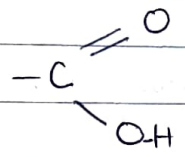
CARBOXYLIC ACIDS

Carboxylic acids are formed by replacing one or more hydrogen atom in an alkane with -COOH group.

- The general formula of carboxylic acids is $C_nH_{2n+1}COOH$ when $n \geq 0$ or R-COOH where R is an alkyl group.

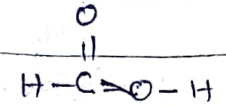
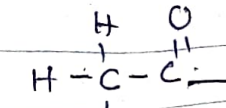
Also it can be represented by general formula $C_nH_{2n}O_2$ when $n \geq 1$

Structural formula is given by



Natural source, of Organic acids

1. Methanoic (formic) acid is found in bees and ants which use it as a defence against the enemy, Stinging nettle plant.
2. Ethanoic (acetic) acid is found in rotting fruits.
3. Octadecanoic (stearic) acid is found in many natural fats and oils.
4. Ascorbic acid (vitamin C) is found in citrus fruits and tomatoes.
5. 2-hydroxy propanoic (lactic) is found in sour milk and in animal muscles.
6. 2-hydroxypropan-1,2,3-trikarboxylic (citric) acid is found in citrus fruits such as lemons, oranges and lime fruits.

Acid	Formula	Structural formula	Condensed formula.
Methanoic acid	HCOOH		HCOOH
Ethanoic acid	~~CH_3COOH~~ $C_2H_4O_2$		(Acetic acid) CH_3COOH

"Refer to the end of the ~~to~~ Carboxylic acid."

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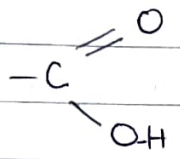

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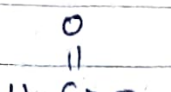
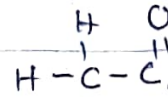
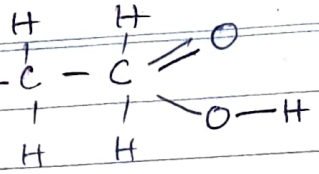
Methanoic acid	$HCOOH$		$HCOOH$
Ethanoic acid	~~CH_3COOH~~ $C_2H_4O_2$		(Acetic acid) CH_3COOH

"Refer to the end of the ~~to~~ Carboxylic acid."

Propanoic acid $C_3H_6O_2$



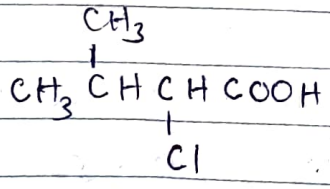
Nomenclature of Carboxylic Acids.

- Unlike in alkanols, the functional group can only be at the end of the carbon chain.
- The position of the carboxylic group ($-COOH$) is therefore not indicated in the name.

1. Find the longest continuous carbon chain containing the carboxylic group.
2. Name this longest chain by replacing the ending -e of the corresponding alkane with -oic acid.
3. Number the carbon atoms in this longest chain beginning at the carboxylic group.
4. Locate and name the attached alkyl group.
5. Complete the name for the carboxylic acid molecule by combining the two component parts together.

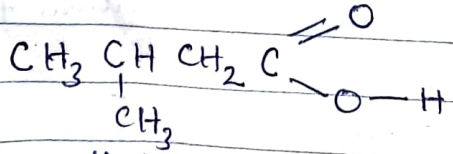
a) (i) $CH_3CH_2CH_2COOH$ - butanoic acid.

(ii)



2-chloro-3-methylbutanoic acid.

(iii)



3-methylbutanoic acid.

Isomerism in Carboxylic Acids

The first three members have no isomers (methanoic, ethanoic and propanoic acid).

1 Butanoic acid

(i) $CH_3CH_2CH_2COOH$

butanoic acid

(ii) $CH_3CH(CH_3)COOH$

2-methylpropanoic acid.

