H_2$$

(iii) Ammonium acetate on heating produces acetamide.

$$CH_3-\overset{\overset{O}{\|}}{C}-ONH_4 \xrightarrow{Heat} CH_3-\overset{\overset{O}{\|}}{C}-NH_2 + H_2O$$

Q.11 What are amino acids? Explain their different types with one example in each case.

Ans. Descriptive question. Consult text book for details.

Q.12 Write a short note on acidic and basic characters of an amino acid.

Ans. On the basis of dipolar ion structure, the acidic and basic reactions of amino acids may be represented as:

(i) **Basic Character:** When an acid is added to an amino acid the carboxylate ion accepts the proton, the basic character is due to this group.

$$R-\underset{\underset{NH_3^+}{|}}{CHCOO^-} + H^+ \longrightarrow R-\underset{\underset{NH_3^+}{|}}{CHCOOH}$$

(accepts the proton)

(ii) **Acidic Character:** When an alkali is added to an amino acid, $-NH_3^+$ group releases the proton and therefore the acidic character is due to this group.

$$R-\underset{\underset{NH_3^+}{|}}{CHCOO^-} + OH^- \longrightarrow R-\underset{\underset{NH_2}{|}}{CHCOO^-} + H_2O$$

Q.13 What is a peptide bond? Write down the formula of a dipeptide.

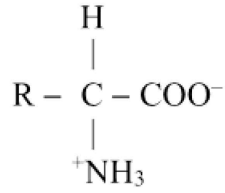
Ans. **Peptide Bond:** A bond formed by the condensation of $-NH_2$ group of one amino acid and carboxylic group of another amino acid is called peptide bond. The peptide bond or linkage is represented as –NH–CO– e.g.,

$$H_2N-\underset{\underset{R}{|}}{CH}-\overset{\overset{O}{\|}}{C}-NH-\underset{\underset{R}{|}}{CH}-COOH$$

(Peptide bond)

Q.14 What are Zwitter ions?

Ans. **Zwitter Ion:** The dipolar ion is called Zwitter ion. It has positive as well as negative ends within the same molecule. Amino acids exist as Zwitter ion.

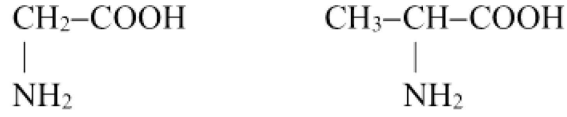


Zwitter ion

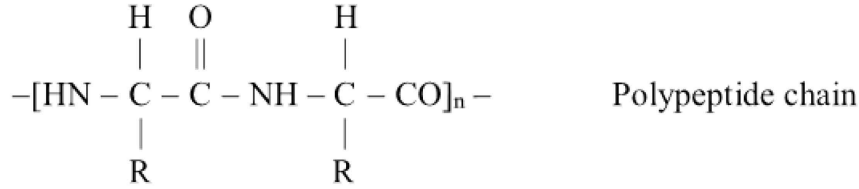
Q.15 What are α-amino acids, proteins and peptides? How are they related?

Ans. **α-amino Acids:** The acids in which amino group are attached to α-carbon are called α-amino acids. e.g.,

Glycine **Alanine**



When amino acids link with each other by peptide bonds a long chain are called polypeptide.



Polypeptide chain

Proteins: If molecular mass of polypeptide chain is more than 10000 then it is called proteins.

Peptide: If molecular mass of polypeptide chain is upto 10000 then it is called peptide.

Q.16 Study the facts given in (a), (b) and (c) below and then answer questions which follow:

(a) A is an organic compound made up of C, H and O. It has a vapour density 15. [Hint: Molecular mass = 2 × Vapour density].

(b) On reduction A gives a compound 'X' which has the following properties:

(i) X is a colourless liauid miscible with water.

(ii) X is neutral to litmus.

(iii) When X is warmed with a few drops of conc. H_2SO_4 followed by a little salicylic acid a characteristic smell is produced.

(c) When X is subjected to strong oxidation, it gives compound B, which has the following properties:

(i) B is a pungent smelling mobile liquid.

(ii) It is miscible with water, alcohol or ether.

(iii) It is corrosive and produces blisters on contact with skin.

(iv) B can be obtained by passing the vapours of A with air over platinum black catalyst.

(v) B liberates H_2 with sodium.

(vi) It gives CO_2 with $NaHCO_3$.

