MOHAMED KHIDER UNIVERSITY OF BISKRA.

FACULTY OF EXACT SCIENCES AND NATURAL AND LIFE SCIENCES

DEPARTMENT OF BIOLOGY

COURSE TITLE: Organic Chemistry II
CHAPTER VI
Level: 1st year LMD

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2.1. Organic Compounds, Formulas, Functions, Nomenclature

2.1.1. Formulas of organic compounds

2.1.2. Functions, functional groups

2.1.3. Nomenclature

2.1.4. Study of organic functions

- Saturated hydrocarbons, alkenes, alkanes, benzene hydrocarbons
- Halogen derivatives, halides
- Alcohols, thiols, thiothers, phenols, polyfunctional amine aldehydes
- polyfunctional heterocycle compounds

2.1. Organic Compounds, Formulas, Functions, Nomenclature

2.1.1. Formulas of organic compounds

Organic compounds are rarely soluble in water and easily decomposed by heat. They are compounds that contain mainly carbon except carbon monoxide (CO), carbon dioxide (CO_2), carbonates (K_2CO_3, Na_2CO_3, $NaHCO_3$), cyanides (KCN, NaCN), disulfide (CS_2) and carbides (CaC_2) which are inorganic compounds.

To write an organic molecule, we must respect the valence of the atoms that constitute this molecule.

Examples:

Valencia of C = 4, Valencia of N = 3, Valencia of O = 2, Valencia of H =Valencia of (Halogen) = 1.

In organic chemistry, there are several ways of writing formulas: Crude formula, Flat developed formula, Semi-developed formula, Simplified formula, … etc.).

a. Brute formula

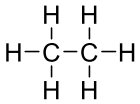
It gives the composition formula of the species considered, that is to say the atoms that compose it and their respective number.

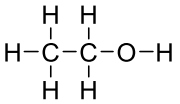
Examples: C_2H_6 (ethane), C_2H_6O (ethanol or methoxymethane).

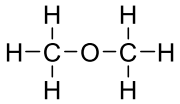
b. Developed formula

It reveals all the bonds forming the molecule under consideration.

Examples: C_2H_6 (ethane) C_2H_6O (ethanol or methoxymethane)



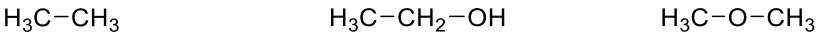




c. Semi-developed formula

Only bonds between carbon atoms and atoms other than hydrogen are shown.

Examples: C_2H_6 (ethane) C_2H_6O (ethanol or methoxymethane)



d. Compact formula

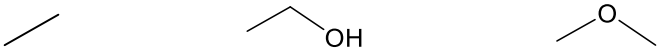
We do not show a bond, but we «range» the atoms by groups.

Examples: CH_3CH_3 (ethane), CH_3CH_2OH (ethanol) or CH_3OCH_3 (methoxymethane)

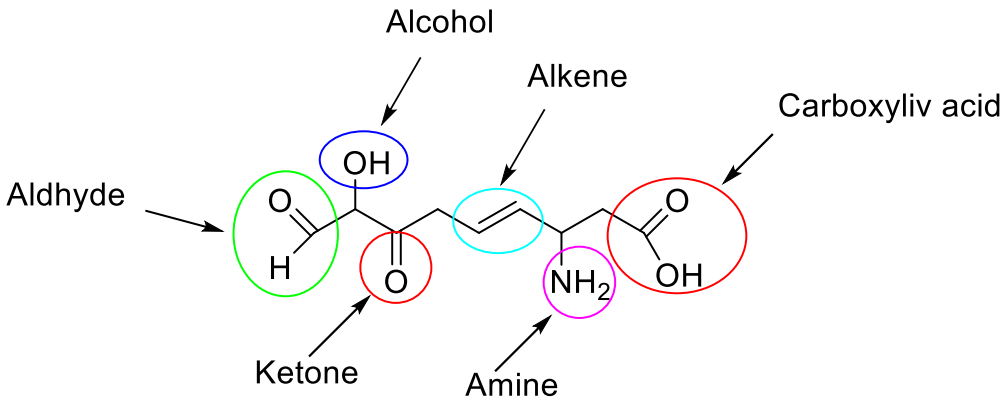
e. Topological formula

In this representation we omit the writing of carbon or hydrogen atoms: a carbon is located at the junction of two lines (bonds).

