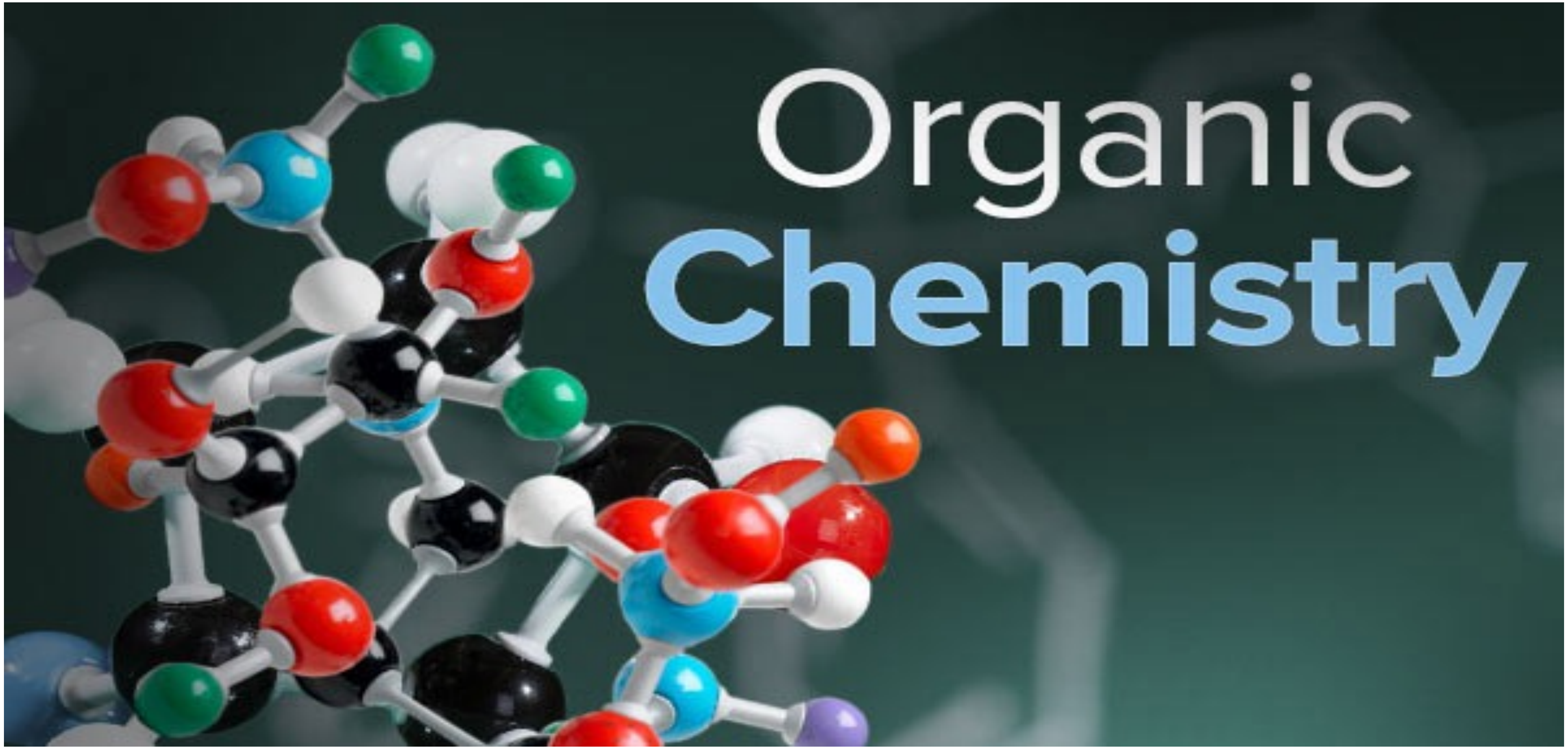


Organic Chemistry 1^{st} level

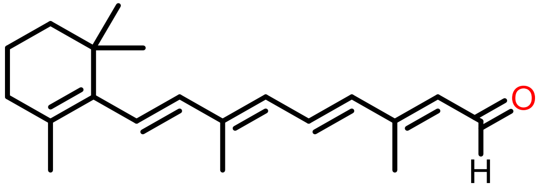
Organic Chemistry 1st level

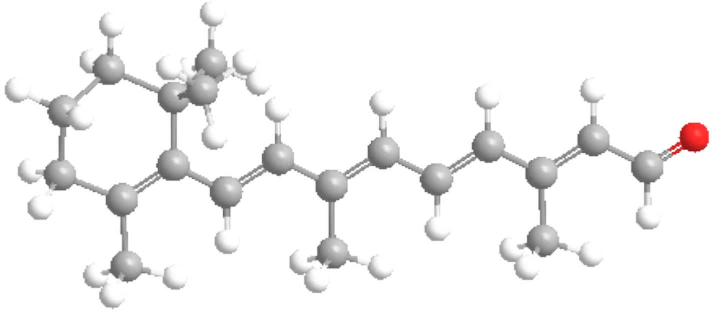
Overview

- A level 1 course, 8-12 lectures part of basic and core organic 1st year chemistry
- Aims: to learn the basic concept of organic chemistry associated with the most common reactions of use to organic chemists, and to understand (roles) which allowing the design of new chemistry reaction. This will prepare you for the next levels of studying.
- Scope: both traditional (from 1800s onwards) and contemporary (up to 2021 developments)
- Course given by ***Mohammed Adnan Abid*** (Uni of Anbar, College of Science, Chemistry Dept).
- Core course materials are ‘Clayden’ (1st and 2nd ed.) and ‘Moodle’; learning objectives at end of each lecture.

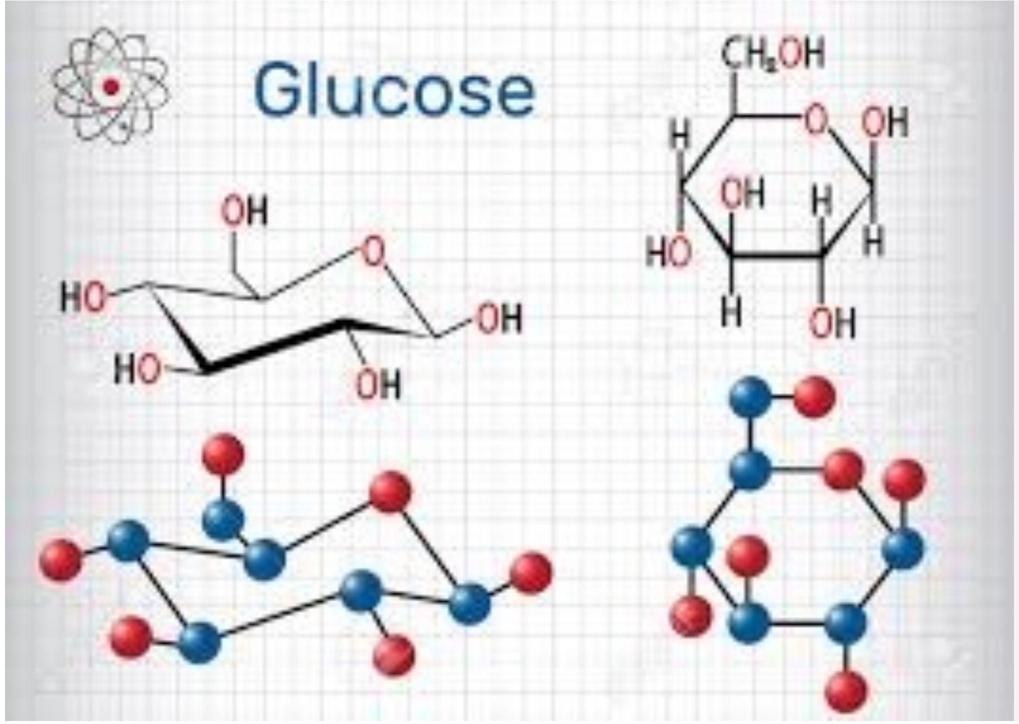
What is the Organic Chemistry?

While you are looking to the screen NOW, your eyes are using an organic compound (retinal) to convert visible light into nerve impulses



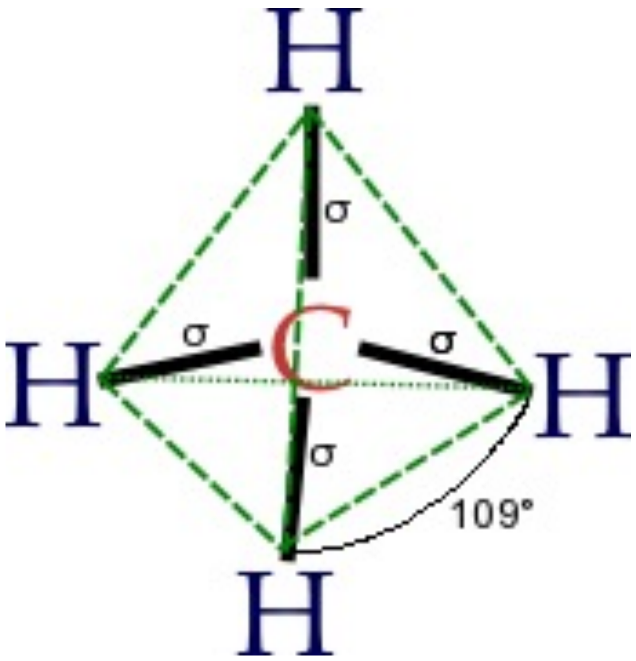


When you picked up ***YOUR*** computer or mobile phone, your muscles were doing chemical reactions on sugars to give you the energy you needed



Organic chemistry started as the chemistry of **life**, when that was thought to be different from the chemistry in the laboratory. Then it became the *carbon compounds*, especially those found in coal. Now it is both, It is the chemistry of the compounds of carbon along with other elements such as are found in living things and elsewhere………… ***To be continued***.

Organic chemistry is the study of the structure, properties, composition, reactions, and preparation of ***carbon-containing compounds***, which include not only ***hydrocarbons*** but also compounds with any number of other elements, including hydrogen (most compounds contain at least one carbon–hydrogen bond), nitrogen, oxygen, halogens, phosphorus, silicon, and sulfur. This branch of chemistry was originally limited to compounds produced by living organisms but has been broadened to include human-made substances such as plastics.



Methane, CH_4; the line-angle structural formula shows four carbon-hydrogen single bonds (σ, in black), and the typical 3D shape of tetrahedral molecules, with ~109° interior bond angles (in dashed-green).

Introduction to Organic Chemistry

- We will talk about hydrocarbons in details later on!!

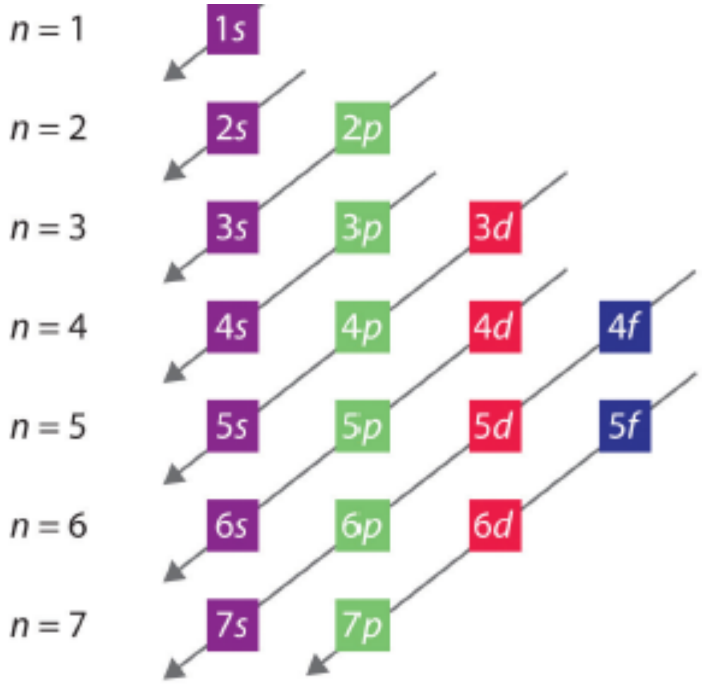
- **Structure and bonding:**

At the end, you will be able to define, and use in context, the key terms below:

- bond strength
- covalent bond
- ionic bond
- Lewis structure
- lone-pair electron
- non-bonding electron

