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TOPIC 11.5: CARBOXYLIC ACIDS

THE ABOUT

CHAPTER ANALYSIS

MASTERY

- Key component of Organic Chemistry
- Important build up to ‘Macromolecules’

EXAM

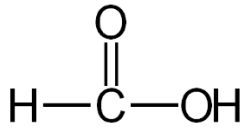
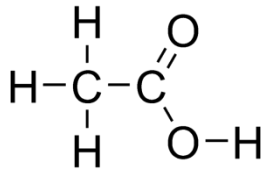
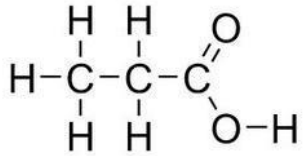
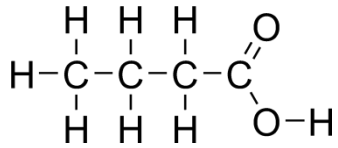
- Know how to draw your –COOH functional group
- Understand how esterification works and the conditions needed

WEIGHTAGE

- **Heavy** overall weightage
- Entire Organic Chemistry portion accounts for **15-20%** of each year’s Chemistry paper

KEY CONCEPT

CARBOXYLIC ACIDS
HOMOLOGOUS SERIES
FUNCTIONAL GROUP
GENERAL FORMULA

Name	Carbon atoms	Molecular Formula	Full Structural Formula	Condensed structural formula
Methanoic acid	1	HCOOH		HCOOH
Ethanoic acid	2	CH_3COOH		CH_3COOH
Propanoic acid	3	C_2H_5COOH		CH_3CH_2COOH
Butanoic acid	4	C_3H_7COOH		$CH_3\,CH_2CH_2COOH$

HOMOLOGOUS SERIES: CARBOXYLIC ACIDS

General Formula

Carboxylic acids have a general formula of **$C_nH_{2n+1}COOH$**

Functional group

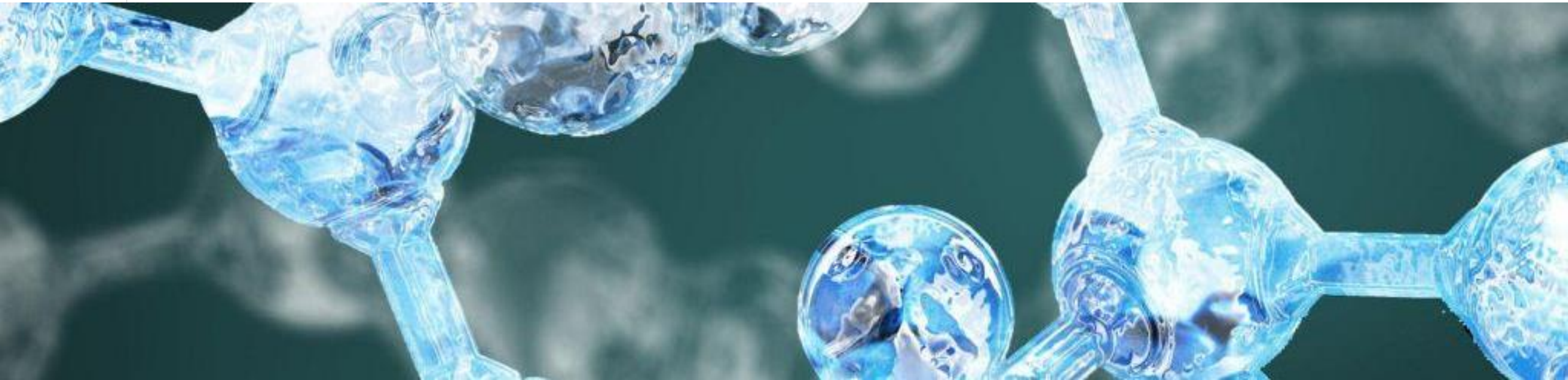
Carboxylic acids contain the **-COOH functional group** known as the **carboxyl group**.