1. What is the molecular mass of A?

2. Identify A, X and B.

3. Give five appropriate reactions to confirm the identities of A, X and B.

4. State one large-scale use of either A, X or B.

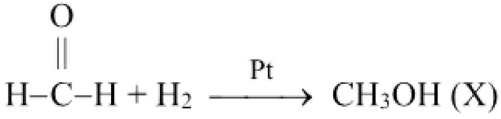
Ans.

(a) Molecular mass = 2 × Vapour density

= 2 × 15 = 30 a.m.u

(b) The compound having C, H and O may be some aldehyde or ketone and not an alcohol. Smallest ketone is acetone having molecular mass 58 a.m.u. The simplest aldhyde with molecular mass 30 a.m.u is form aldehyde.

A = HCHO

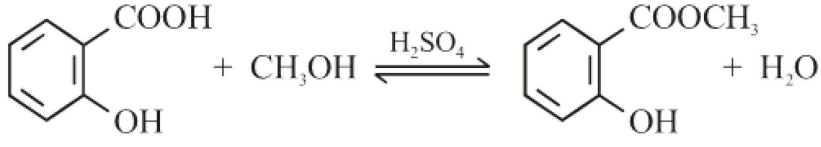


Properties of X(CH_3OH):

(i) CH_3OH is colourless liquid, miscible with water.

(ii) CH_3O is neutral to litmus.

(iii) When CH_3OH is warmed with few drops of conc. H_2SO_4 and salicylic acid, a characteristic smell of methyl salicylate is obtained.



(c) When CH_3OH (X) undergoes oxidation, if changes to formic acid (B).

$$CH_3OH \xrightarrow{[O]} HCHO \xrightarrow{[O]} HCOOH$$

Properties of Formic Acid (B):

(i) HCOOH has pungent smell.

(ii) It is miscible with water, alcohol and ether due to hydrogen bonding.

(iii) It is corrosive and produce blisters when contact with skin.

(iv) "A" on air oxidation in the presence of catalyst changes to B.

$$\underset{\text{(A)}}{H-\overset{\overset{O}{\|}}{C}-H} + \underset{\text{air}}{[O]} \xrightarrow{\text{Pt-black}} \underset{\text{(B)}}{H-\overset{\overset{O}{\|}}{C}-OH}$$

(v) $HCOOH + 2Na \longrightarrow 2HCOONa + CO_2 + H_2O$

A = HCHO B = HCOOH C = CH_3OH

DO YOU KNOW?

(1) Acetyl salicylic acid is called asprin.

(2) Grignard's reagents react with CO_2 to form carboxylic acids.

(3) Amyl acetate has banana flavour.

(4) Octyl acetate has orange flavour.

(5) Ethyl butyrate has pine apple flavour.

(6) Benzyl acetate has Jasmine flavour.

(7) Acetic acid solidefies at 17°C as ice like mass. It is called glacial acetic acid.

(8) The amino acids which the body can synthesize are called non-essential amino acids.

(9) The amino acids which the body is not able to synthesize are called essential amino acids.

(10) Poly peptide having molar mass more than 10,000 is called protein.

(11) Amino acids exist as Zwitter ion.

(12) Alanine is neutral amino acid.

(13) Aspartic acid is acidic amino acid.

(14) Lysine is basic amino acid.

(15) Amyl-butyrate has apricot flavour.

(16) Ethyl-isovalerate has apple flavour.

(17) Methyl-phenyl acetate is present in honey.

(18) Methyl cinamate is present in strawberry.

(19) Methyl acetate is present in glue.

CHAPTER 13

CARBOXYLIC ACID

MULTIPLE CHOICE QUESTIONS

1. Ninhydrin reacts with amino acid to form product which has colour:

(a) Blue **(b)** Violet

(c) Bluish violet **(d)** Red

2. Slight oxidation of primary alcohol gives:

(a) Ketone **(b)** Organic acid

(c) Aldehyde **(d)** An ester

3. Which of the following is the strongest acid:

(a) HCOOH **(b)** CH_3COOH

(c) $CH_3 - CH_2 - COOH$ **(d)** $Cl - CH_2 - COOH$

4. Which of the following esters shows the flavour of orange:

(a) Benzyl acetate **(b)** Iso-butyl formate

(c) Octyl acetate **(d)** Ethyl butyrate

5. Which acid is used in the manufacture of synthetic fibre:

(a) Formic acid **(b)** Acetic acid

(c) Carbonic acid **(d)** Benzoic acid

6. Some amino acids are most important because they are the final product of hydrolysis of peptide and protein and they are:

(a) α-amino acid **(b)** β-amino acid

(c) γ-amino acid **(d)** All of the above

7. In amino acid proton is transferred from one point to the other point and this dipolar ion is called:

(a) Oxonium ion **(b)** Carbonium ion

(c) Zwitter ion **(d)** Carbanion

8. Which of the following is neutral amino acid:

(a) Glycine **(b)** Histidine

(c) Lysine **(d)** Aspartic acid

9. The amino acid which body can synthesize are called:

(a) Essential **(b)** Non-essential

(c) Acidic **(d)** Basic

10. Amino acids are classified into following types:

(a) Acidic **(b)** Basic

(c) Neutral **(d)** All

11. By convention a peptide having molecular mass upto 10,000 is called:

(a) Peptide **(b)** Polypeptide

(c) Protein **(d)** Dipeptide

12. Acetic acid is manufactured commercially by:

(a) Distillation **(b)** Fermentation

(c) Ozonolysis **(d)** Esterification

13. Which of the following derivative can't be prepared directly from acetic acid:

(a) Acetic anhydride **(b)** Acetyl chloride

(c) Acetamide **(d)** Ethyl ethanoate

14. Which reagent is used to reduce a carboxylic group to an alcohol:

(a) H_2/Ni **(b)** HI/P

(c) $NaBH_4$ **(d)** $LiAlH_4$

15. The solution of which acid is used for seasoning of food:

(a) Formic acid **(b)** Acetic acid

(c) Benzoic acid **(d)** Butanoic acid

16. Which one of the following element is not present in all proteins:

(a) Carbon **(b)** Hydrogen

(c) Nitrogen **(d)** Sulphur

17. **The IUPAC name of** $\begin{matrix} CH_2 - COOH \\ | \\ CH_2 - COOH \end{matrix}$ **is:**

(a) Succinic acid **(b)** Butanoic acid

(c) Dibutanoic acid **(d)** But-1, 4-dioc acid

18. $C_2H_5Br \xrightarrow{KCN} A \xrightarrow{H_2O/H^+} B$

The compound 'B' is:

(a) Acetic acid **(b)** Propanoic acid

(c) Ethyl alcohol **(d)** Propionaldehyde

19. **Which of the following will react with both ethanol and ethanoic acid at room temperature:**

(a) $CaCO_3$ **(b)** CuO

(c) Na-metal **(d)** CH_3OH

20. **Which one of the following is not an amino acid:**

(a) Alanine **(b)** Glycine

(c) Aspartic acid **(d)** Aniline

21. **Which one of the following metal can evolve hydrogen from acetic acid:**

(a) Na **(b)** Fe

(c) Al **(d)** Cu

22. **Which one of the following is not a dicarboxylic acid:**

(a) Malonic acid **(b)** Valeric acid

(c) Maleic acid **(d)** Succinic acid

23. **The compound** $\begin{matrix} HO - CH - COOH \\ | \\ HO - CH - COOH \end{matrix}$ **is commonly called:**

(a) Lactic acid **(b)** Citric acid

(c) Tartaric acid **(d)** Succinic acid

24. **Reverse of esterification is known as:**

(a) Trans esterification **(b)** Dehydration

(c) Hydrolysis **(d)** Decarboxylation

25. The general formula of monocarboxylic acid:

(a) C_nH_nCOOH **(b)** $C_nH_{2n+1}COOH$

(c) $C_nH_{2n}COOH$ **(d)** $C_nH_{2n-2}COOH$

26. The simplest of all amino acid:

(a) Lysine **(b)** Glycine

(c) Alanine **(d)** Aspartic acid

27. Carboxylic acid can be changed to acid chloride by the treatment with:

(a) S_2Cl_2 **(b)** $SOCl_2$

(c) HCl **(d)** HOCl

28. Which product is not formed when acetic acid reacts with $SOCl_2$ (Thionyl chloride):

(a) CH_3Cl **(b)** CH_3COCl

(c) HCl **(d)** SO_2

29. Which one of the following reagent is used to convert acetic acid to ethane?

(a) $LiAlH_4$ **(b)** HI and Red P

(c) P_2O_5 **(d)** $SOCl_2$ and pyridine

30. The weakest carboxylic acid:

(a) HCOOH **(b)** CH_3CH_2COOH

(c) CH_3COOH **(d)** $ClCH_2COOH$

answers

1.	(c)	**2.**	(c)	**3.**	(a)	**4.**	(c)	**5.**	(b)
6.	(a)	**7.**	(c)	**8.**	(a)	**9.**	(b)	**10.**	(d)
11.	(b)	**12.**	(b)	**13.**	(c)	**14.**	(d)	**15.**	(b)
16.	(d)	**17.**	(d)	**18.**	(b)	**19.**	(c)	**20.**	(d)
21.	(a)	**22.**	(b)	**23.**	(c)	**24.**	(c)	**25.**	(b)
26.	(b)	**27.**	(b)	**28.**	(a)	**29.**	(b)	**30.**	(b)

SOLVED EXERCISE

Q.1 Fill in the blanks:

(i) Formula of malonic acid is ————.