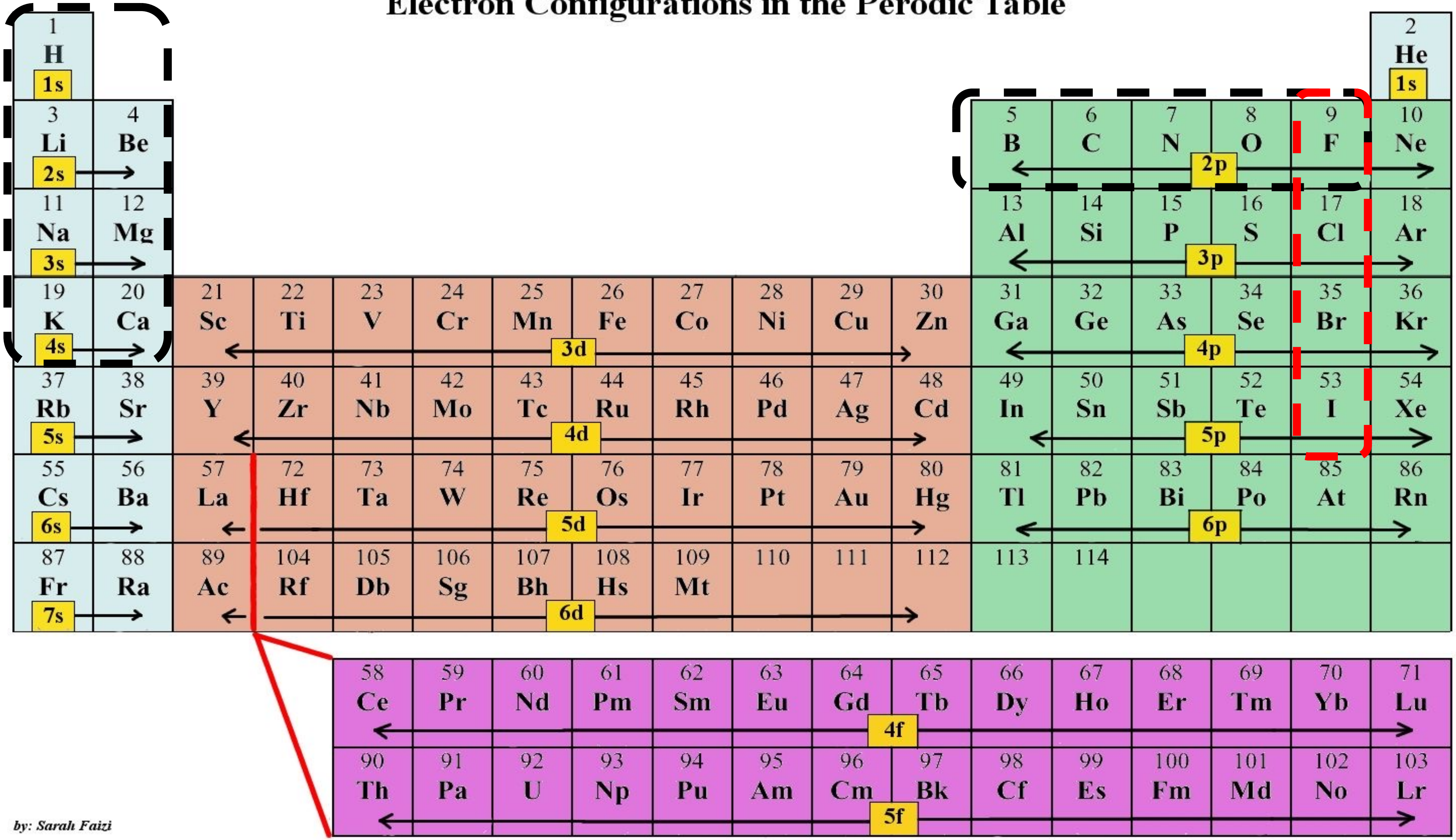
Introduction to Organic Chemistry

To draw Lewis structures successfully, you need to know the number of valence electrons present in each of the atoms involved. *Memorize* the number of valence electrons possessed by each of the elements commonly encountered in organic chemistry: C, H, O, N, S, P and the halogens.



Most of these concepts will be studied in inorganic chemistry.

Electron Configurations in the Perodic Table



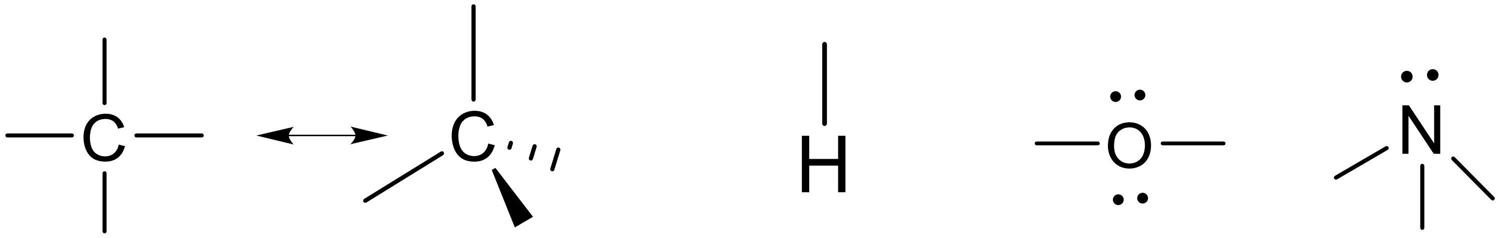
1 **H**																	2 **He**
3 **Li**	4 **Be**											5 **B**	6 **C**	7 **N**	8 **O**	9 **F**	10 **Ne**
11 **Na**	12 **Mg**											13 **Al**	14 **Si**	15 **P**	16 **S**	17 **Cl**	18 **Ar**
19 **K**	20 **Ca**	21 **Sc**	22 **Ti**	23 **V**	24 **Cr**	25 **Mn**	26 **Fe**	27 **Co**	28 **Ni**	29 **Cu**	30 **Zn**	31 **Ga**	32 **Ge**	33 **As**	34 **Se**	35 **Br**	36 **Kr**
37 **Rb**	38 **Sr**	39 **Y**	40 **Zr**	41 **Nb**	42 **Mo**	43 **Tc**	44 **Ru**	45 **Rh**	46 **Pd**	47 **Ag**	48 **Cd**	49 **In**	50 **Sn**	51 **Sb**	52 **Te**	53 **I**	54 **Xe**
55 **Cs**	56 **Ba**	57 **La**	72 **Hf**	73 **Ta**	74 **W**	75 **Re**	76 **Os**	77 **Ir**	78 **Pt**	79 **Au**	80 **Hg**	81 **Tl**	82 **Pb**	83 **Bi**	84 **Po**	85 **At**	86 **Rn**
87 **Fr**	88 **Ra**	89 **Ac**	104 **Rf**	105 **Db**	106 **Sg**	107 **Bh**	108 **Hs**	109 **Mt**	110	111	112	113	114				

58 **Ce**	59 **Pr**	60 **Nd**	61 **Pm**	62 **Sm**	63 **Eu**	64 **Gd**	65 **Tb**	66 **Dy**	67 **Ho**	68 **Er**	69 **Tm**	70 **Yb**	71 **Lu**
90 **Th**	91 **Pa**	92 **U**	93 **Np**	94 **Pu**	95 **Am**	96 **Cm**	97 **Bk**	98 **Cf**	99 **Es**	100 **Fm**	101 **Md**	102 **No**	103 **Lr**

by: Sarah Faizi

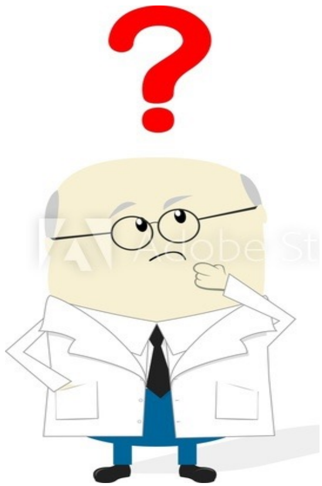
Introduction to Organic Chemistry

- *Note:* When drawing any organic structure, you must remember that a neutral carbon atom will almost always have four bonds.
- Similarly, hydrogen always has one bond; neutral oxygen atoms have two bonds; and neutral nitrogen atoms have three bonds. By committing these simple rules to memory, you can avoid making unnecessary mistakes later in the course.



Introduction to Organic Chemistry

- Why are some substances chemically bonded molecules and others are an association of ions???!!!



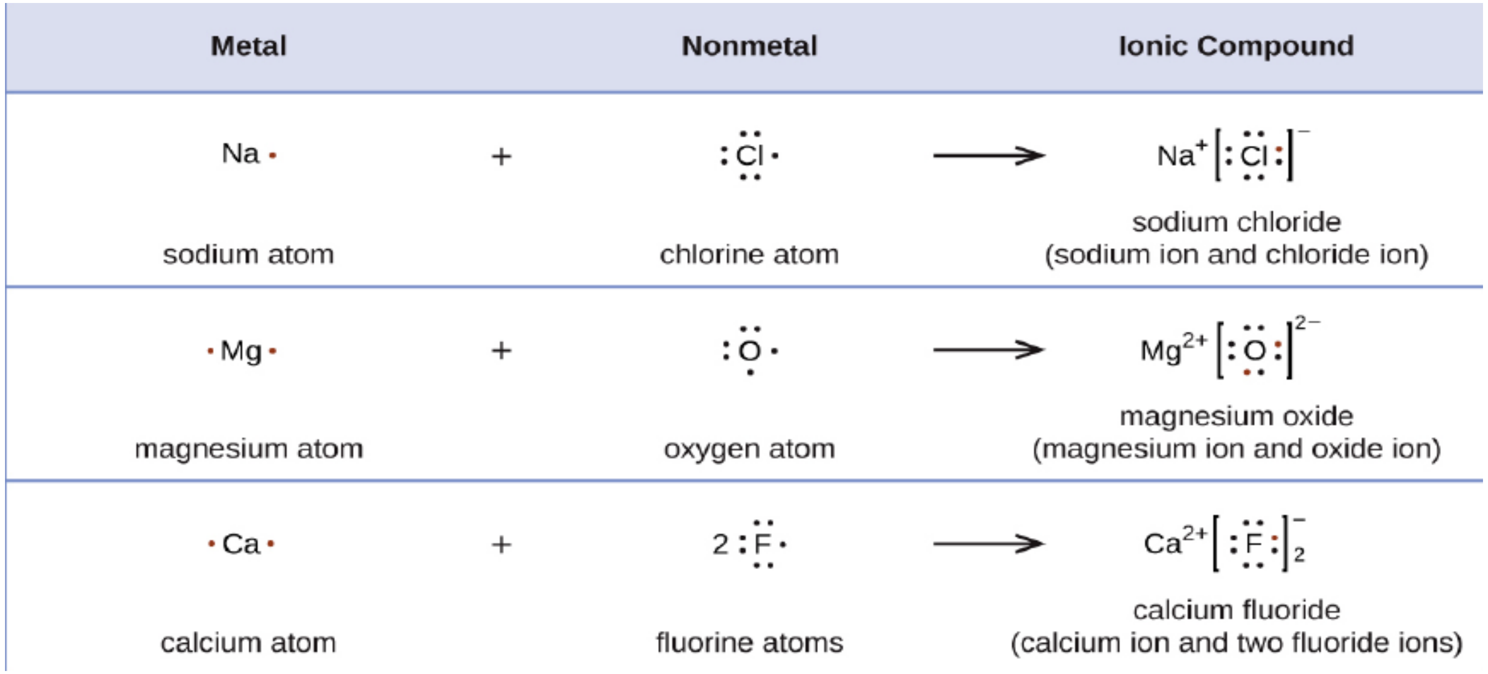
- The answer to this question depends upon the *electronic structures of the atoms* and *nature of the chemical forces* within the compounds.

Introduction to Organic Chemistry

FOR THIS:

Chemical bonds are typically classified into **three** main types: **ionic bonds**, **covalent bonds**, and **metallic bonds**:

1. **Ionic bonds** results from electrostatic forces that exist between ions of opposite charge. These bonds typically involve a metal with a nonmetal.