2 Pentanoic acid (C_4H_9COOH) or $(C_5H_{10}O_2)$.

(i) $CH_3(CH_2)_3COOH$

Pentanoic acid

(ii) $CH_3CH(CH_3)CH_2COOH$

3-methylbutanoic acid

(iii) $CH_3CH_2CH(CH_3)COOH$

2-methyl butanoic acid

(iv) $CH_3C(CH_3)_2COOH$

2, 2-dimethylpropanoic acid.

Laboratory Preparation of Ethanoic Acid

It is prepared by oxidation of alcohol using potassium dichromate (VI) solution in the presence of dilute sulphuric acid.

$$C_2H_5OH + 2[O] \xrightarrow[K_2Cr_2O_7]{\text{acidified}} CH_3COOH + H_2O$$

PROPERTIES OF CARBOXYLIC ACIDS

(a) Physical Properties

1. Boiling Point & Melting Point increase as the number of carbon / molecular mass increases.
2. Ethanoic acid is soluble in water.
3. Ethanoic acid is a colourless, corrosive acid with a typical smell and a sour taste.
4. Acetic acid (ethanoic acid) freezes at 17°C to form an icy shine mass called glacial acetic acid.
5. Acetic acid is a good solvent for iodine, sulphur and phosphorus.

(b) Chemical Properties

1. Ethanoic acid is a weak acid which turns blue litmus paper red (Acid properties of acetic acid).

$$CH_3COOH + H_2O \rightleftharpoons CH_3COO^-(aq) + H^+(aq)$$

2. Neutralization reaction by alkalis and basis

$$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$$

Sodium ethanoate

3. Acetic acid gives effervescence of carbon dioxide with carbonates and bicarbonates

$$CH_3COOH + Na_2CO_3 \rightarrow CH_3COONa + H_2O + CO_2$$

$$CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2.$$

3 Esterification reaction - is the reaction in which carboxylic acid reacts with an alcohol to form an ester.

$CH_3COOH + CH_2CH_3OH \xrightarrow[\text{conc}]{H_2SO_4} CH_3COOCH_2CH_3 + H_2O$

ethyl ethanoate.

4 Reaction with metals

$CH_3COOH + Fe \rightarrow (CH_3COO)_2Fe_{(aq)} + H_{2(g)}$

SAPONIFICATION

The process of making soap is called Saponification.

When higher acids with large number of carbon atoms in them (fatty acids) are hydrolysed with inorganic bases like NaOH, they form the corresponding salts of the fatty acids called soaps as they have cleansing action.

Fat or oil + Sodium hydroxide → soap + glycerol.

Example

$C_{17}H_{35}COOH + NaOH \rightarrow C_{17}H_{35}COONa + C_2H_5OH$

(Salt of stearic acid. - soap).

Detergents are cleansing agents that improve the cleansing power / properties of water.

- A detergent therefore should be able to
  (i) dissolve substances which water cannot eg. grease, oil fat
  (ii) be washed away after cleaning

There are two types of detergents

(i) Soapy detergents usually called soap is derived from reacting concentrated sodium hydroxide solution with stearic acid (octadecanoic acid).

$NaOH_{(aq)} + C_{17}H_{35}COOH \rightarrow C_{17}H_{35}COONa + C_2H_5OH$

(ii) Soapless Detergents

Soapless detergents usually called detergent is a long chain salt formed from by-products of fractional distillation of Crude oil.

But also it can be made by reacting

(i) Concentration sulphuric (VI) acid with long chain alkanol eg octadecanol to form alkyl hydrogen sulphate(VI).

1. $C_{17}H_{35}CH_2OH + H_2SO_4 \rightarrow C_{17}H_{35}-CH_2-O-SO_3^-H^+ + H_2$

(ii) Alkyl hydrogen sulphate (VI) is then neutralized with alkali (NaOH)

$C_{17}H_{35}-CH_2-O-SO_3^-H^+_{(aq)} + NaOH \rightarrow C_{17}H_{35}CH_2-O-SO_3^-N$
$+ H_2O.$

Advantages of soapless detergents

(i) do not form scum with hard water
(ii) Are cheap to manufacture / buying.
(iii) Are made from petroleum products but soap is made from fats / oil for human consumption.

