Al-Mustaqbal University
Department of Radiological Techniques

Subject: - General Chemistry (1) lecture (6) --2024-2025

Assist.prof. Dr.Thamer A.A.M Alalwani

Alcohols, ketone, Aldehyde and Carboxylic Acid

1- 1-Alcohols:-

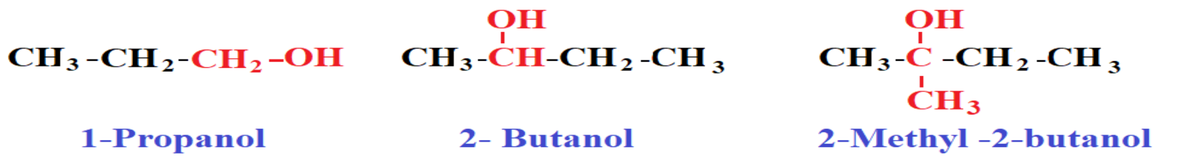
Alcohol: An organic substance formed when a hydroxyl group is substituted for a hydrogen atom in a hydrocarbon.

Classification of Alcohols

Primary alcohols:- In a primary (1°) alcohol, the carbon atom that carries the -OH group is only attached to one alkyl group.

Secondary alcohols :- In a secondary (2°) alcohol, the carbon atom with the –OH group attached is joined directly to two alkyl groups, which may be the same or different.

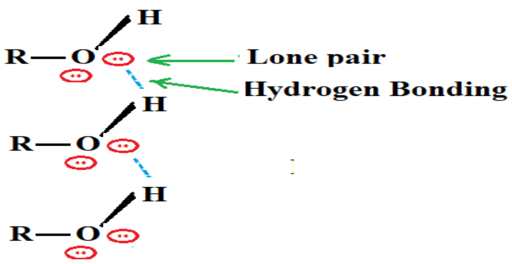
Tertiary alcohols: - In a tertiary (3°) alcohol, the carbon atom holding the –OH group is attached directly to three alkyl groups, which may be any combination of the same or different groups.



1-Propanol Primary Alcohol (1°) | 2- Butanol Secondary Alcohol (2°) | 2-Methyl -2-butanol Tertiary Alcohol (3°)

Physical and Properties of Alcohol:-

1. The Boiling Point of Alcohols Alcohols generally have higher boiling points in comparison to other hydrocarbons having equal molecular masses. This is due to the presence of intermolecular hydrogen bonding between hydroxyl groups of alcohol molecules.



In general, the boiling point of alcohols increases with an increase in the number of carbon atoms in the aliphatic carbon chain. On the other hand, the boiling point decreases with an increase in branching in aliphatic carbon chains the Van der Waals forces decreases with a decrease in surface area. **Thus primary alcohols have a higher boiling point**.

2. Solubility of Alcohols

The solubility of alcohol in water is governed by the hydroxyl group present. The hydroxyl group in alcohol is involved in the formation of intermolecular hydrogen bonding. Thus, hydrogen bonds are formed between water and alcohol molecules which make alcohol soluble in water. This table shows that alcohols have higher boiling points and greater solubility in H_2O the alkanes with the same number of carbons. It also shows that the boiling point of alcohols increase with the number of carbon atoms.

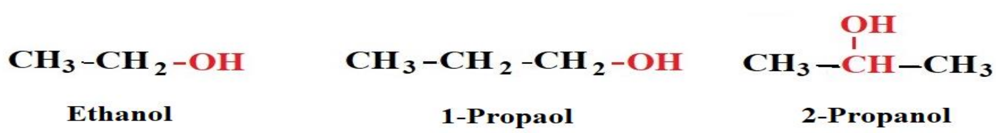
Compound	IUPAC Name	Melting Point (°C)	Boiling Point (°C)	Solubility in H_2O at 23°C
CH_4	Methane	-182.5	-161.7	3.5 ml (gas)/ 100 mL
CH_3OH	Methanol	-97.8	65.0	Infinite
CH_3CH_2OH	Ethanol	-114.7	78.5	Infinite
$CH_3CH_2CH_2CH_2OH$	1-Butanol	-89.5	117.3	8.0 g/100 ml

Systematic Names IUPAC Nomenclature of Alcohols

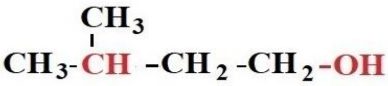
1-Find the longest chain containing the hydroxyl group (OH). If there is a chain with more carbons than the one containing the OH group, it will be named as a substituent.