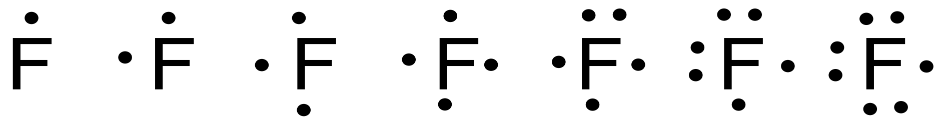


Metal		Nonmetal		Ionic Compound
$\mathrm{Na}\cdot$ sodium atom	+	$:\ddot{\mathrm{Cl}}\cdot$ chlorine atom	$\longrightarrow$	$\mathrm{Na}^{+}[:\ddot{\mathrm{Cl}}:]^{-}$ sodium chloride (sodium ion and chloride ion)
$\cdot\mathrm{Mg}\cdot$ magnesium atom	+	$:\ddot{\mathrm{O}}\cdot$ oxygen atom	$\longrightarrow$	$\mathrm{Mg}^{2+}[:\ddot{\mathrm{O}}:]^{2-}$ magnesium oxide (magnesium ion and oxide ion)
$\cdot\mathrm{Ca}\cdot$ calcium atom	+	$2:\ddot{\mathrm{F}}\cdot$ fluorine atoms	$\longrightarrow$	$\mathrm{Ca}^{2+}[:\ddot{\mathrm{F}}:]_{2}^{-}$ calcium fluoride (calcium ion and two fluoride ions)

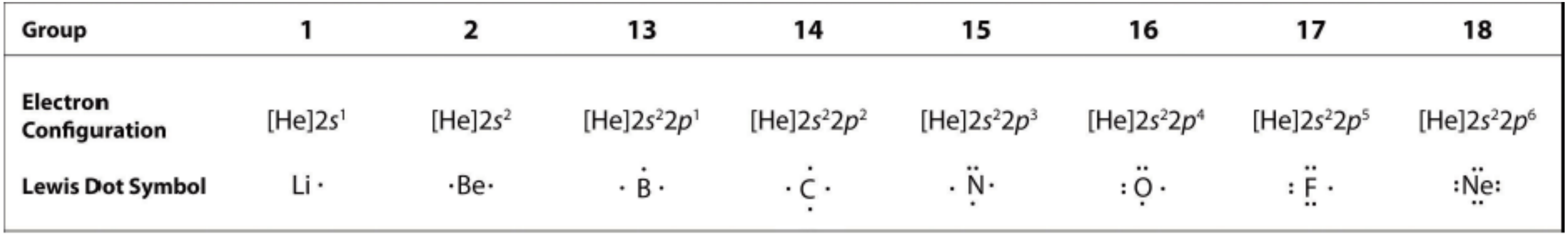
Introduction to Organic Chemistry

Lewis Dot symbols

To write an element's Lewis dot symbol, we place dots representing its valence electrons, one at a time, around the element's chemical symbol. Up to four dots are placed above, below, to the left, and to the right of the symbol (in any order, as long as elements with four or fewer valence electrons have no more than one dot in each position). The next dots, for elements with more than four valence electrons, are again distributed one at a time, each paired with one of the first four. Fluorine, for example, with the electron configuration $1s^2\ 2s^2\ 2p^5$, has seven valence electrons, so its Lewis dot symbol is constructed as follows:



Introduction to Organic Chemistry



Group	1	2	13	14	15	16	17	18
Electron Configuration	[He]$2s^1$	[He]$2s^2$	[He]$2s^22p^1$	[He]$2s^22p^2$	[He]$2s^22p^3$	[He]$2s^22p^4$	[He]$2s^22p^5$	[He]$2s^22p^6$
Lewis Dot Symbol	Li·	·Be·	·Ḃ·	·Ċ̣·	·Ṇ̈·	:Ö̤·	:F̤̈·	:N̤̈e:

Lewis used the unpaired dots to predict the number of bonds that an element will form in a compound. Consider the symbol for nitrogen in Figure above, the Lewis dot symbol explains why nitrogen, with three unpaired valence electrons, tends to form compounds in which it shares the unpaired electrons to form three bonds. Boron, which also has three unpaired valence electrons in its Lewis dot symbol, also tends to form compounds with three bonds, whereas carbon, with four unpaired valence electrons in its Lewis dot symbol, tends to share all of its unpaired valence electrons by forming compounds in which it has four bonds. Lewis symbols are a tool to help draw structures.

Introduction to Organic Chemistry

I encourage all of you to read the Octet Rule

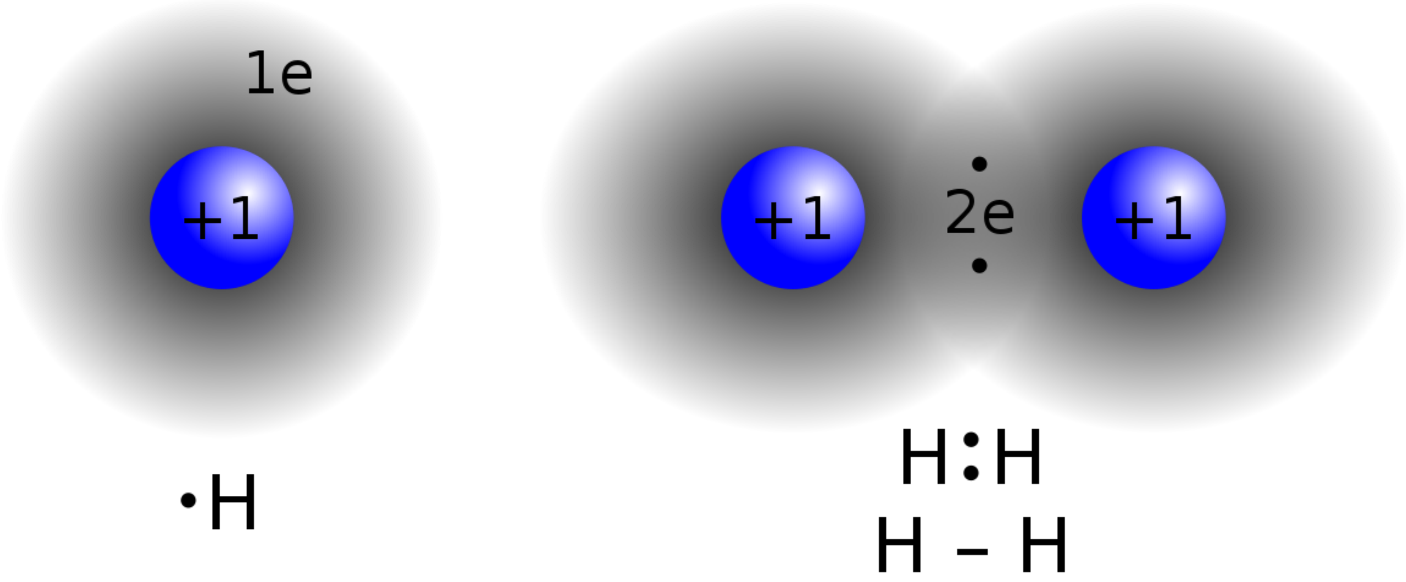
AND

The main differences between Covalent and Ionic bond

Introduction to Organic Chemistry

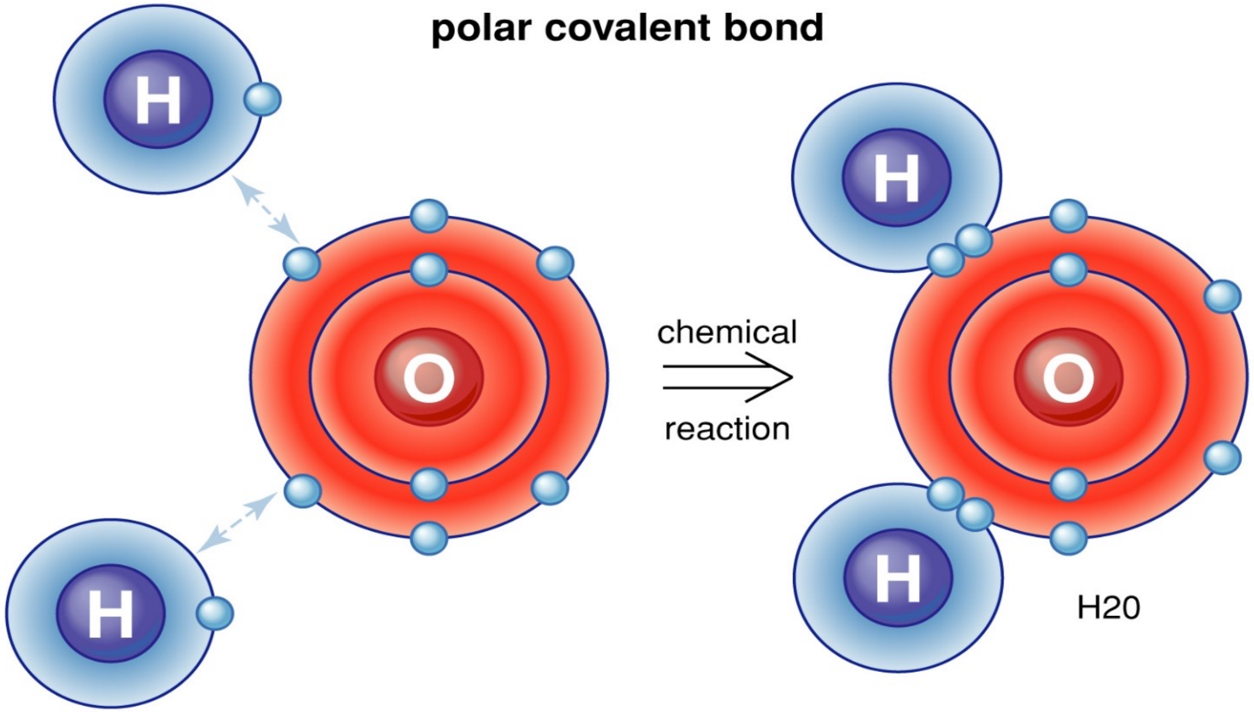
2. **Covalent bonds** result from **the sharing of electrons between two atoms**. The bonds typically involve one nonmetallic element with another.

- When two atoms of the same element form a covalent bond are the shared electrons actually shared equally between the atoms, *e.x.* H_2, $O_2$and CH_4.



Introduction to Organic Chemistry

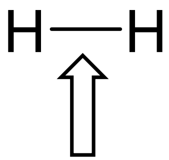
- When atoms of different elements share electrons through covalent bonding, the electron will be drawn more toward the atom with the higher electronegativity resulting in a polar covalent bond such as H_2O.



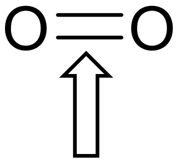
Introduction to Organic Chemistry

We have three types of covalent bond

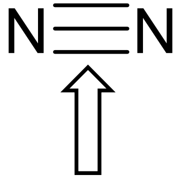
1. Single bond (σ)