(ii) Methyl nitrile upon acidic hydrolysis produces ————.

(iii) Melting points of carboxylic acids containing even number of carbon atoms are ———— than the next lower and higher members containing odd number of carbon atoms.

(iv) Acetic acid on heating with ———— produces acetic anhydride.

(v) Acid chloride and acid anhydride are called ———— of acid.

(vi) Pure acetic acid is called ————.

(vii) Formula of alanine is ————.

(viii) Proline is a ———— amino acid.

(ix) A peptide having a molecular mass more than 10,000 is called ————.

answers

(i)	$HOOC\text{-}CH_2\text{-}COOH$	**(ii)**	acetic acid	**(iii)**	higher
(iv)	P_2O_5	**(v)**	derivative	**(vi)**	glacial acetic acid
(vii)	$CH_3\text{-}\underset{\displaystyle NH_2}{\underset{\vert}{CH}}\text{-}COOH$	**(viii)**	neutral	**(ix)**	protein

Q.2 Indicate True or False:

(i) Acetic acid exists as a dimer in benzene.

(ii) First three aliphatic acids have fruity smells.

(iii) Carboxylic acids on reduction with $LiAlH_4$ produce alkenes.

(iv) Acetic acid on dehydration produces CO and H_2.

(v) Sodium formate on heating with soda lime produces $NaHCO_3$ and hydrogen.

(vi) Amino acids exist as Zwitter ion.

(vii) Histidine is an acidic amino acid.

(viii) A peptide having molecular mass upto 10000 is called protein.

(ix) Phthalic acid is a monocarboxylic acid.

(x) Formula of glycine is CH_2COOH.

answers

(i)	True	**(ii)**	False	**(iii)**	False	**(iv)**	False	**(v)**	False
(vi)	True	**(vii)**	False	**(viii)**	False	**(ix)**	False	**(x)**	False

Q.3 Multiple choice questions. Encircle the correct answer:

(i) Acetic acid is manufactured by:

(a) Distillation **(b)** Fermentation

(c) Ozonolysis **(d)** Esterification

(ii) A carboxylic acid contains:

(a) A hydroxyl group **(b)** A carboxyl group

(c) A hydroxyl and carboxyl group **(d)** A carboxyl and an aldehydic group

(iii) Which acid is used in the manufacture of synthetic fibre:

(a) Formic acid **(b)** Oxalic acid

(c) Carbonic acid **(d)** Acetic acid

(iv) Which of the following derivative cannot be prepared directly from acetic acid:

(a) Acetamide **(b)** Acetyl chloride

(c) Carbonic acid **(d)** Acetic acid

(v) Which reagent is used to reduce a carboxylic group to an alcohol:

(a) H_2/Ni **(b)** H_2/Pt

(c) $NaBH_4$ **(d)** $LiAlH_4$

(vi) The solution of which acid is used for seasoning of food:

(a) Formic acid **(b)** Acetic acid

(c) Benzoic acid **(d)** Butanoic acid

(vii) **Organic compounds X and Y react together to form organic compound Z. What type of compounds can X, Y and Z be:**

	X	Y	Z
(a)	alcohol	ester	acid
(b)	acid	ester	alcohol
(c)	ester	alcohol	acid
(d)	alcohol	acid	ester

(viii) **An aqueous solution of an organic compound reacts with sodium carbonate to produce carbon dioxide gas. Which one of the following could be the organic compound:**

(a) $CH_2 = CH - CH_3$ **(b)** $CH_3 - CHO$

(c) $CH_3COOC_2H_5$ **(d)** $CH_3 - CH_2 - COOH$

(ix) **Which of the following is not a fatty acid:**

(a) Propanoic acid **(b)** Acetic acid

(c) Phthalic acid **(d)** Butanoic acid

(x) **Acetamide is prepared by:**

(a) Heating ammonium acetate **(b)** Heating methyl cyanide

(c) Heating ethyl acetate **(d)** The hydrolysis of methyl cyanide

answers

(i)	(b)	**(ii)**	(b)	**(iii)**	(d)	**(iv)**	(a)	**(v)**	(d)
(vi)	(b)	**(vii)**	(d)	**(viii)**	(d)	**(ix)**	(c)	**(x)**	(a)

Q.4 **Write down the structural formulae of the following:**

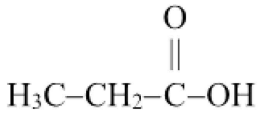
(i) Valeric acid **(ii) Propionic acid** **(iii) Oxalic acid**

(iv) Benzoic acid **(v) Acetic anhydride** **(vi) Acetyl chloride**

Ans.