Examples: C_2H_6 (ethane) C_2H_6O (ethanol or methoxymethane)



2.1.2. Functions, functional groups



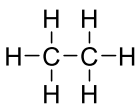
2.1.2.1. Hydrocarbons:

In general, hydrocarbons are composed only of carbon and hydrogen atoms.

***a.* Alkanes:** Alkanes are saturated compounds. Their brute formula is $\mathbf{C_nH_{2n+2}}$. The name of the alkanes ends with the suffix "**ane**".

Example:

C_2H_6 : Eth**ane** ⇒



Note:

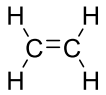
When hydrogen "H" is removed from an alkane, an alkyl with the formula C_nH_{2n+1} is obtained.

Table : Nomenclature of the first alkanes and alkyl radicals.

Numbers of atoms « C »	Alkane name C_nH_{2n+2}	Brute formula	Formula of C_nH_{2n+1}	Alkyl Group Name (Radical)
1	methane	CH_4	CH_3-	methyl
2	ethane	C_2H_6	C_2H_5-	ethyl
3	propane	C_3H_8	C_3H_7-	propyl
4	butane	$C_{10}H_{10}$	$C_{10}H_9$-	butyl
5	pentane	C_5H_{12}	C_5H_{11}-	pentyl
6	hexane	C_6H_{14}	C_6H_{13}-	hexyl
7	heptane	C_7H_{16}	C_7H_{15}-	heptyl
8	octane	C_8H_{18}	C_8H_{17}-	octyl
9	nonane	C_9H_{20}	C_9H_{19}-	nonyl
10	decane	$C_{10}H_{22}$	$C_{10}H_{21}$-	decyl

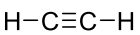
b. **Alkenes:** Alkanes are unsaturated compounds. Their brute formula is $\mathbf{C_nH_{2n}}$. The name of the alkanes ends with the suffix "**ene**".

Example:

C_2H_4 : Eth**ene** ⇒ 

c. **Alkenes:** Alkanes are unsaturated compounds. Their brute formula is $\mathbf{C_nH_{2n-2}}$. The name of the alkanes ends with the suffix "**yne**".

Example:

C_2H_2 : Eth**yne** ⇒ 

2.1.2.2. Alcohols and Ethers:

Incorporation of an oxygen atom into carbon- and hydrogen-containing molecules leads to new functional groups and new families of compounds. When the oxygen atom is attached by single bonds, the molecule is either an alcohol or ether.

a. Alcohols:

Alcohols are derivatives of hydrocarbons in which an –OH group has replaced a hydrogen atom. Although all alcohols have one or more hydroxyl (–OH) functional groups, they do not behave like bases such as NaOH and KOH. NaOH and KOH are ionic compounds that contain OH– ions. Alcohols are covalent molecules; the –OH group in an alcohol molecule is attached to a carbon atom by a covalent bond.

$R-OH$ ⇒ Suffix: “ol” ; Prefix: “Hydroxyl”

Example:

Ethanol ⇒ H_3C-OH

b. Ethers:

Ethers are compounds that contain the functional group –O–. Ethers do not have a designated suffix like the other types of molecules we have named so far. In the IUPAC system, the oxygen atom and the smaller carbon branch are named as an alkoxy substituent and the remainder of the molecule as the base chain, as in alkanes.

As shown in the following compound, the red symbols represent the smaller alkyl group and the oxygen atom, which would be named “methoxy.” The larger carbon branch would be ethane, making the molecule methoxyethane.

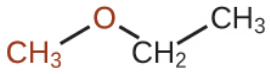
Many ethers are referred to with common names instead of the IUPAC system names. For common names, the two branches connected to the oxygen atom are named separately and followed by “ether.” The common name for the compound shown in is ethylmethyl ether

R_1-O-R_2

Example:

Methoxyethane. ⇒

Ethylmethyl ether



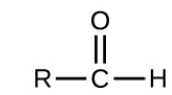
2.1.2.3. Aldehydes, Ketones, Carboxylic Acids, and Esters

Another class of organic molecules contains a carbon atom connected to an oxygen atom by a double bond, commonly called a carbonyl group. The trigonal planar carbon in the carbonyl group can attach to two other substituents leading to several subfamilies (aldehydes, ketones, carboxylic acids and esters).