2-Place the OH on the lowest possible number for the chain.

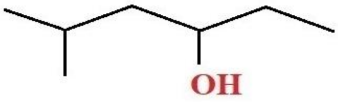
3-Remove the final e from the parent alkane chain and add -ol. When multiple alcohols are present use di, tri, et.c before the ol, after the parent name.



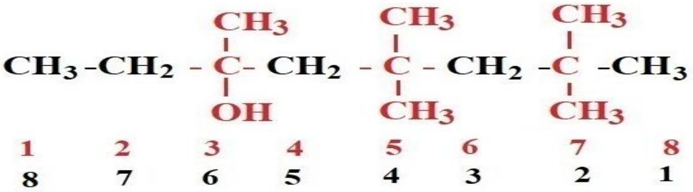
(2-Butanol)



(3-Methyl-1-butanol)



5-Methyl-3-hexanol

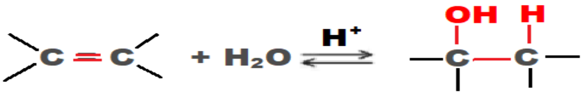


3,5,5,7,7-penta-Methyl-3-octanol

Preparation of Alcohols: -

1- Hydration of Alkenes:-

This is electrophilic addition of H_2O to alkenes.

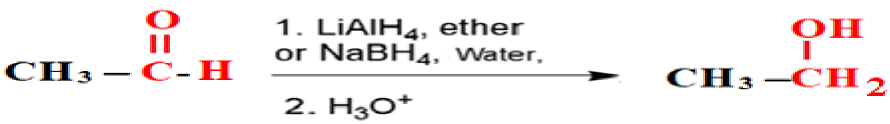


2-Reduction of Classes of Organic Compounds: -

In this type of reaction the alcohols can be prepared by reducing a number of classes of organic compounds as follows: -

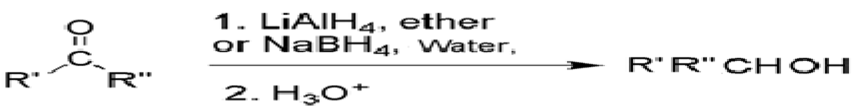
a-From Aldehydes: -

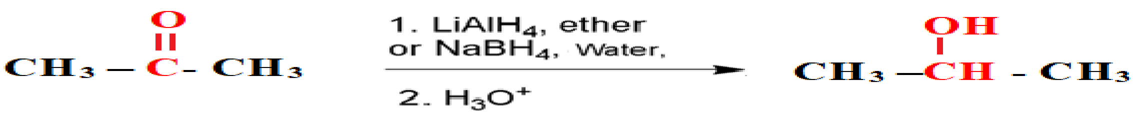
Synthesis of alcohol from an aldehyde by reduction.



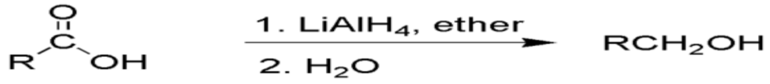
b- From Ketones: -

The synthesis of an alcohol from a ketone by reduction reaction.





c-From Carboxylic Acids:-

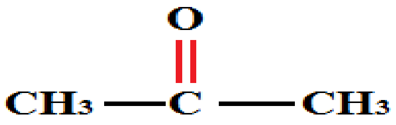


$CH_3CH_2\text{-}COOH + H_2 \rightarrow CH_3CH_2\text{-}CH_2OH + H_2O$

2-Aldehydes and Ketones

Introduction :-

Aldehydes are defined as unsaturated organic compounds that contain terminal carbonyl groups. Whereas, ketones are defined as unsaturated organic compounds that contain an intermediate or non-terminal carbonyl group.



