CARBON COMPOUNDS

FUNCTIONAL GROUP

◊ **Functional Group** - Single atom or group of atoms, that have similar chemical properties are called functional group. For example: Halogen group, Carboxyl group, Aldehyde group, etc. These functional group **confer specific properties to the compound**, regardless of the length and nature of the carbon chain. Functional Group is a heteroatom.

Functional group	Prefix	Suffix	Symbol
Halogen	Chloro– for chlorine, Bromo– for bromine Iodo– for iodine	n/a	-Cl -Br -I
Alcohol	n/a	ol	-OH
Aldehyde	n/a	al	-CHO
Ketone	n/a	one	O ‖ -C-
Carboxylic acid	n/a	oic acid	-COOH

◊ **Homologous Series** is a series of compounds in which the same functional group substitutes for hydrogen in a carbon chain is called a **homologous series**. Eg. CH_3OH, C_2H_5OH, C_3H_7OH and C_4H_9OH. Here the chemical properties are all very similar. Formulae of successive compounds differ by a $–CH_2-$ unit.

Functional Group ALCOHOL

Methanol	CH_3OH
Ethanol	C_2H_5OH
Propanol	C_3H_7OH
Butanol	C_4H_9OH

Functional Group CARBOXYLIC ACID

Methanoic acid	HCOOH
Ethanoic acid	CH_3COOH
Propanoic acid	C_2H_5COOH
Butanoic acid	C_3H_7COOH

◊ As the molecular mass increases in any homologous series, a gradation in physical properties is seen. **This is because the melting points and boiling points increase with increasing molecular mass**. Other physical properties such as solubility in a particular solvent also show a similar gradation. But the **chemical properties**, which are determined solely by the functional group, **remain similar in a homologous series**.

NOMENCLATURE OF CARBON COMPOUNDS

◊ The names of compounds in a homologous series are based on the name of the basic carbon chain modified by a "prefix" "phrase before" or "suffix" "phrase after" indicating the nature of the functional group.

◊ Naming a carbon compound can be done by the following method –

(i) Identify the number of carbon atoms in the compound. A compound having three carbon atoms would have the name propane.

(ii) In case a functional group is present, it is indicated in the name of the compound with either a prefix or a suffix.

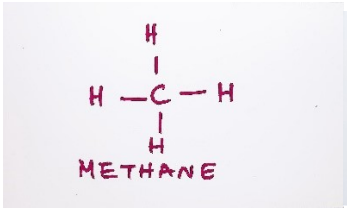
(iii) If the name of the functional group is to be given as a suffix, the name of the carbon chain is modified by deleting the final 'e' and adding the appropriate suffix. For example, a three-carbon chain with a ketone group would be named in the following manner – Propane – 'e' = propan + 'one' = propanone.

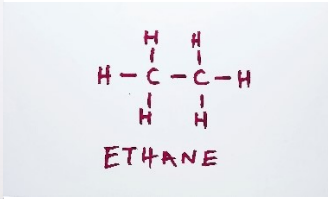
(iv) If the carbon chain is unsaturated, then the final 'ane' in the name of the carbon chain is substituted by 'ene' or 'yne' .For example, a three-carbon chain with a double bond would be called propene and if it has a triple bond, it would be called propyne.

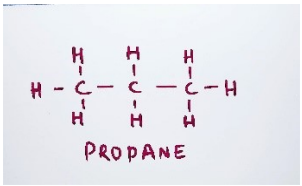
(v) For branches - Identify the longest chain. Then number the carbon atoms in such a fashion that the functional group; if any; would come at the lowest number. Then identify the branches and so number them so as to end up with the lowest number for carbon on which the branch exists.