Isomerism

Carboxylic acid molecules that contain **at least four carbon atoms display isomerism.**

KEY CONCEPT

CARBOXYLIC ACIDS
PHYSICAL PROPERTIES
PRODUCTION OF ETHANOIC ACID
ESTERIFICATION



PHYSICAL PROPERTIES

Physical properties of carboxylic acids

As the relative molecular mass of the carboxylic acids increases,

- Melting and boiling points of the carboxylic acids increase
- Densities of the carboxylic acids increase
- Viscosities of the carboxylic acids increase
- Flammability of the carboxylic acids decrease
- Carboxylic acids **are soluble in water; solubility decrease as the carbon atoms increases**

MAKING ETHANOIC ACID

PRODUCTION OF ETHANOIC ACID

1) **Oxidation of alcohol**

2) **Oxidation of methane**

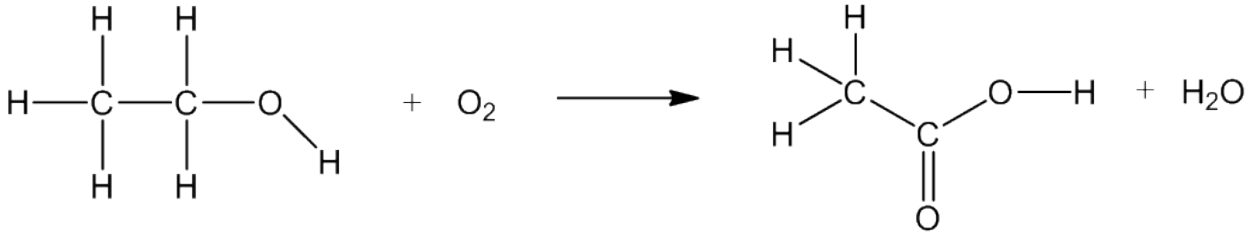
PRODUCTION OF CARBOXYLIC ACID

1) **Oxidation of alcohol**

Ethanol C_2H_5OH is converted to ethanoic acid CH_3COOH using bacteria / oxidising agents.

Enzymes in bacteria help to catalyse the reaction.

C_2H_5OH (aq) + O_2 (g) → CH_3COOH (aq) + H_2O (l)



2) Oxidation (Using methane)*

Most of the ethanoic acid in industries is produced using methane (natural gas).

Methane is converted to ethanoic acid in the presence of air.

2 CH_4 (g) + 2 O_2 (g) → CH_3COOH (aq) + 2 H_2O (l)

WEAK ACID

Carboxylic acids are **weak acids** that **dissociate partially in water** to release a low concentration of H^+ ions.

The solutions formed are weak electrolytes as well.

$$\mathbf{CH_3COOH\ (aq) \rightleftharpoons CH_3COO^-\ (aq) + H^+\ (aq)}$$

NAME OF SALT FORMED

Carboxylic acids react slowly with moderately reactive metals, bases and carbonates to form a salt as one of its products.

The name of the salt is based on the molecular formula of the anion.

The prefix of the anion is based on the number of carbon atoms in the anion and the suffix is fixed as '-ate'.

Reactants	**Name of salt formed**
Potassium hydroxide + propanoic acid	Potassium propanoate
Aqueous ammonia + pentanoic acid	Ammonium pentanoate

CHEMICAL REACTIONS

CHEMICAL REACTIONS OF CARBOXYLIC ACIDS

1) Esterification

Esters real-life applications

Esters can be used as artificial food flavourings to add fruity flavours to sweet foods and drinks such as soda flavouring, jellies and ice creams.

Esters are also good solvents for organic compounds.

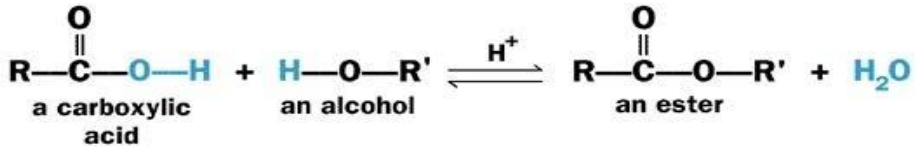
Esters have low B.P and are used as solvents for glues, paints and perfumes

CARBOXYLIC ACID & ALCOHOL REACTION (ESTERIFICATION)

When warmed with small amounts of sulfuric acid as catalyst, carboxylic acids and alcohols undergo a chemical reaction to form an organic compound known as an ester.