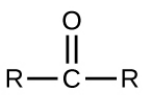
a. Aldehydes and Ketones

Both **aldehydes** and **ketones** contain a **carbonyl group**, a functional group with a carbon-oxygen double bond.

The names for aldehyde and ketone compounds are derived using similar nomenclature rules as for alkanes and alcohols, and include the class-identifying suffixes: **“-al”** and **”-one”**, respectively:



Functional group of an aldehyde

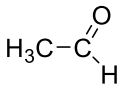


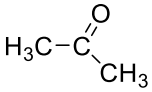
Functional group of a ketone

Aldehydes ⇒ Prefix: "Formyl"

Ketones ⇒ Prefix: "Oxo"

Examples:

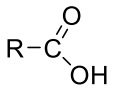
 ⇒ Ethanal

 ⇒ Prppanone

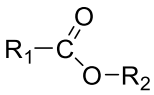
b. Carboxylic Acids and Esters

Both **carboxylic acids** and **esters** contain a carbonyl group with a second oxygen atom bonded to the carbon atom in the carbonyl group by a single bond. In a carboxylic acid, the second oxygen atom also bonds to a hydrogen atom. In an ester, the second oxygen atom bonds to another carbon atom. The names for carboxylic acids and esters include prefixes that denote the lengths of the carbon chains in the molecules and are derived following nomenclature rules similar to those for inorganic acids and salts.

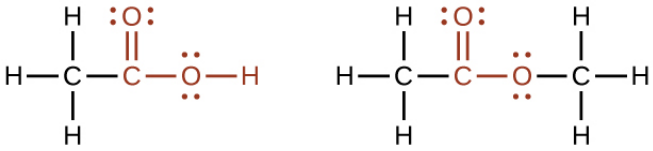
Carboxylic Acids

 ⇒ Suffix: "**oic acid**"

Esters

 ⇒ Suffix: "**R_2--, R_1-oate**"

Examples:



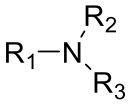
ethanoic acid (acetic acid)

methyl ethanoate (methyl acetate)

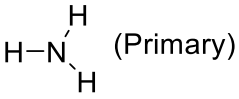
The functional groups for an acid and for an ester are shown in red in these formulas.

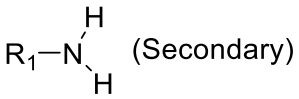
2.1.2.4. Amines and Amides

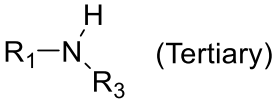
a. Amines are molecules that contain carbon-nitrogen bonds. The nitrogen atom in an amine has a lone pair of electrons and three bonds to other atoms, either carbon or hydrogen. Various nomenclatures are used to derive names for amines, but all involve the class-identifying suffix –ine as illustrated here for a few simple.



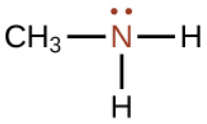
⇒ Suffix: "amine" ; Prefix: "Amino"



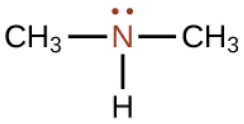




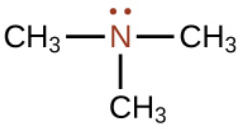
Examples:



methyl amine

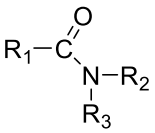


dimethyl amine



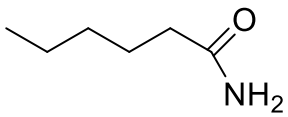
trimethyl amine

b. Amides are molecules that contain nitrogen atoms connected to the carbon atom of a carbonyl group. Like amines, various nomenclature rules may be used to name amides, but all include use of the class-specific



⇒ Suffix : -amide ; Prefix: "Amido"

Examples:



Hexamide