Name	**Structural Formula**
Valeric acid	$H_3C - CH_2 - CH_2 - CH_2 - COOH$

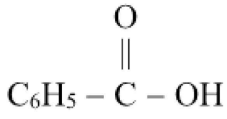
Propionic acid



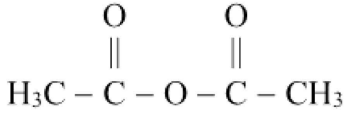
Oxalic acid



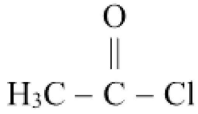
Benzoic acid



Acetic anhydride

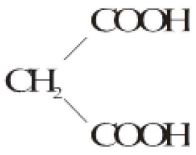


Acetyl chloride

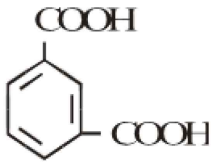


Q.5 Write down the names of the following compounds by IUPAC system:

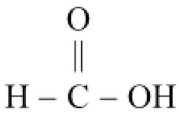
(i)



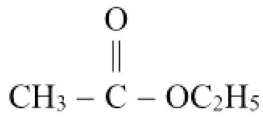
(ii)



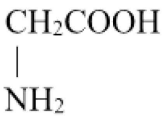
(iii)



(iv)

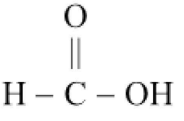


(v)



(vi) $HCOOC_3H_7$

Ans.

Structure	UPAC Name
$HOOC - CH_2 - COOH$	1, 3-propane dioic acid.
	1, 3-benzene dicarboxylic acid
	Methanoic acid
$CH_3 - COOC_2H_5$	Ethyl acetate

$NH_2 - CH_2 - COOH$	α-aminoethanoic acid
$HCOOC_3H_7$	n-propyl formate

Q.6 How would you convert acetic acid into?

Ans.

(a) Methane:

$$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$$

$$CH_3COONa + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$$

(b) Acetyl chloride:

$$CH_3COOH + SOCl_2 \xrightarrow{\text{Pyridine}} CH_3 - \overset{\overset{O}{\|}}{C} - Cl + SO_2 + HCl$$

(c) Acetamide:

$$CH_3 - \overset{\overset{O}{\|}}{C} - OH + NH_3 \longrightarrow CH_3 - COO^-NH_4^+$$

$$CH_3 - COONH_4^+ \xrightarrow{\text{Heat}} CH_3 - \overset{\overset{O}{\|}}{C} - NH_2 + H_2O$$

(d) Acetic anhydride:

$$2CH_3 - \overset{\overset{O}{\|}}{C} - OH \xrightarrow[-H_2O]{P_2O_5} CH_3 - \overset{\overset{O}{\|}}{C} - O - \overset{\overset{O}{\|}}{C} - CH_3$$

Q.7 (a) What are fatty acids?

(b) What is vinegar? Describe how is vinegar prepared from ethanol?

Ans.

(a) Fatty Acids: Long chain aliphatic carboxylic acids are called fatty acids especially the higher members of carboxylic acids which are obtained by the hydrolysis of fats and oils are called fatty acids. e.g.,

(i) Palmitic acid ($C_{15}H_{31}COOH$)

(ii) Stearic acid ($C_{17}H_{35}COOH$) etc.

(b) **Vinegar:** A liquid containing 3-6% acetic acid is called vinegar. It is prepared from ethanol which is obtained by the fermentation of sugar, starch etc. Ethanol is oxidized to vinegar by bacteria. It may also be oxidized by using $K_2Cr_2O_7$ + conc. H_2SO_4 as follow:

$$H_3C-CH_2-OH + [O] \xrightarrow{K_2Cr_2O_7,\ H_2SO_4} H_3C-\overset{O}{\overset{\|}{C}}-H + H_2O$$

$$H_3C-\overset{O}{\overset{\|}{C}}-H + [O] \xrightarrow{K_2Cr_2O_7,\ H_2SO_4} H_3C-\overset{O}{\overset{\|}{C}}-OH$$

Q.8 **How would you carry out the following conversions:**

(i) Acetic acid into acetamide **(ii) Acetic acid into acetone**

Ans.