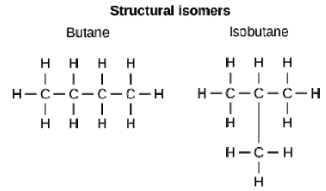
Examples

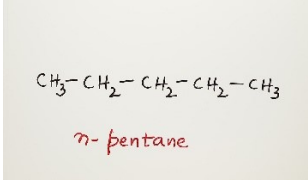
Including Structural Isomers

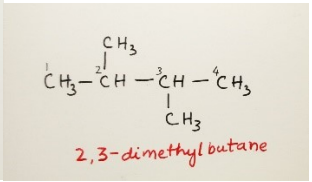


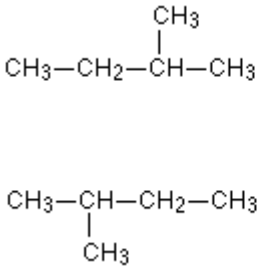


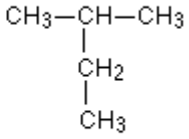


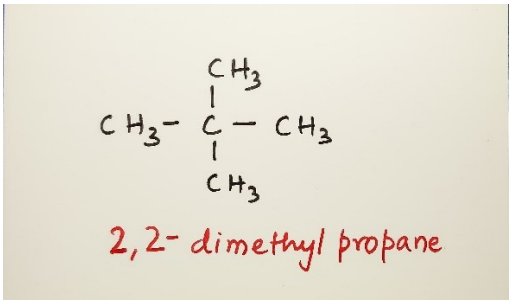












CARBON COMPOUNDS

CHEMICAL PROPERTIES OF CARBON COMPOUNDS

1. Combustion

Carbon, in all its allotropic forms, burns in oxygen to give carbon dioxide along with the release of heat and light.

$$C + O_2 \Rightarrow CO_2 + Heat + Light$$
$$CH_4 + 2O_2 \Rightarrow CO_2 + 2H_2O + Heat + Light$$
$$CH_3C_2OH + O_2 \Rightarrow CO_2 + H_2O + Heat + Light$$

Saturated hydrocarbons will generally give a **clean flame** while unsaturated carbon compounds will give a **yellow flame** with lots of black smoke. However, limiting the supply of air results in incomplete combustion of even saturated hydrocarbons giving a sooty flame.

2. Oxidation Reaction

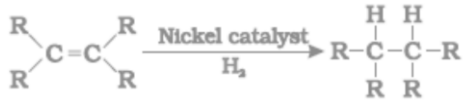
In addition to this complete oxidation, we have reactions in which alcohols are converted to carboxylic acids –

$$CH_3CH_2OH \xrightarrow{\text{(Alkaline } KMnO_4/\text{Acidified } K_2Cr_2O_7)} CH_3COOH$$

Alkaline potassium permanganate or acidified potassium dichromate are oxidising alcohols to acids, that is, adding oxygen to the starting material. Hence they are known as oxidising agents.

3. Addition Reaction

Unsaturated hydrocarbons add hydrogen in the presence of catalysts such as palladium or nickel to give saturated hydrocarbons. Catalysts are substances that cause a reaction to occur or proceed at a different rate without the reaction itself being affected. This reaction is commonly used in the **hydrogenation of vegetable oils** using a nickel catalyst. Vegetable oils generally have long unsaturated carbon chains while animal fats have saturated carbon chains.



Animal fats generally contain saturated fatty acids which are said to be harmful for health. Oils containing unsaturated fatty acids should be chosen for cooking.

4. Substitution Reaction

Saturated hydrocarbons are fairly unreactive and are inert in the presence of most reagents. However, in the presence of sunlight, chlorine is added to hydrocarbons in a very fast reaction. It is called a **substitution reaction** because one type of atom or a group of atoms takes the place of another. A number of products are usually formed with the higher homologues of alkanes.

$$CH_4 + Cl_2 + Sunlight \Rightarrow CH_3Cl + HCl$$

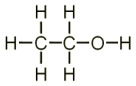
Similarly, ethane gives chloroethane when it reacts with chlorine in the presence of sunlight.

$$C_2H_6 + Cl_2 + Sunlight \Rightarrow C_2H_5Cl + HCl$$

SOME IMPORTANT ORGANIC COMPOUNDS

ETHANOL

Formula: C_2H_5OH



Structure:

Functional Group present: -OH (Alcohol)

Properties of Ethanol:

a) Pure Ethanol is a colourless liquid.
b) Ethanol is a liquid at room temperature.
c) Ethanol is also soluble in water in all proportions.
d) It is combustible and burns with a blue flame.
e) Consumption of small quantities of dilute ethanol causes drunkenness. However, intake of even a small quantity of pure ethanol (called absolute alcohol) can be lethal. Also, long-term consumption of alcohol leads to many health problems.