2. Doubled Bond (σ, π)

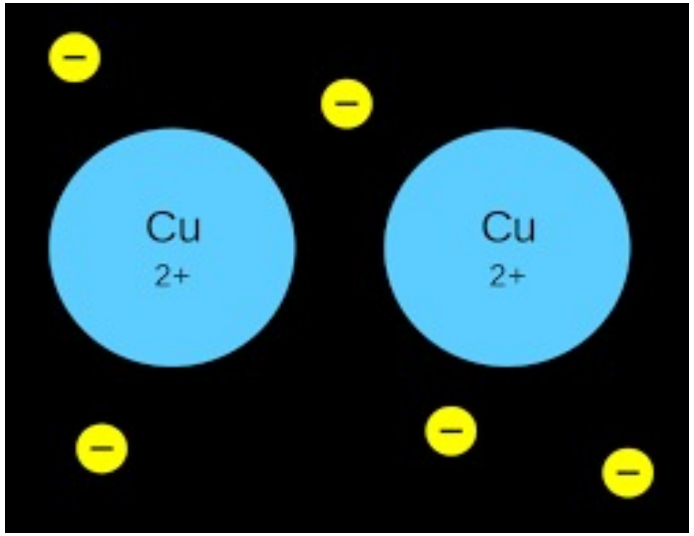


3. Triple Bond (π, σ, π)



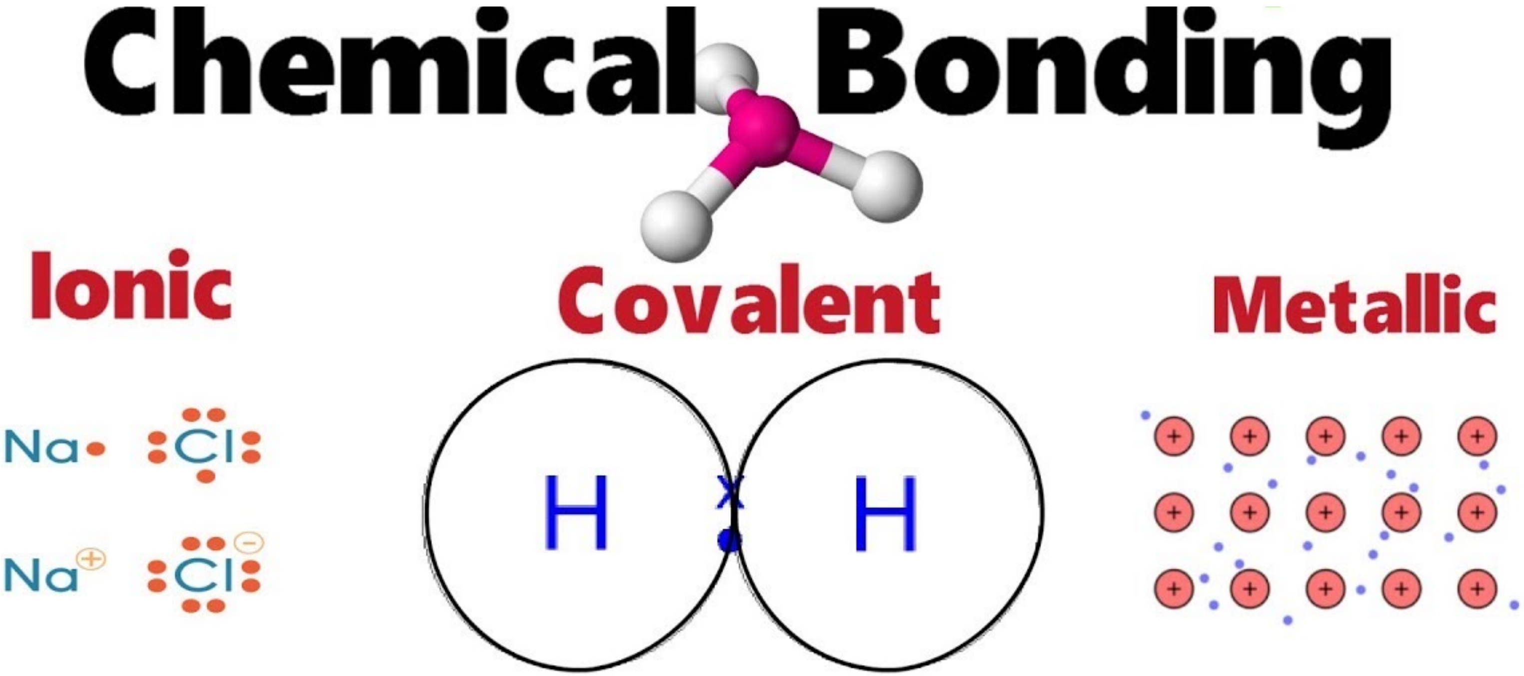
Introduction to Organic Chemistry

3. Metallic bonds are found in solid metals (copper, iron, aluminum) with each metal atom bonded to several neighboring metal atoms and the bonding electrons are free to move throughout the 3-dimensional structure. This type is *NOT* important in this course



Introduction to Organic Chemistry

To summaries



Introduction to Organic Chemistry

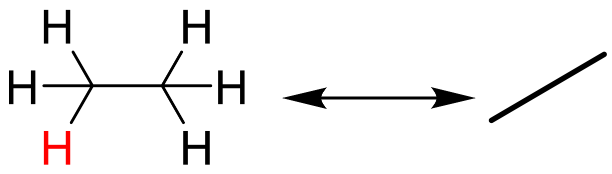
❖ Functional Group

What is the functional group?

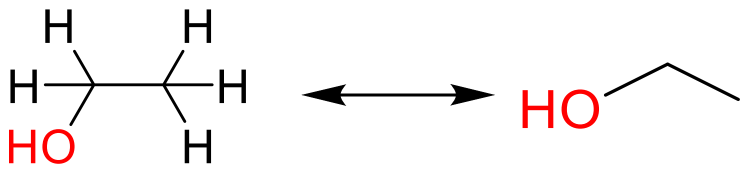
It refers to specific atoms bonded in a certain arrangement that give a compound certain physical and chemical properties. In other way, it is a specific group of atoms or bonds within a compound that is responsible for the characteristic chemical reactions of that compound.

Introduction to Organic Chemistry

The difference between ethanol and ethane is the functional group, the OH or hydroxyl group. We know that these chemical properties (being able to react with acids, bases, and oxidizing agents) are properties of the hydroxyl group and not just of ethanol because other compounds containing OH groups (in other words, other alcohols) have similar properties, whatever their hydrocarbon frameworks.

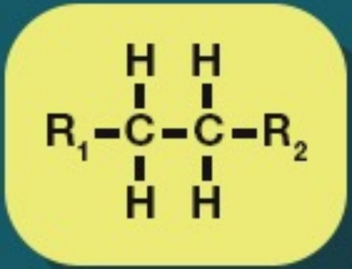


Ethane

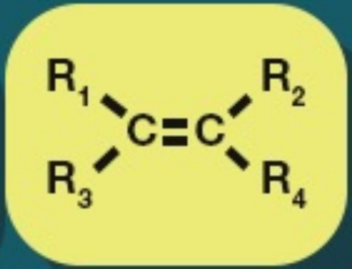


Ethanol

FUNCTIONAL GROUPS


$R_1-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-R_2$

ALKANE


ALKENE

$R_1-C\equiv C-R_2$

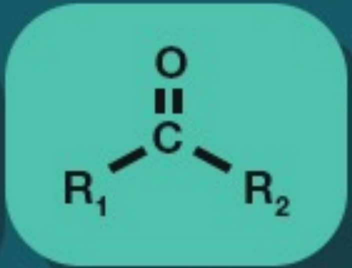
ALKYNE


ARENE

$R-X$

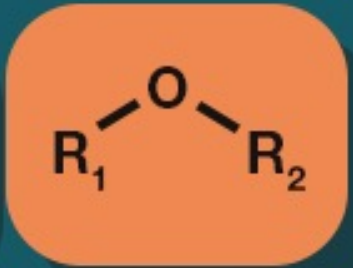
HALOALKANE


ALDEHYDE


KETONE

$R-OH$

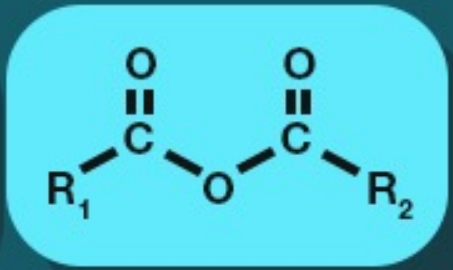
ALCOHOL


ETHER

$R-NH_2$

AMINE


CARBOXYLIC ACID


ACID ANHYDRIDE


ESTER


AMIDE

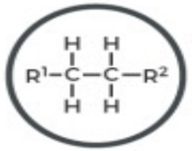

ACYL HALIDE

- 🟨 HYDROCARBONS
- 🟫 AROMATICS
- 🟪 OTHER HETEROATOMICS
- 🟧 SIMPLE OXYGEN HETEROATOMICS
- 🟩 CARBONYL COMPOUNDS
- 🟦 CARBOXYLIC ACIDS AND DERIVATIVES

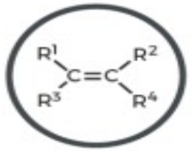
FUNCTIONAL GROUPS IN ORGANIC CHEMISTRY

Functional groups are the characteristic groups in organic molecules that give them their reactivity. In the formulae below, R represents the rest of the molecule and X represents any halogen atom.

● Hydrocarbons ● Halogen-containing groups ● Oxygen-containing groups ● Nitrogen-containing groups ● Sulfur-containing groups ● Phosphorus-containing groups

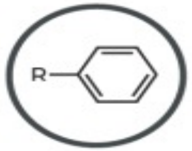


ALKANE
Naming: -ane
e.g. ethane



ALKENE
Naming: -ene
e.g. ethene

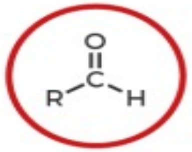
ALKYNE
Naming: -yne
e.g. ethyne



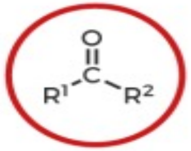
ARENE
Naming: -yl benzene
e.g. ethyl benzene

HALOALKANE
Naming: halo-
e.g. chloroethane

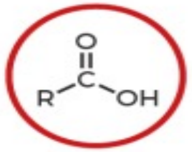
ALCOHOL
Naming: -ol
e.g. ethanol



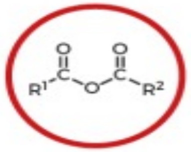
ALDEHYDE
Naming: -al
e.g. ethanal



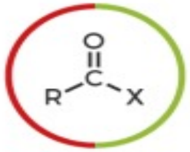
KETONE
Naming: -one
e.g. propanone



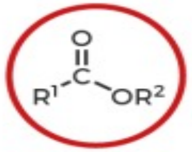
CARBOXYLIC ACID
Naming: -oic acid
e.g. ethanoic acid



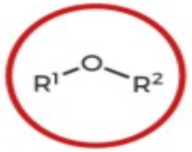
ACID ANHYDRIDE
Naming: -oic anhydride
e.g. ethanoic anhydride



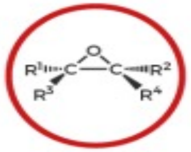
ACYL HALIDE
Naming: -oyl halide
e.g. ethanoyl chloride



ESTER
Naming: -yl -oate
e.g. ethyl ethanoate

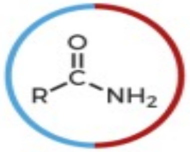


ETHER
Naming: -oxy -ane
e.g. methoxyethane

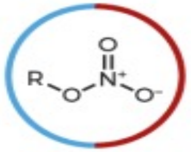


EPOXIDE
Naming: -ene oxide
e.g. ethene oxide

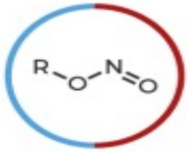
AMINE
Naming: -amine
e.g. ethanamine



AMIDE
Naming: -amide
e.g. ethanamide

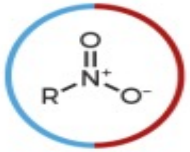


NITRATE
Naming: -yl nitrate
e.g. ethyl nitrate

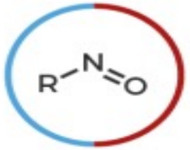


NITRITE
Naming: -yl nitrite
e.g. ethyl nitrite

NITRILE
Naming: -nitrile
e.g. ethanenitrile

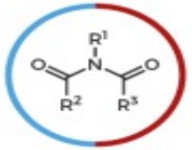


NITRO
Naming: nitro-
e.g. nitromethane



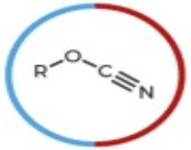
NITROSO
Naming: nitroso-
e.g. nitrosoethane

IMINE
Naming: -imine
e.g. ethanimine



IMIDE
Naming: -imide
e.g. succinimide

AZIDE
Naming: -yl azide
e.g. phenylazide

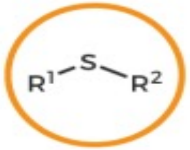


CYANATE
Naming: -yl cyanate
e.g. methyl cyanate

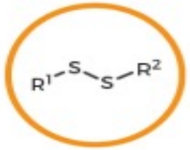
ISOCYANATE
Naming: -yl isocyanate
e.g. methyl isocyanate

AZO COMPOUND
Naming: azo-
e.g. azoethane

THIOL
Naming: -thiol
e.g. methanethiol



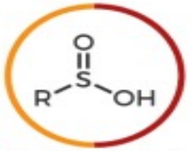
SULFIDE
Naming: sulfide
e.g. dimethyl sulfide



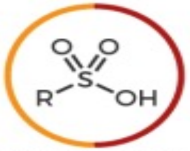
DISULFIDE
Naming: disulfide
e.g. dimethyl disulfide

SULFOXIDE
Naming: sulfoxide
e.g. dimethyl sulfoxide

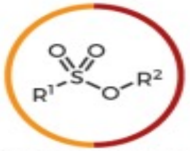
SULFONE
Naming: sulfone
e.g. dimethyl sulfone



SULFINIC ACID
Naming: -sulfinic acid
e.g. benzenesulfinic acid



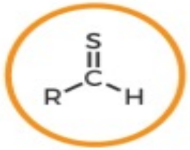
SULFONIC ACID
Naming: -sulfonic acid
e.g. benzenesulfonic acid



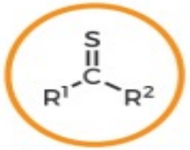
SULFONATE ESTER
Naming: -yl sulfonate
e.g. methylmethanesulfonate