Aceton / Propanon

Generally, the common names of ketones consist of the names of the groups attached to the carbonyl group, followed by the word *ketone*. (Note the similarity to the naming of ethers.) Another name for acetone, then, is *dimethyl ketone*. The ketone with four carbon atoms is ethyl methyl ketone.

Ethyl metyl keton / 2-Butanon

IUPAC rules for naming aldehydes and ketones:

1. **The stem names of aldehydes and ketones are derived from those of the parent alkanes, defined by the longest continuous chain (LCC) of carbon atoms that contains the functional group.**
2. **For an aldehyde, drop the *-e* from the alkane name and add the ending *-al*. Methanal is the IUPAC name for formaldehyde, and ethanal is the name for acetaldehyde.**
3. **For a ketone, drop the *-e* from the alkane name and add the ending *-one*. Propanone is the IUPAC name for acetone, and butanone is the name for ethyl methyl ketone.**
4. **To indicate the position of a substituent on an aldehyde, the carbonyl carbon atom is always considered to be C1; it is unnecessary to designate this group by number.**
5. **To indicate the position of a substituent on a ketone, number the chain in the manner that gives the carbonyl carbon atom the lowest possible number. In cyclic ketones, it is understood that the carbonyl carbon atom is C1.**

Example:- **Give the IUPAC name for each compound.**

(a) (b) (c)

Solution

a. **1)-There are five carbon atoms in the long carbon chain .**
   2)-The methyl group (CH_3) is a substituent on the second carbon atom of the chain.
   3)- The aldehyde carbon atom is always C1.
   4)- The name is derived from pentane. Dropping the -*e* and adding the ending -*al* gives pentanal.
   5)-The methyl group on the second carbon atom makes the name 2-methylpentanal.

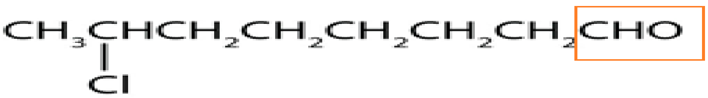
b. **1)-There are five carbon atoms in the long carbon chain .**
   2)- The carbonyl carbon atom is C3, and there methyl groups on C2 and C4.
   3)-The IUPAC name is 2,4-dimethyl-3-pentanone.

c. **1)-There are six carbon atoms in the ring.**
   2)-The compound is cyclohexanone. No number is needed to indicate the position of the carbonyl group because all six carbon atoms are equivalent.

Example :- Draw the structure for)-7-Chlorooctanal compound.

Solution 1)- The *octan*- part of the name tells us that the long carbon chain has eight carbon atoms.

2)-There is a chlorine (Cl) atom on the seventh carbon atom; numbering from the carbonyl group and counting the carbonyl carbon atom as C1, we place the Cl atom on the seventh carbon atom.



Example Draw the structure for each compound. A)-Butanal b)- 2-hexanone

Solution (a) (b)

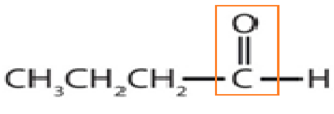
Where aldehydes and ketones different

An aldehyde differents from a ketone by having a hydrogen atom attached to the carbonyl group.

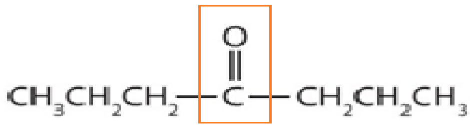
This makes the aldehydes very easy to oxidize. For example, ethanal, CH_3CHO, is very easily oxidised to either ethanoic acid, CH_3COOH, or ethanoate ions, CH_3COO^{-1}

Ketones don't have that hydrogen atom and are resistant to oxidation. They are only oxidised by powerful oxidising agents which have the ability to break carbon-carbon bonds

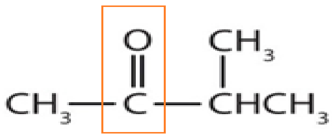
Example :- Classify each compound as an aldehyde or a ketone. Give the common name for each ketone .



(1)



(2)



(3)

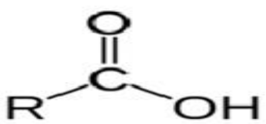
Solution 1-This compound has the carbonyl group on an end carbon atom, so it is an aldehyde.