Reactions of Ethanol:

(i) **Reaction with sodium**: Alcohols react with sodium leading to the evolution of hydrogen. With ethanol, the other product is **sodium ethoxide.**

$$2Na + 2CH_3CH_2OH \rightarrow 2CH_3CH_2O^-Na^+ + H_2$$
(Sodium ethoxide)

(ii) **Reaction to give unsaturated Hydrocarbon (Dehydration reaction)**: Heating ethanol at 443 K with excess concentrated Sulphuric Acid results in the dehydration of ethanol to give **ethene** –

$$CH_3CH_2OH \xrightarrow{\text{Hot Conc } H_2SO_4} CH_2{=}CH_2 + H_2O$$

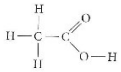
The concentrated sulphuric acid can be regarded as a dehydrating agent which removes water from ethanol.

Uses

a) Ethanol is commonly called alcohol and is the active ingredient of all alcoholic drinks.
b) Ethanol is a good solvent, it is also used in medicines such as tincture iodine, cough syrups, and many tonics.
c) Ethanol is used for preparation of chloroform, ethanoic acid, ethanal etc.
d) It is used in the preparation of perfumes.

ETHANOIC ACID

Formula: CH_3COOH



Structure:

Functional Group present: -COOH (Carboxylic Acid)

Properties of Ethanoic Acid:

a) Ethanoic acid is commonly called acetic acid and belongs to a group of acids called carboxylic acids.
b) 5-8% solution of acetic acid in water is called vinegar and is used widely as a preservative in pickles.
c) The melting point of pure ethanoic acid is 290 K and hence it often freezes during winter in cold climates. This gave rise to its name **glacial acetic acid**.
d) The group of organic compounds called carboxylic acids unlike mineral acids like HCl, which are completely ionised, carboxylic acids are weak acids.

Reactions of ethanoic acid:

(i) **Esterification reaction:** Esters are most commonly formed by reaction of an acid and an alcohol. Ethanoic acid reacts with absolute ethanol in the presence of an acid catalyst to give an ester –

$$\underset{\text{Ethanoic Acid}}{CH_3COOH} + \underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow{\text{Acid}} \underset{\text{Ester}}{CH_3\text{-}\overset{\overset{O}{\|}}{C}\text{-}O\text{-}CH_2\text{-}CH_3}$$

Esters are sweet-smelling substances. These are used in making perfumes and as flavouring agents. Esters react in the presence of an acid or a base to give back the alcohol and carboxylic acid. This reaction is known as saponification because it is used in the preparation of soap.

$$CH_3COOC_2H_5 \xrightarrow{NaOH} C_2H_5OH + CH_3COOH$$

(ii) **Reaction with a base:** Like mineral acids, ethanoic acid reacts with a base such as sodium hydroxide to give a salt (sodium ethanoate or commonly called sodium acetate) and water:

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

(iii) **Reaction with carbonates and hydrogencarbonates:** Ethanoic acid reacts with carbonates and hydrogencarbonates to give rise to a salt, carbon dioxide and water. The salt produced is commonly called sodium acetate.

$$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + H_2O + CO_2$$
$$CH_3COOH + NaHCO_3 \rightarrow 2CH_3COONa + H_2O + CO_2$$

(iv) **Reduction**: Acetic Acid on reduction with lithium aluminium hydride, results in formation of ethanal, which on further reduction gives ethanol.

$$\underset{\text{Ethanoic Acid}}{CH_3COOH} \xrightarrow{-LiAlH_4} \underset{\text{Ethanal}}{CH_3CHO} \xrightarrow{-LiAlH_4} \underset{\text{Ethanol}}{CH_3CH_2OH}$$

Uses:

a) Ethanoic aid is used in the manufacture of dyes and perfumes
b) Manufacture of rubber from latex and casein from milk. It is used for coagulation.
c) In dilute form is used as vinegar and in the concentrated form as a solvent.
d) In form of organic esters as perfumes.