(i) **Steps Involved:**

(a) $$CH_3COOH + NH_3 \longrightarrow CH_3COO^-N^+H_4$$

(b) $$CH_3COOH^-N^+H_4 \longrightarrow CH_3-\overset{O}{\overset{\|}{C}}-NH_2 + H_2O$$

Acetamide

(ii) **Steps Involved:**

(a) $$2CH_3-\overset{O}{\overset{\|}{C}}-OH + Ca(OH)_2 \longrightarrow CH_3-\overset{O}{\overset{\|}{C}}-O-Ca-O-\overset{O}{\overset{\|}{C}}-CH_3 + 2H_2O$$

(b) $$CH_3-\overset{O}{\overset{\|}{C}}-O-Ca-O-\overset{O}{\overset{\|}{C}}-CH_3 \xrightarrow{\text{Dry distillation}} CH_3-\overset{O}{\overset{\|}{C}}-CH_3 + CaCO_3$$

Acetone

Q.10 **What happens when the following compounds are heated:**

(i) Calcium acetate **(ii) Sodium formate and soda lime**

(iii) Ammonium acetate

Ans.

(i) Calcium acetate on heating produce acetone. The reaction is:

$$CH_3-\overset{\overset{O}{\|}}{C}-O-Ca-O-\overset{\overset{O}{\|}}{C}-CH_3 \xrightarrow{\text{Heating}} CH_3-\overset{\overset{O}{\|}}{C}-CH_3 + CaCO_3$$

(ii) Sodium formate on heating with soda lime produces sodium carbonate and hydrogen. The reaction is:

$$H-\overset{\overset{O}{\|}}{C}-ONa + NaOH \xrightarrow[CaO]{\text{Heat}} Na_2CO_3 + H_2$$

(iii) Ammonium acetate on heating produces acetamide. As following:

$$CH_3-\overset{\overset{O}{\|}}{C}-ONH_4 \xrightarrow{\text{Heat}} CH_3-\overset{\overset{O}{\|}}{C}-NH_2 + H_2O$$

Q.11 What are amino acids? Explain their different types with one example in each case.

Ans. Descriptive question. Consult text book for details.

Q.12 Write a short note on acidic and basic characters of an amino acid.

Ans. On the basis of dipolar ion structure, the acidic and basic reactions of amino acids may be represented as:

(i) **Basic Character:** When an acid is added to an amino acid the carboxylate ion accepts the proton, the basic character is due to this group.

$$R-\underset{\underset{NH_3^+}{|}}{CHCOO^-} + H^+ \longrightarrow R-\underset{\underset{NH_3^+}{|}}{CHCOOH}$$

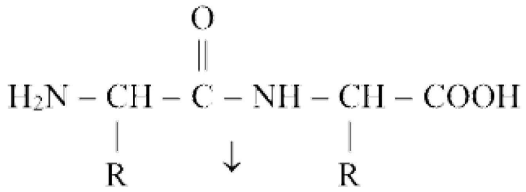
(accepts the proton)

(ii) **Acidic Character:** When an alkali is added to an amino acid, $-NH_3^+$ group releases the proton and therefore the acidic character is due to this group.

$$R-\underset{\underset{NH_3^+}{|}}{CHCOO^-} + OH^- \longrightarrow R-\underset{\underset{NH_2}{|}}{CHCOO^-} + H_2O$$

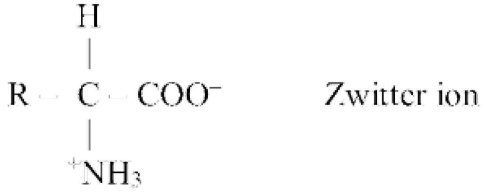
Q.13 What is a peptide bond? Write down the formula of a dipeptide.

Ans. **Peptide Bond:** A bond formed by the condensation of $-NH_2$ group of one amino acid and carboxylic group of another amino acid is called peptide bond. The peptide bond or linkage is represented as –NH–CO– e.g.,



Q.14 What are Zwitter ions?

Ans. **Zwitter Ion:** The dipolar ion is called Zwitter ion. It has positive as well as negative ends within the same molecule. Amino acids exist as Zwitter ion.