Disadvantages of soapless detergents

→ They are non-biodegradable while soapy detergents, They persist in water during sewage treatment by causing foaming in rivers, lakes and streams, leading to marine / aquatic death.

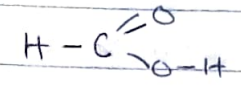
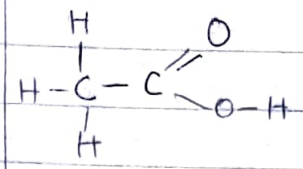
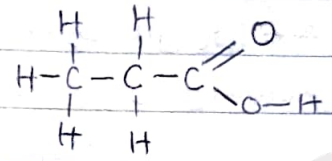
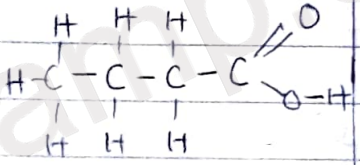
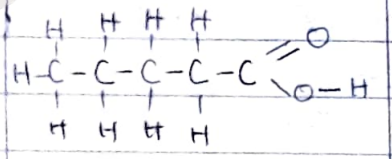
→ The reaction of a carboxylic acid with an alcohol to form an ester.

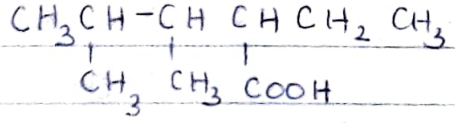
→ ~~Uses~~ uses of Alkanoic acid

- It is used as Vinegar in cooking and as preservative.
- It is used in manufacture of dyes, perfumes, plastics, rubber
- It is used as a solvent in laboratory and industry.
- Ethanoic acid, is used in the manufacture of esters used in perfumes rep

RECAP

Members of ~~Alcohol~~ Homologous series

	Carboxylic Acid	Formula	Structural formula	Condensed formula
1	Methanoic acid n = 1	$HCOOH$		$HCOOH$
2	Ethanoic acid n = 2	CH_3COOH		CH_3COOH
3	Propanoic acid n = 3	C_2H_5COOH		CH_3CH_2COOH
4	Butanoic acid n = 4	C_3H_7COOH		$CH_3CH_2CH_2COOH$
5	Pentanoic acid n = 5	C_4H_9COOH		$CH_3CH_2CH_2CH_2COOH$

1. Name  2-ethyl-3,4-dimethyl pentanoic acid.

2. By using chemical eqn, show how will you obtain
   (i) Sodium ethoxide (ii) ethyl ethanoate (iii) ethene from ethanol?

3. A hydrocarbon, R, contains 80% carbon by mass (a) Calculate the empirical formula of R.
   (b) If the molecular mass of R is 30, determine the molecular formula
   (c) Write an equation for complete combustion of R.

The names of fxnal groups

- OH – hydroxyl
- COOH – Carboxyl.

Fxnal group → An atom or a group of atoms present in a molecule which largely determines its chemical properties
→ is an atom or group of atoms in a molecule that is responsible for its chemical reactions
→ An atom or group of atoms which makes an organic compound reactive and decides its functions

X – ~~Are~~ are groups of atoms that are common to a given homologous series and are responsible for chemical reactions. Examples of fxnal groups

Constituent of soil (5)
(i) mineral – largest component
(ii) water – second
(iii) organic matter
(iv) Gases
(v) Microorganisms

Homologous series is a series of organic compounds related to each other by the same functional group.

The weathering basis of agents can be classified as
(a) Physical weathering – The physical agents responsible for such weathering are temper. wind, water, ice etc
(b) chemical weathering – when different chemical processes are involved in weathering. Important chemical weathering agents are moisture, water and air.
(c) Biological weathering – various types of microorganisms extract minerals from rocks as their energy source. This ultimately leads to change in the physical structures and mineral composition of the rocks.