THIOCYANATE
Naming: thiocyanate
e.g. ethyl thiocyanate

ISOTHIOCYANATE
Naming: isothiocyanate
e.g. ethyl isothiocyanate



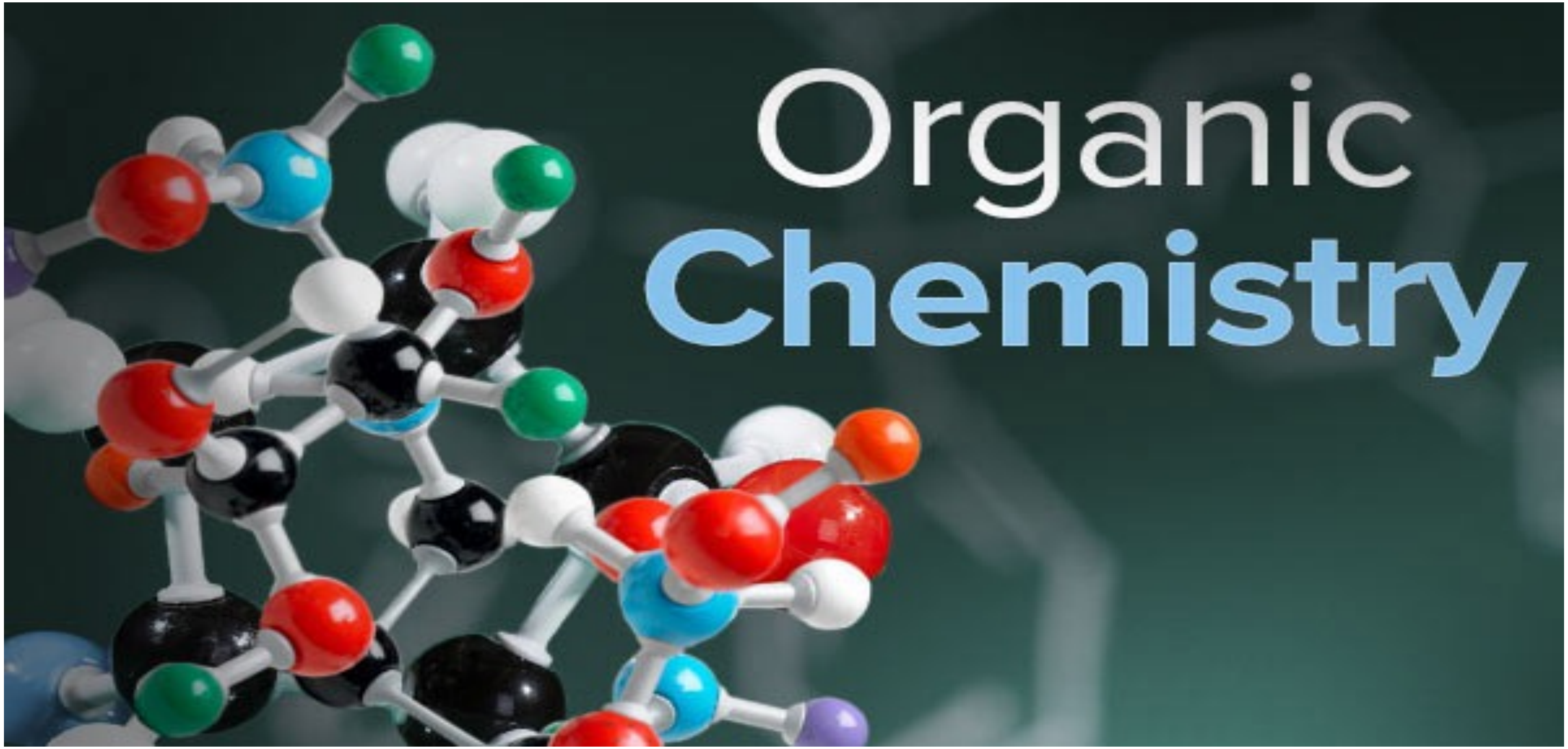
THIAL
Naming: -thial
e.g. ethanethial



THIOKETONE
Naming: -thione
e.g. propanethione

PHOSPHINE
Naming: phosphane
e.g. methylphosphane

Thank you for attention



Organic Chemistry 1st level

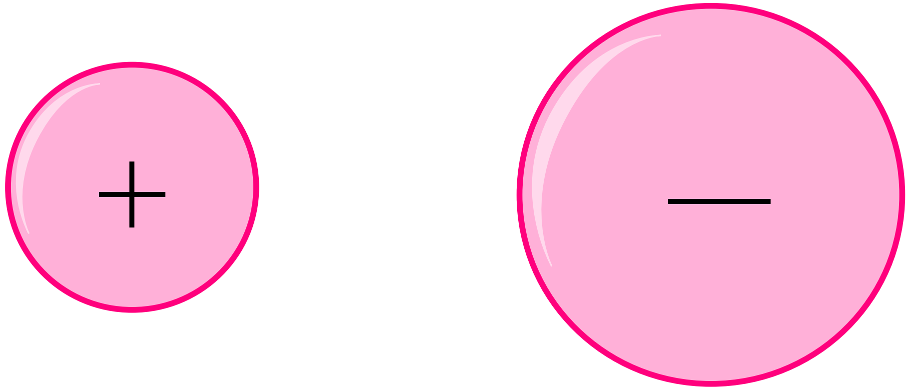
Introduction to Organic Chemistry

- Dipole Moments
- Structure
- Resonance (we may not able to cover this in our lecture today)

Introduction to Organic Chemistry

Dipole Moment

It occurs when there is a separation of charge, this happen when atoms in a molecule share electrons unequally.

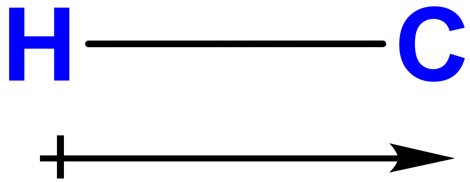


It can also occur between two ions in an ionic bond or between atoms in a covalent bond

Introduction to Organic Chemistry

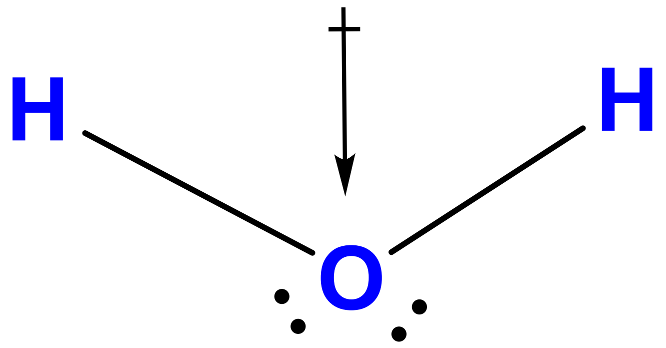
Dipole Moment occurs

- when one atom is more electronegative than another, resulting in that atom pulling more tightly on the shared pair of electrons.



Introduction to Organic Chemistry

- when one atom has a lone pair of electrons and the difference of electronegativity vector points in the same way e.g H_2O



μ: is the Dipole Moments and measured by Debye unit

Introduction to Organic Chemistry

- The dipole moment has a magnitude and a direction.
- It can be noted that the symbols δ^{+} and δ^{-} represent the two electric charges that arise in a molecule which are equal in magnitude but are of opposite signs.
- Dipole moment decreases when the bond length is increasing.
- Dipole moment is proportional with electronegativity.

Introduction to Organic Chemistry

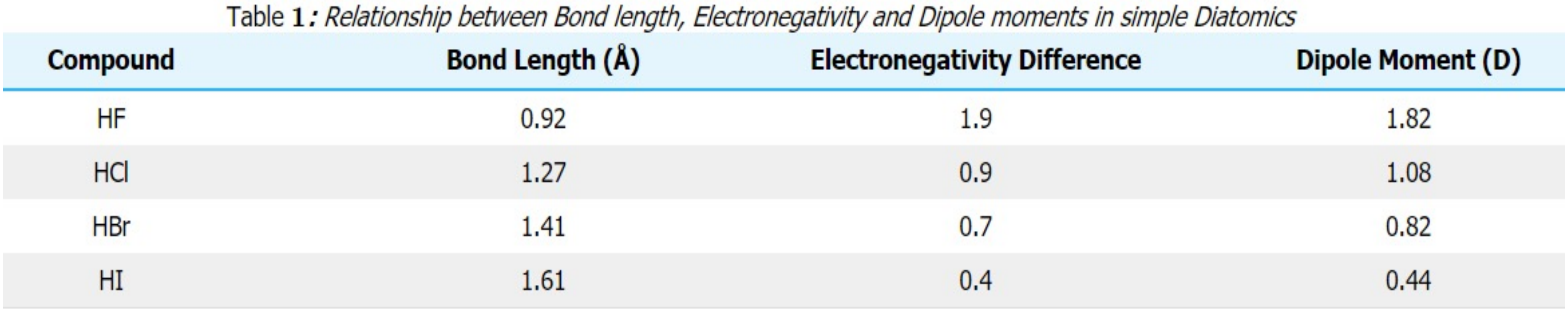


Table **1**: *Relationship between Bond length, Electronegativity and Dipole moments in simple Diatomics*

Compound	**Bond Length (Å)**	**Electronegativity Difference**	**Dipole Moment (D)**
HF	0.92	1.9	1.82
HCl	1.27	0.9	1.08
HBr	1.41	0.7	0.82
HI	1.61	0.4	0.44

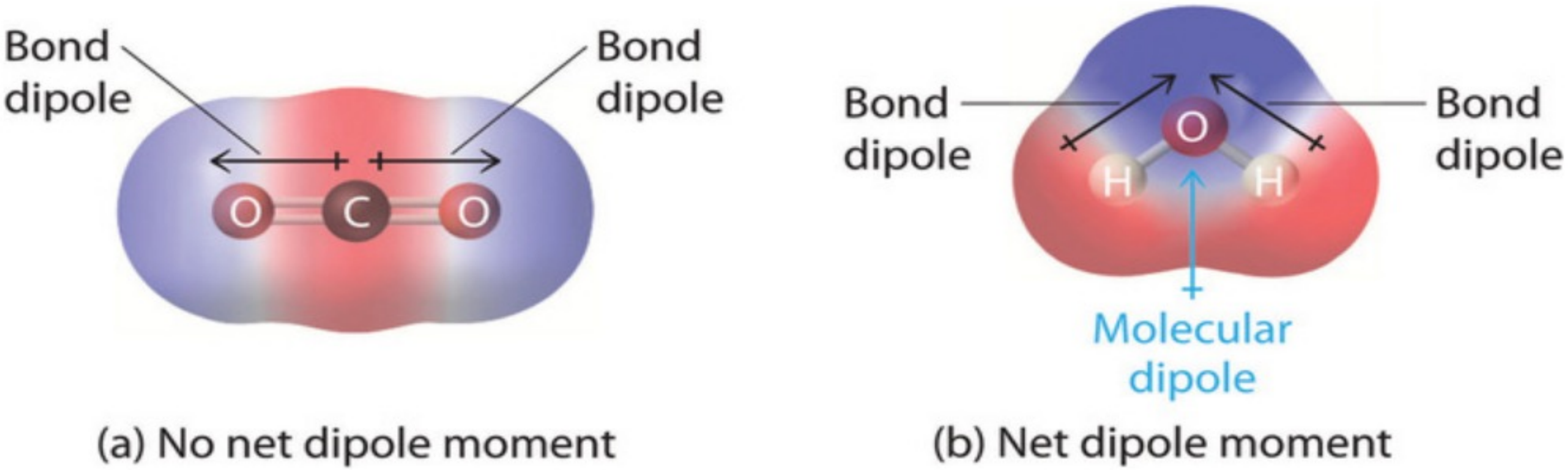
Introduction to Organic Chemistry

Polarity and Structure of Molecules

- The shape of a molecule and the polarity of its bonds determine the OVERALL POLARITY of that molecule.
- A molecule that contains polar bonds, might not have any overall polarity, depending upon its shape.
- The simple definition of whether a complex molecule is polar or not depends upon whether its overall centers of positive and negative charges overlap.
- If these centers lie at the same point in space, then the molecule has no overall polarity (and is non polar). If a molecule is completely symmetric, then the dipole moment vectors on each molecule will cancel each other out, making the molecule nonpolar.
- A molecule can only be polar if the structure of that molecule is not symmetric.

Introduction to Organic Chemistry

Polarity and Structure of Molecules



(a) No net dipole moment (b) Net dipole moment

- A good example of a nonpolar molecule that contains polar bonds is carbon dioxide (in Figure above in the left). This is a linear molecule and each C=O bond is, in fact, polar. The central carbon will have a net positive charge, and the two outer oxygen atoms a net negative charge. However, since the molecule is linear, these two bond dipoles cancel each other out (*i.e.* the vector addition of the dipoles equals zero) and the overall molecule has a zero dipole moment ($\mu=0$).