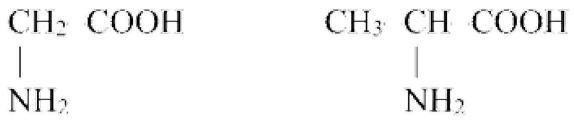


Zwitter ion

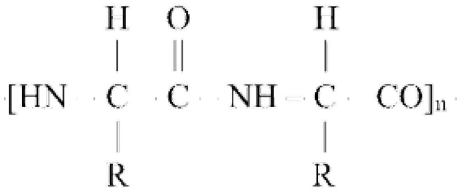
Q.15 What are α-amino acids, proteins and peptides? How are they related?

Ans. **α-amino Acids:** The acids in which amino group are attached to α-carbon are called α-amino acids. e.g.,

Glycine **Alanine**



When amino acids link with each other by peptide bonds a long chain are called polypeptide.



Polypeptide chain

Proteins: If molecular mass of polypeptide chain is more than 10000 then it is called proteins.

Peptide: If molecular mass of polypeptide chain is upto 10000 then it is called peptide.

Q.16 Study the facts given in (a), (b) and (c) below and then answer questions which follow:

(a) A is an organic compound made up of C, H and O. It has a vapour density 15. [Hint: Molecular mass = 2 × Vapour density].

(b) On reduction A gives a compound 'X' which has the following properties:

(i) X is a colourless liauid miscible with water.

(ii) X is neutral to litmus.

(iii) When X is warmed with a few drops of conc. H_2SO_4 followed by a little salicylic acid a characteristic smell is produced.

(c) When X is subjected to strong oxidation, it gives compound B, which has the following properties:

(i) B is a pungent smelling mobile liquid.

(ii) It is miscible with water, alcohol or ether.

(iii) It is corrosive and produces blisters on contact with skin.

(iv) B can be obtained by passing the vapours of A with air over platinum black catalyst.

(v) B liberates H_2 with sodium.

(vi) It gives CO_2 with $NaHCO_3$.

1. What is the molecular mass of A?

2. Identify A, X and B.

3. Give five appropriate reactions to confirm the identities of A, X and B.

4. State one large-scale use of either A, X or B.

Ans.

(a) Molecular mass = 2 × Vapour density

= 2 × 15 = 30 a.m.u

(b) The compound having C, H and O may be some aldehyde or ketone and not an alcohol. Smallest ketone is acetone having molecular mass 58 a.m.u. The simplest aldhyde with molecular mass 30 a.m.u is form aldehyde.

A = HCHO

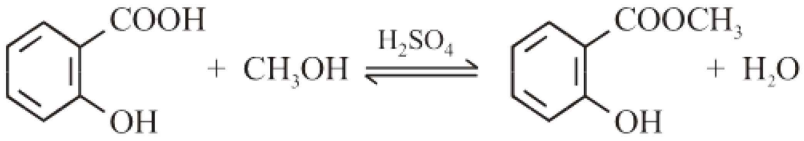
$$H-\overset{\overset{O}{\|}}{C}-H + H_2 \xrightarrow{Pt} CH_3OH\ (X)$$

Properties of X(CH_3OH):

(i) CH_3OH is colourless liquid, miscible with water.

(ii) CH_3O is neutral to litmus.

(iii) When CH_3OH is warmed with few drops of conc. H_2SO_4 and salicylic acid, a characteristic smell of methyl salicylic acid is obtained.



(c) When CH_3OH (X) undergoes oxidation, if changes to formic acid (B).

$$CH_3OH \xrightarrow{[O]} HCHO \xrightarrow{[O]} HCOOH$$

Properties of Formic Acid (B):

(i) HCOOH has pungent smell.

(ii) It is miscible with water, alcohol and ether due to hydrogen bonding.

(iii) It is corrosive and produce blisters when contact with skin.

(iv) "A" on air oxidation in the presence of catalyst changes to B.

$$\underset{\text{(A)}}{H-\overset{\overset{O}{\|}}{C}-H} + [O] \xrightarrow[\text{air}]{\text{Pt-black}} \underset{\text{(B)}}{H-\overset{\overset{O}{\|}}{C}-OH}$$

(v) $HCOOH + 2Na \longrightarrow 2HCOONa + CO_2 + H_2O$

A = HCHO B = HCOOH C = CH_3OH

DO YOU KNOW?