The reaction is reversible.

carboxylic acid + alcohol ⇌ ester + water
(sulfuric acid & warming)



(Where R and R' are general hydrocarbon groups)

The name of an ester comes in two halfs – the prefix and the suffix.

The first half of the name depends on the structure of the **alcohol**.

The second half of the name depends on the structure of the **carboxylic acid** and it will ends with **'-oate'**.

Organic compounds used to form the ester		
Alcohol	**Acid**	**Name of ester**
Ethanol	Methanoic acid	Ethyl methan<u>oate</u>
Propanol	Butanoic acid	Propyl butan<u>oate</u>

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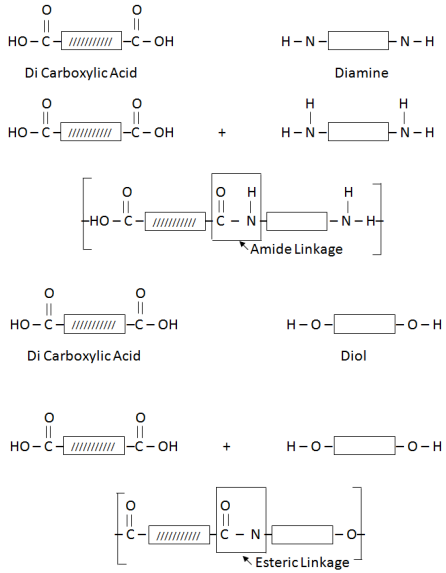
POLYMER

Condensation Polymerisation
(elimination of water)



LONG CHAIN ALKANE

H_2 gas
(For Haber process)

Catalytic Cracking
(Al_2O_3 & SiO_2, 600 °C)

Addition Polymerisation
(High temp & pressure)

SUGAR

$C_6H_{12}O_6 \rightarrow C_2H_5OH + CO_2$

Fermentation
(37°C, yeast & no O_2)

Oxidation
(acidified aqueous potassium manganate(VII) / exposed to air)

Hydration
(300 °C & 60-70 atm, Phosphoric(V) acid)

ALKANE
C - C

Hydrogenation
(200 °C & nickel)

# ALKENE
C = C

ALCOHOL
-OH

CARBOXYLIC ACID
-COOH

Substitution
(UV light)

Bromination
(Test for C=C bonds)

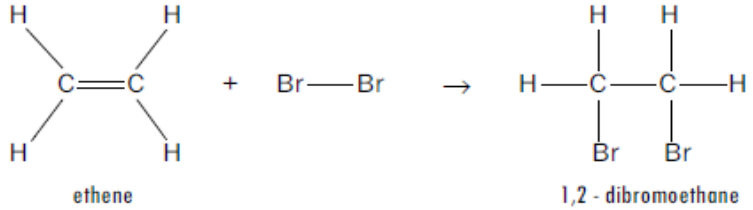
Esterification
(warm, sulfuric acid)

Prefix

Meth- 1
Eth- 2
Prop- 3
But- 4
Pent- 5
Hex- 6
Hep- 7
Oct- 8
Non- 9
Dec- 10

$CH_4 (g) + Br_2 (g) \rightarrow CH_3Br (g) + HBr (g)$

$C_2H_4 (g) + Br_2 (aq) \rightarrow C_2H_4Br_2 (aq)$



ESTER + H_2O
-COO-

ALL ORGANIC COMPOUNDS
Complete Combustion

$X + O_2 (g) \rightarrow CO_2 (g) + 2H_2O (l)$

Incomplete Combustion

$X + O_2 (g) \rightarrow CO (g) + 2H_2O (l)$

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