2-This compound has the carbonyl group on an interior carbon atom, so it is a ketone. Both alkyl groups are propyl groups. The name is therefore dipropyl ketone.

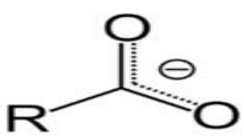
3-This compound has the carbonyl group between two alkyl groups, so it is a ketone. One alkyl group has three carbon atoms and is attached by the middle carbon atom; it is an isopropyl group. A group with one carbon atom is a methyl group. The name is therefore isopropyl methyl ketone.

3-Carboxylic acid

A carboxylic acid is an organic compound that contains a carboxyl group (C(=O)OH). The general formula of a carboxylic acid is R–COOH, with R referring to the rest of the molecule. Carboxylic acids occur widely. Important examples include the amino acids and acetic acid. Deprotonation of a carboxyl group gives a carboxylate anion.



Structure of a carboxylic acid



Structure of a Carboxylate Anion

Nomenclature of Carboxylic Acids :-

The guidelines that must be followed in the IUPAC nomenclature of carboxylic acids are listed below.

1-The suffix (e) in the name of the corresponding alkane is replaced with (oic acid).

2-When the aliphatic chain contains only one carboxyl group, the carboxylic carbon is always numbered one. For example, CH_3COOH is named as ethanoic acid.

3-When the aliphatic chain contains more than one carboxyl group, the total number of carbon atoms is counted and the number of carboxyl groups is represented by Greek numeral prefixes such as (di-, tri- , etc).

4-A carboxylic acid is named by adding these prefixes and suffixes to the parent alkyl chain. Arabic numerals are used for indicating the positions of the carboxyl group.

5-The name "carboxylic acid" assigned for a carboxyl substituent on a carbon chain. An example of such nomenclature is the name 2-carboxyfuran for the compound 2-Furoic acid$C_5H_4O_3$, 5-Mmethyl-3-heptenoic acid.

Formic acid	Methanoic acid	$HCOOH$	CH_2O_2
Acetic acid	Ethanoic acid	CH_3COOH	$C_2H_4O_2$
Propionic acid	Propanoic acid	CH_3CH_2COOH	$C_3H_6O_2$
Butyric acid	Butanoic acid	$CH_3(CH_2)_2COOH$	$C_4H_8O_2$
Valeric acid	Pentanoic acid	$CH_3(CH_2)_3COOH$	$C_5H_{10}O_2$
Caproic acid	Hexanoic acid	$CH_3(CH_2)_4COOH$	$C_6H_{12}O_2$
Enanthic acid	Heptanoic acid	$CH_3(CH_2)_5COOH$	$C_7H_{14}O_2$
Caprylic acid	Octanoic acid	$CH_3(CH_2)_6COOH$	$C_8H_{16}O_2$
Lauric acid	Dodecanoic acid	$CH_3(CH_2)_{10}COOH$	$C_{12}H_{24}O_2$
Myristic acid	Tetradecanoic acid	$CH_3(CH_2)_{12}COOH$	$C_{14}H_{28}O_2$
Palmitic acid	Hexadecanoic acid	$CH_3(CH_2)_{14}COOH$	$C_{16}H_{32}O_2$
Margaric acid	Heptadecanoic acid	$CH_3(CH_2)_{15}COOH$	$C_{17}H_{34}O_2$
Stearic acid	Octadecanoic acid	$CH_3(CH_2)_{16}COOH$	$C_{18}H_{36}O_2$

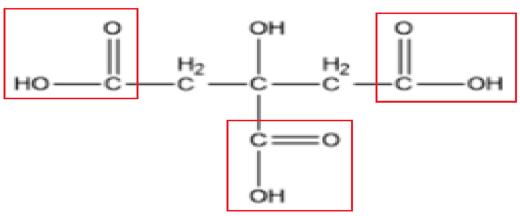
Classification of Carboxylic :-

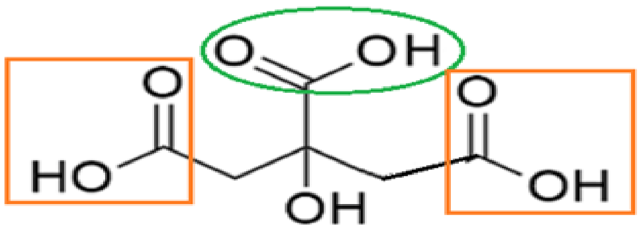
a- Carboxylic acids are classified according to the number of carboxylic groups as:-