1. Acetyl salicylic acid is called asprin.
2. Grignard's reagents react with CO_2 to form carboxylic acids.
3. Amyl acetate has banana flavour.
4. Octyl acetate has orange flavour.
5. Ethyl butyrate has pine apple flavour.
6. Benzyl acetate has Jasmine flavour.
7. Acetic acid solidifies at 17°C as ice like mass. It is called glacial acetic acid.
8. The amino acids which the body can synthesize are called non-essential amino acids.
9. The amino acids which the body is not able to synthesize are called essential amino acids.
10. Poly peptide having molar mass more than 10,000 is called protein.
11. Amino acids exist as Zwitter ion.
12. Alanine is neutral amino acid.
13. Aspartic acid is acidic amino acid.
14. Lysine is basic amino acid.
15. Amyl-butyrate has apricot flavour.
16. Formula of tear-gas is $C_6H_5 - CO - CH_2Cl$.

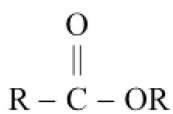
SHORT QUESTIONS

Q.1 What are fatty acids?

Ans. The aliphatic mono-carboxylic acids are also called fatty acids. These acids are obtained by the hydrolysis of fats having long chain alkyl group and oils which are natural glycerides or ester of glycerol.

Q.2 What is an ester?

Ans. Esters are the derivatives of carbocylic acids which are formed when carboxylic acid reacts with alcohol in the presence of H_2SO_4.



$CH_3COOC_2H_5$ (ethyl acetate)

All fats and oils are esters.

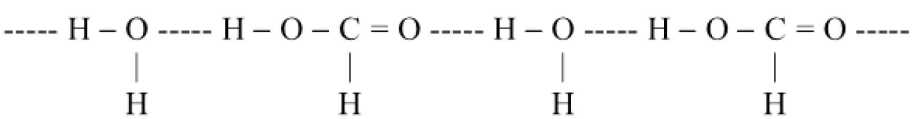
Q.3 Define esterification with one example?

Ans. Alcohol and carboxylic acid reacts in the presence of conc. H_2SO_4 to form an ester and this process is called esterification.



Q.4 Lower carboxylic acids are water soluble, why?

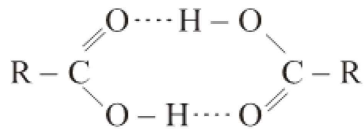
Ans. Lower carboxylic acids are water soluble due to hydrogen bonding with water.



The solubility of carboxylic acid decreases by increasing chain length of alkyl group which is non-polar and insoluble.

Q.5 In non-polar solvent like benzene the molecular mass of carboxylic acid becomes double?

Ans. In non-polar solvents like benzene, carboxylic acids exist in dimeric form. When molecular mass is determined that dimer behave like a single particle and molecular mass becomes double.



dimer of carboxylic acid

Q.6 Melting point of even number of carboxylic acids are greater than melting points of odd number of carboxylic acids, why?

Ans. Carboxylic acids with even number of carbon atoms have more closer packing because terminal groups are present in opposite direction. In carboxylic acids with odd carbons have terminal groups in same direction and has less closer packing.



Carboxylic acid with even carbons.



Carboxylic acid with odd carbons.

For example, melting point of butyric acid is –6°C while that of valeric acid is –36°C.

Q.7 Give two reactions of carboxylic acid in which O-H bond is broken?

Ans. (i) $CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$

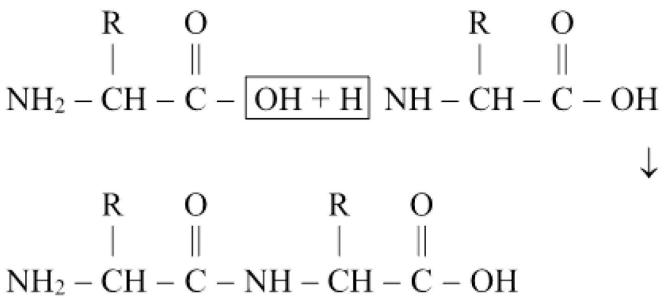
(ii) $2CH_3COOH + 2Na \longrightarrow 2CH_3COONa + H_2$

Q.8 What is difference between essential and non-essential amino acids?

Ans. The amino acids which are synthesized in our body are called non-essential amino acids. Out of 20 amino acids 10 are non-essential. The amino acids which are not synthesized by our body are called essential amino acids.

Q.9 What is peptide bond?

Ans. If carboxylic group of one amino acid and amino group of other amino acid get condensed with elimination of H_2O molecule, the resulting CO-NH-bond is called peptide bond.



Peptide bond

Q.10 What is meant by internal salt?

Ans. Amino acids exist in the form of Zwitter ions or dipolar ion. This ion is formed by the transfer of proton from carboxylic acid to NH_2 group. This dipolar structure is called internal salt.