Introduction to Organic Chemistry

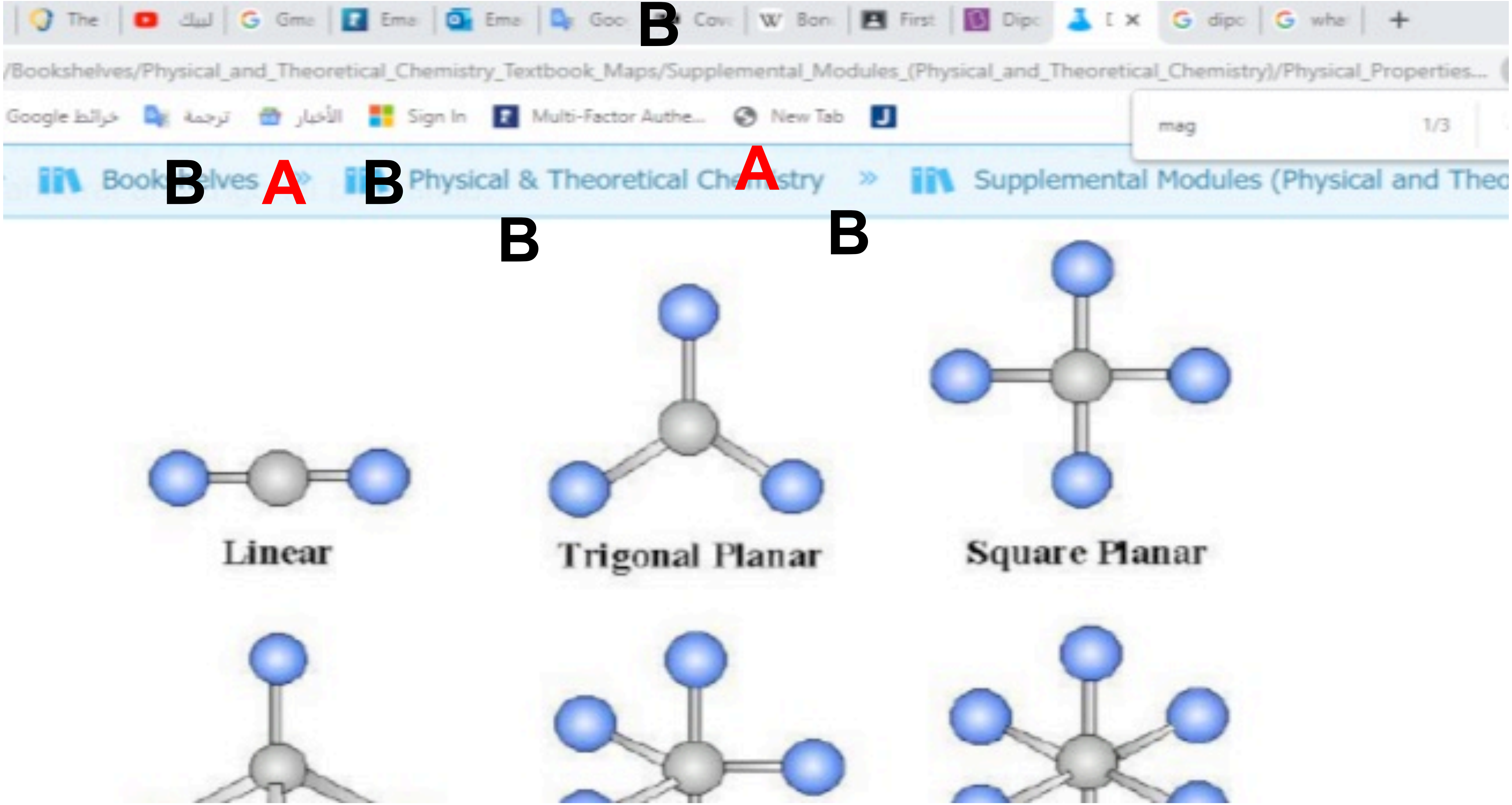
Bonds dipoles in **BeF_2**

Total bond moment in **BeF_2**

Introduction to Organic Chemistry

Polarity and Structure of Molecules

For AB_n molecules, where A is the central atom and B are all the same types of atoms, there are certain molecular geometries which are symmetric. Therefore, they will have no dipole even if the bonds are polar. These geometries include linear, trigonal planar, tetrahedral, octahedral and trigonal bipyramid.

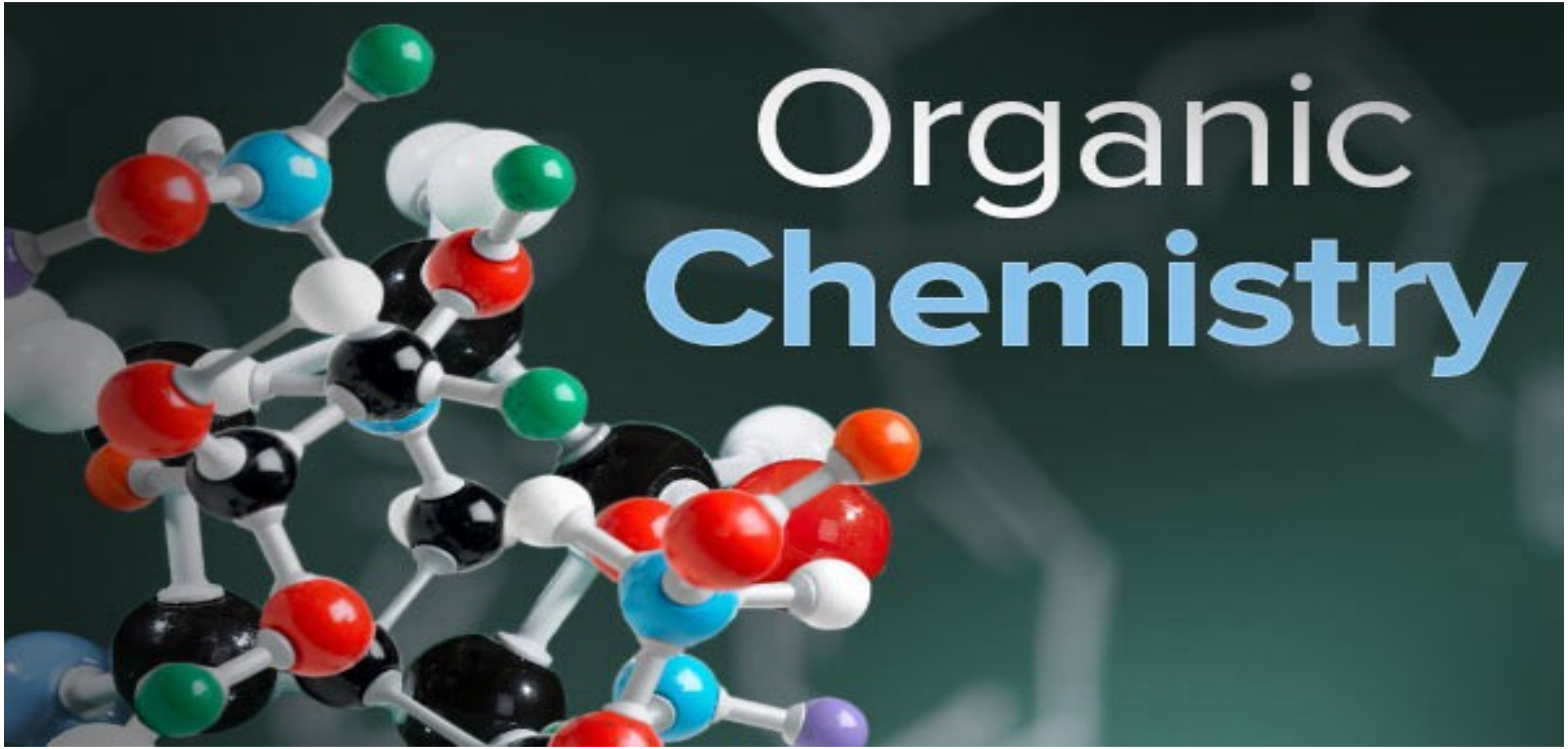

B
B
A
B
B
A
B
/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Physical_Properties...
Google خرائط
ترجمة
الأخبار
Sign In
Multi-Factor Authe...
New Tab
mag
1/3
Bookshelves
Physical & Theoretical Chemistry
Supplemental Modules (Physical and Theo
Linear
Trigonal Planar
Square Planar

Introduction to Organic Chemistry

To summarise

- The bond dipole moment uses the idea of electric dipole moment to measure the polarity of a chemical bond within a molecule. It occurs whenever there is a separation of positive and negative charges.
- The shape of a molecule and the polarity of its bonds determine the OVERALL POLARITY of that molecule.
- If a molecule is completely symmetric, then making the molecule nonpolar.
- These geometries include linear, trigonal planar, tetrahedral, octahedral and trigonal bipyramid will have no dipole moment even if the bonds are polar.

Thank you for attention



Organic Chemistry 1st level

Introduction to Organic Chemistry

- Acid
- Base
- Acid and Base reactions

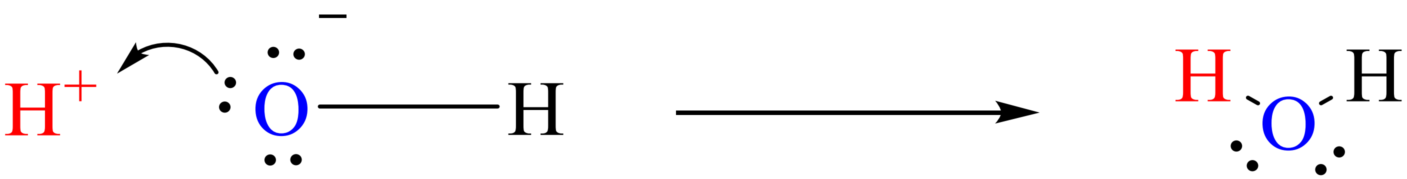
Introduction to Organic Chemistry

Acid is the latin word “acere” which means “sour”. According to Arrhenius that acid is any species increases the concentration of H^+.

$$HCl\ (aq) \longrightarrow H^+\ (aq) + Cl^-\ (aq)$$

Introduction to Organic Chemistry

- In the Lewis theory of acid-base reactions, acids accept pairs of electrons. A **Lewis acid** is therefore any substance, such as the H^+ ion, that can accept a pair of nonbonding electrons. In other words, a Lewis acid is an **electron-pair acceptor**.



- There are many examples of acids such as HCl, H_2SO_4, HNO_3, CH_3COOH (acetic acid).

Introduction to Organic Chemistry

- An Arrhenius base is defined as any species that increases the concentration of hydroxide ions, OH^-, in aqueous solution. An example of an Arrhenius base is the highly soluble sodium hydroxide, NaOH.

$$\mathrm{NaOH\ (aq)} \longrightarrow \mathrm{Na^+\ (aq)} + \mathrm{OH^-\ (aq)}$$

- A **Lewis base** is any substance, such as the OH^- ion, that can donate a pair of nonbonding electrons. A Lewis base is therefore **an electron-pair donor**.

Introduction to Organic Chemistry

- **Acid-base reactions**

$$\mathrm{HF\,(aq)} \longrightarrow \mathrm{H^{+}\,(aq)} + \mathrm{F^{-}\,(aq)}$$

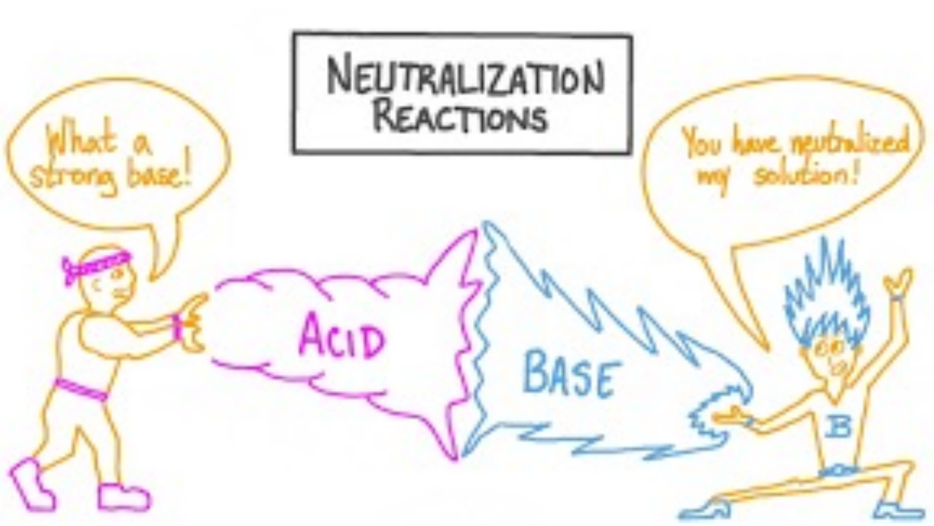
$$\mathrm{LiOH\,(aq)} \longrightarrow \mathrm{Li^{+}\,(aq)} + \mathrm{OH^{-}\,(aq)}$$