1-Monocarboxylic acid, Example :-Ethanoic acid (acetic acid) CH_3COOH

2-Dicarboxylic acids containing two carboxyl groups, examples: Oxalic (Ethanedioic) acid $HO_2C\text{-}CO_2H$. Butanedioic acid $HO_2C\text{-}CH_2CH_2\text{-}CO_2H$

3-Tricarboxylic acid

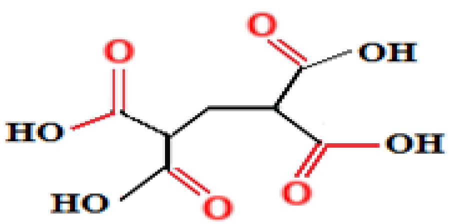




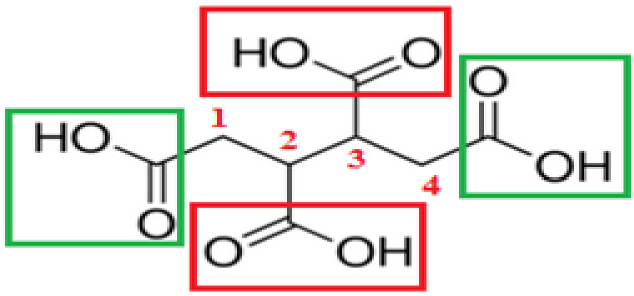
Citric acid

4- Tetracarboxylic acid.

1,1,3,3-Propanetetracarboxylic acid



1,1,3,3-Propanetetracarboxylic acid



1,2,3,4-Butanetetracarboxylic acid

b- Carboxylic acids are classified according to the nature and composition of the bonds:

1-Fatty acids medium to long-chain saturated and unsaturated monocarboxylic acids, with even number of carbons, examples: docosahexaenoic acid($C_{22}H_{32}O_2$) $CH_3CH_2CH=CHCH_2CH=CH-CH_2$ $CH=CH$ CH_2- $CH=CHCH_2CH=CHCH_2CH=$ $CHCH_2CH_2COOH$.

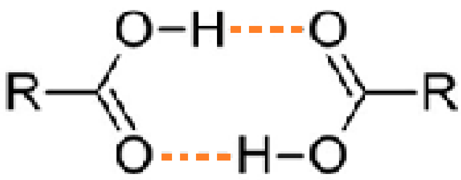
2-Unsaturated monocarboxylic acids acrylic acid (2-propenoic acid) $CH_2=CHCOOH$, used in polymer synthesis

3- Amino acids the building-blocks of proteins .

4- Aromatic carboxylic acids containing at least one aromatic ring, examples: benzoic acid C_6H_5COOH .

Physical Properties of Carboxylic Acids: -

- **Carboxylic acid molecules are polar due to the presence of two electronegative oxygen atoms.**
- **They also participate in hydrogen bonding due to the presence of the carbonyl group (C=O) and the hydroxyl group.**
- **When placed in nonpolar solvents, these compounds form dimers via hydrogen bonding between the hydroxyl group of one carboxylic acid and the carbonyl group of the other.**



- **The solubility of compounds containing the carboxyl functional group in water depends on the size of the compound. The smaller the compound (the shorter the R group), the higher the solubility.**
- **The boiling point of a carboxylic acid is generally higher than that of water.**
- **They generally have a strong sour smell. However, their esters have pleasant odors and are therefore used in perfumes.**
- **These compounds have the ability to donate protons and are therefore Bronsted-Lowry acids.**
- **Acidity :- Carboxylic acids are typically weak acids, meaning that they only partially dissociate into H_3O^+ cations and $RCOO^-$ anions in neutral aqueous solution.**