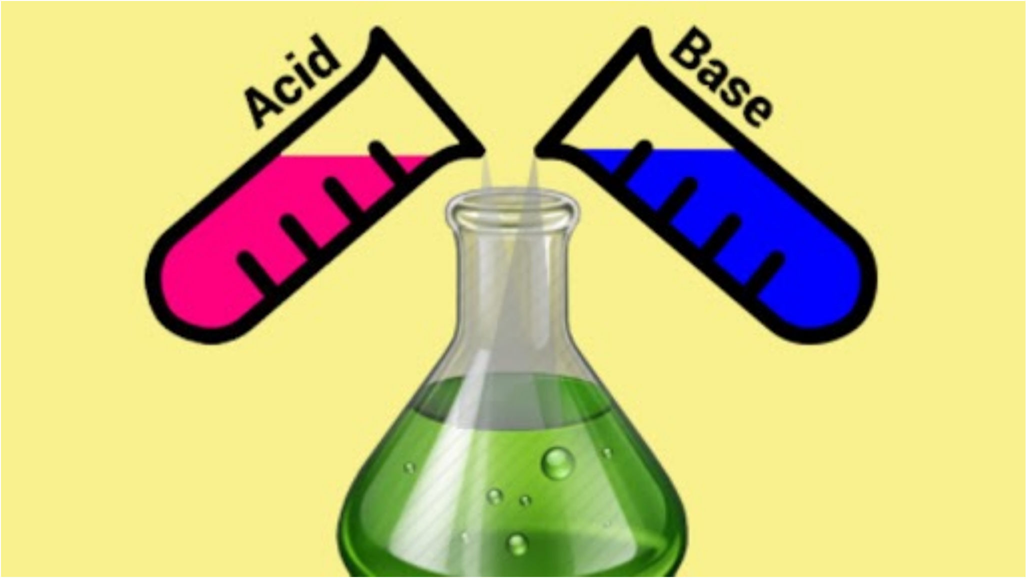
$$\mathrm{H^{+}\,(aq)} + \mathrm{OH^{-}\,(aq)} \longrightarrow \mathrm{H_2O} \quad \text{Water}$$

$$\mathrm{Li^{+}\,(aq)} + \mathrm{F^{-}\,(aq)} \longrightarrow \mathrm{LiF} \quad \text{Salt}$$

Introduction to Organic Chemistry

- Neutralization





Introduction to Organic Chemistry

Strong Acids	**Strong Bases**
HCl	LiOH
HBr	NaOH
HI	KOH
$HClO_4$	RbOH
HNO_3	CsOH
	$Ca(OH)_2$
	$Sr(OH)_2$
	$Ba(OH)_2$

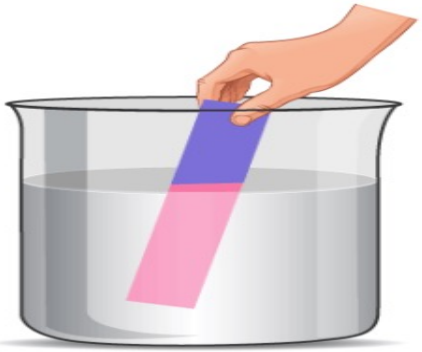
Introduction to Organic Chemistry

- 1. Acids have a sour taste.
- 2. Acids are corrosive.
- 3. Acids change the color of certain vegetable dyes, such as litmus, from blue to red.
- 4. Acids lose their acidity when they are combined with alkalies.

1- Alkalies feel slippery

2- Alkalies change the color of litmus from red to blue.

3- Alkalies become less alkaline when they are combined with acids.



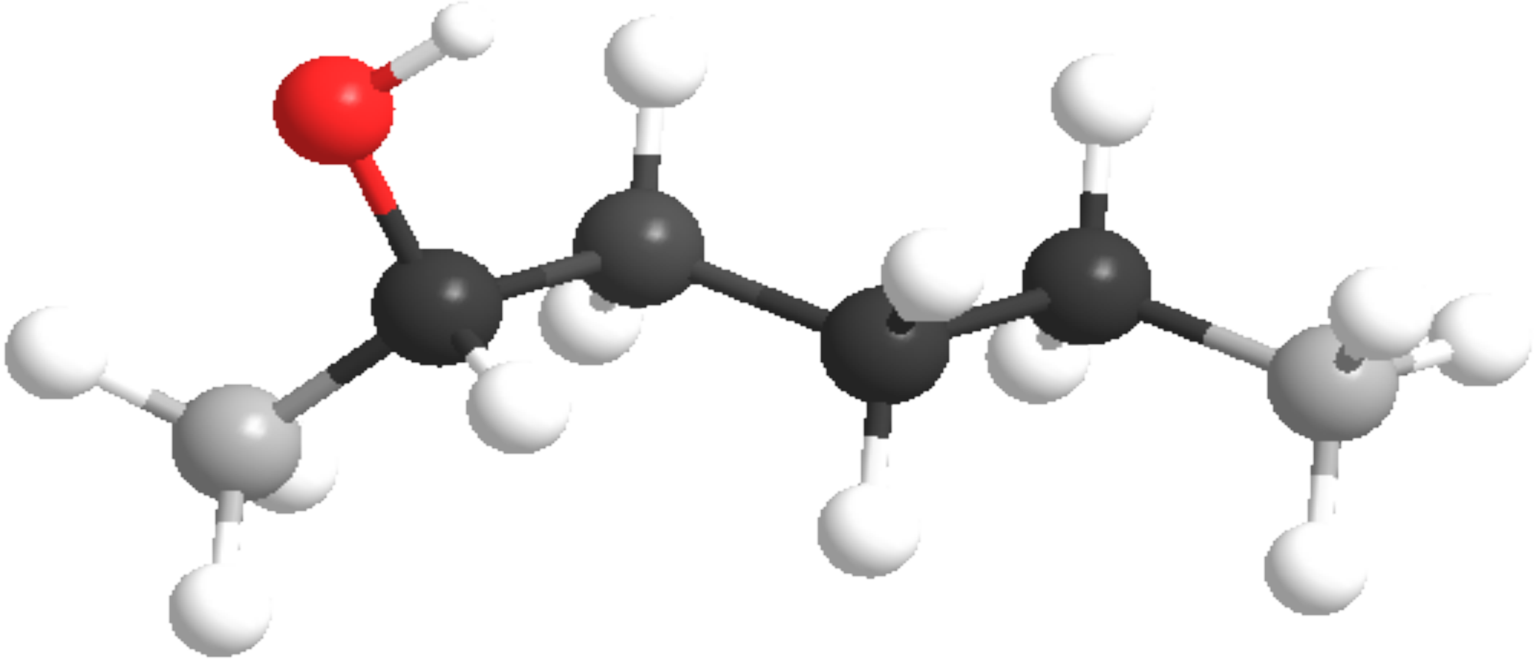
Acid

Blue litmus turns red

Base

Red litmus turns blue

Thank you for attention



Hydrocarbons

by

Mohammed Adnan Abid

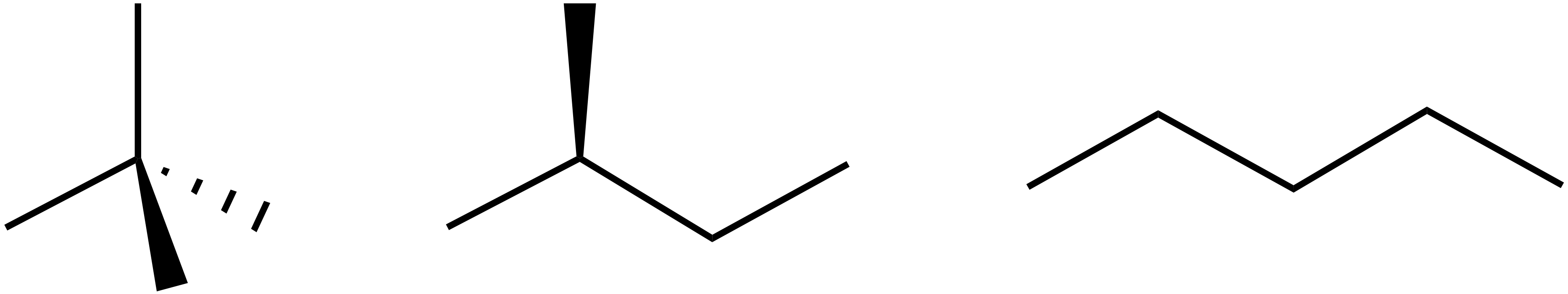
Hydrocarbons

- What are the hydrocarbons
- How many groups can hydrocarbons be classified
- How can nomenclature the hydrocarbons
- The physical properties of hydrocarbons

Hydrocarbons

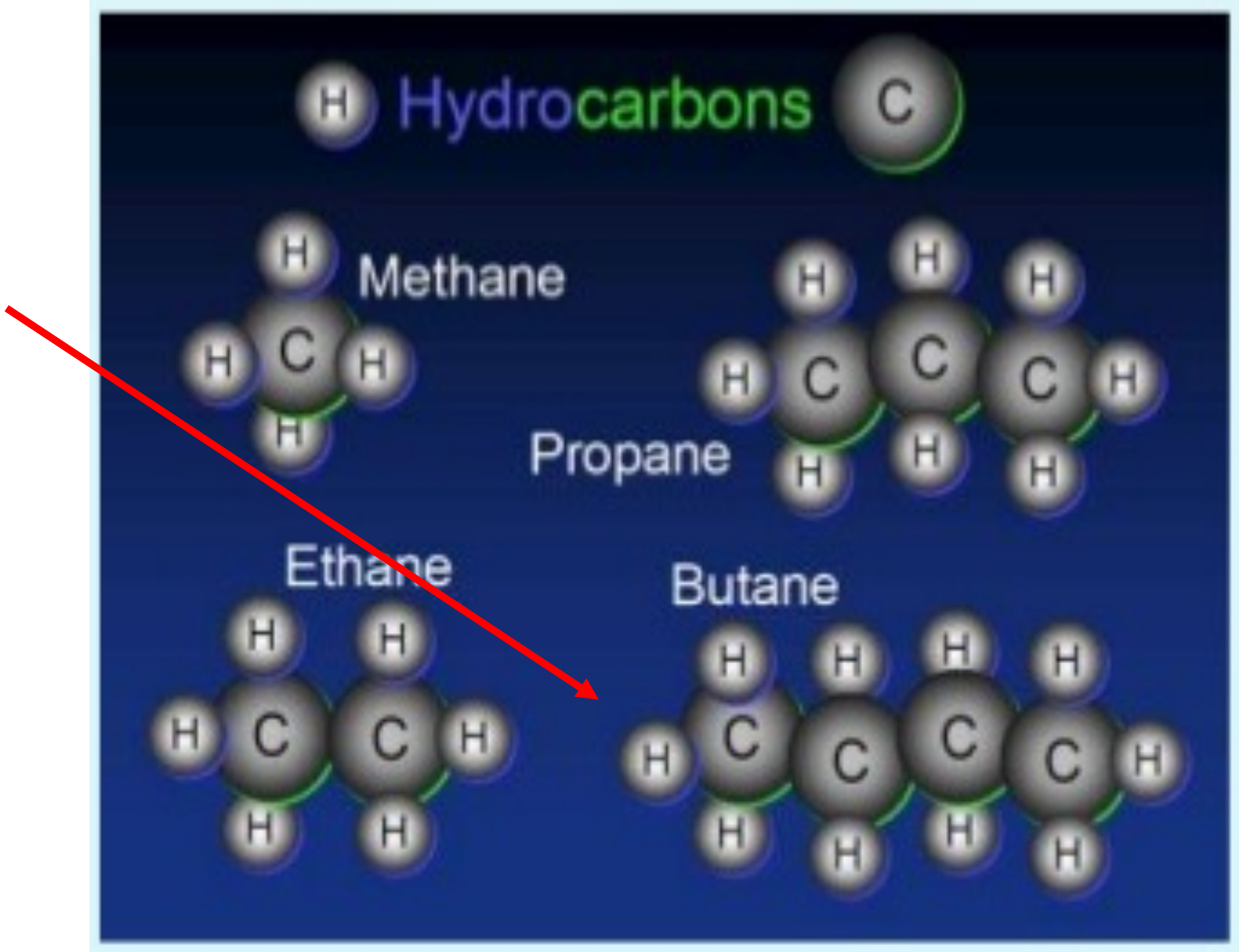
Hydrocarbons

Are the simplest organic compounds which are made up of Carbon and Hydrogen atoms only. Hydrocarbons are naturally-occurring compounds and form the basis of crude oil, natural gas, coal, and other important energy sources. They are highly flammable and produce carbon dioxide, water, and heat when they are burned. Therefore, hydrocarbons are highly effective as a source of fuel.



Hydrocarbons

Butane for example is the one of hydrocarbons, which is used as cooking gas in our daily activities. It is a gas at room temperature and atmospheric pressure. Butane is a highly flammable, colorless. Normal butane can be used for gasoline blending, as a fuel gas, fragrance extraction solvent, either alone or in a mixture with propane.



Hydrocarbons

- Depending upon the type of carbon-carbon bonds present, hydrocarbons can be classified into three main categories:

1. Saturated Hydrocarbons
2. Unsaturated Hydrocarbons
3. Aromatic Hydrocarbons

Hydrocarbons

Saturated Hydrocarbons

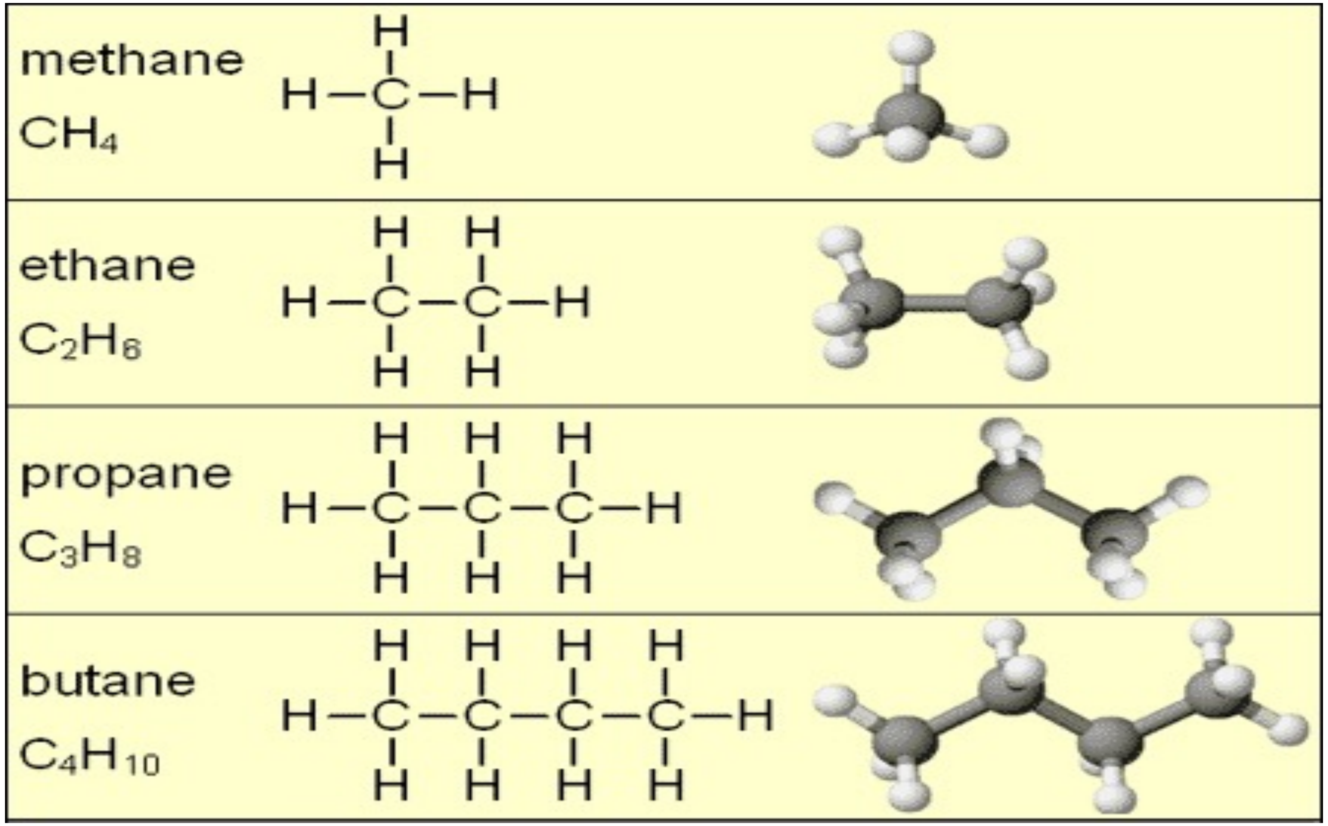
In these compounds, carbon-carbon atoms and carbon-hydrogen atoms are held together by single bonds. These single bonded compounds are the simplest hydrocarbons. These types of hydrocarbons don't have double or triple bonds. In terms of hybridization, they have Sp^3 hybridised carbon atom with no Sp^2 or Sp hybridised carbon atoms. They are together called as **alkanes** which have a general formula C_nH_{2n+2}. For example, CH_4, C_3H_8.

Hydrocarbons

These compounds called SATURATED (alkanes) due to they have maximum number of bonded hydrogen.

The main formula of alkane is

$$C_nH_{2n+2}$$



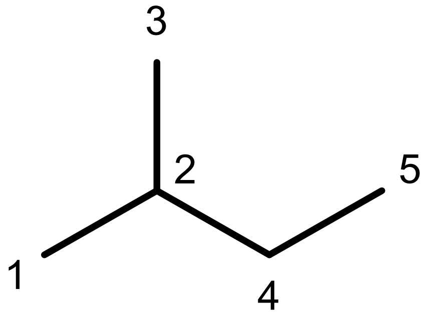
Hydrocarbons

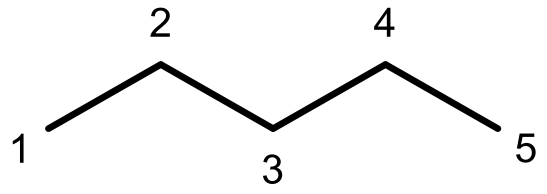
Alkanes

Also known as paraffins, are the simplest of organic compounds. They are saturated hydrocarbons that form an homologous series with the general formula C_nH_{2n+2}. The first few in the series are methane, ethane, propane, and butane; from pentane on they are named after the number of carbon atoms in the molecule. Lower members in the series are gases; from pentane (C_5H_{12}) to heptadecane ($C_{17}H_{36}$) they are liquids; higher members are waxy solids.

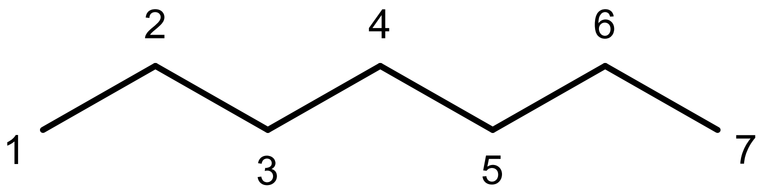
Hydrocarbons

- Alkanes with four or more carbon atoms have several isomers (will talk about it later on).





- The straight-chain isomers being called normal alkanes (*n*-alkanes).



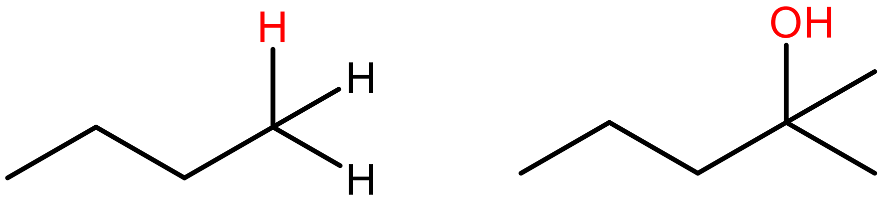
- Branched alkanes are named as derivatives of the longest straight chain in the molecule.

Hydrocarbons

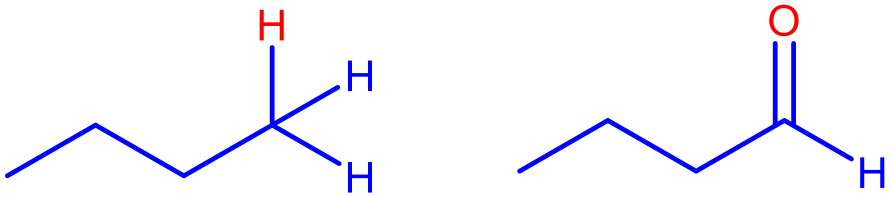
- Alkanes are soluble in most organic solvents, but not in water.
- The lower alkanes are less reactive than the higher ones.
- Typical reactions include combustion in air, decomposition and rearrangement on heating, isomerization and condensation with alkenes (with acid catalyst), nitration, sulfonation, and halogenation by fluorine, chlorine, and bromine (with heat and light).

Hydrocarbons

- Alkanes are converted into other compounds by replacing a hydrogen with other functional groups. The most important substitutions for biochemistry are -OH (alcohol), -CHO (aldehyde), -COO-R- (ester, R=alkyl group), -COOH (carboxylic acid), $-PO_4$ (organic phosphate), and $-NH_2$ (amine).



Alcohol



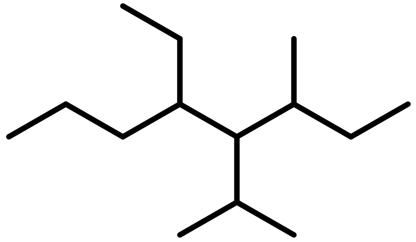
Aldehyde

Hydrocarbons

Alkanes also can be divided into two categories:

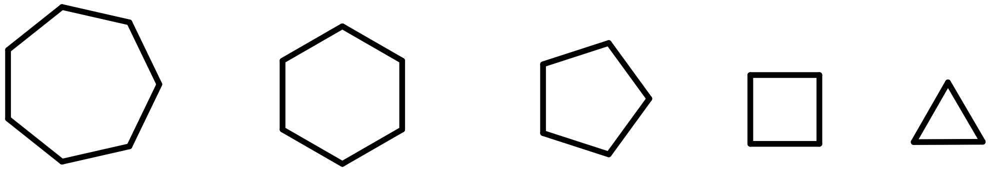
1. Open chain or Acyclic alkanes

Straight-chain alkanes



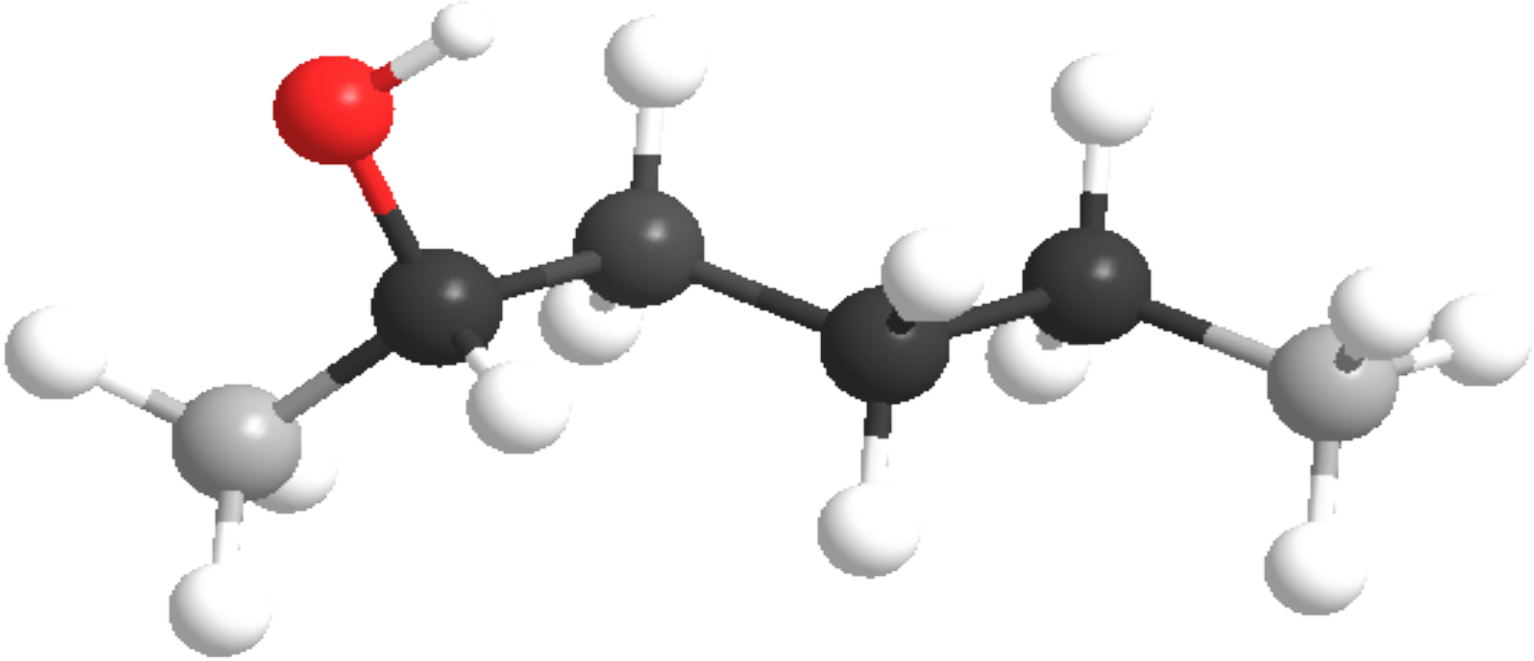
Branched alkanes

2. Cycloalkanes or cyclic alkanes: These hydrocarbons possess one or multiple carbon rings. The hydrogen atom is attached to the carbon ring.



cyclo alkanes

Thank you for attention



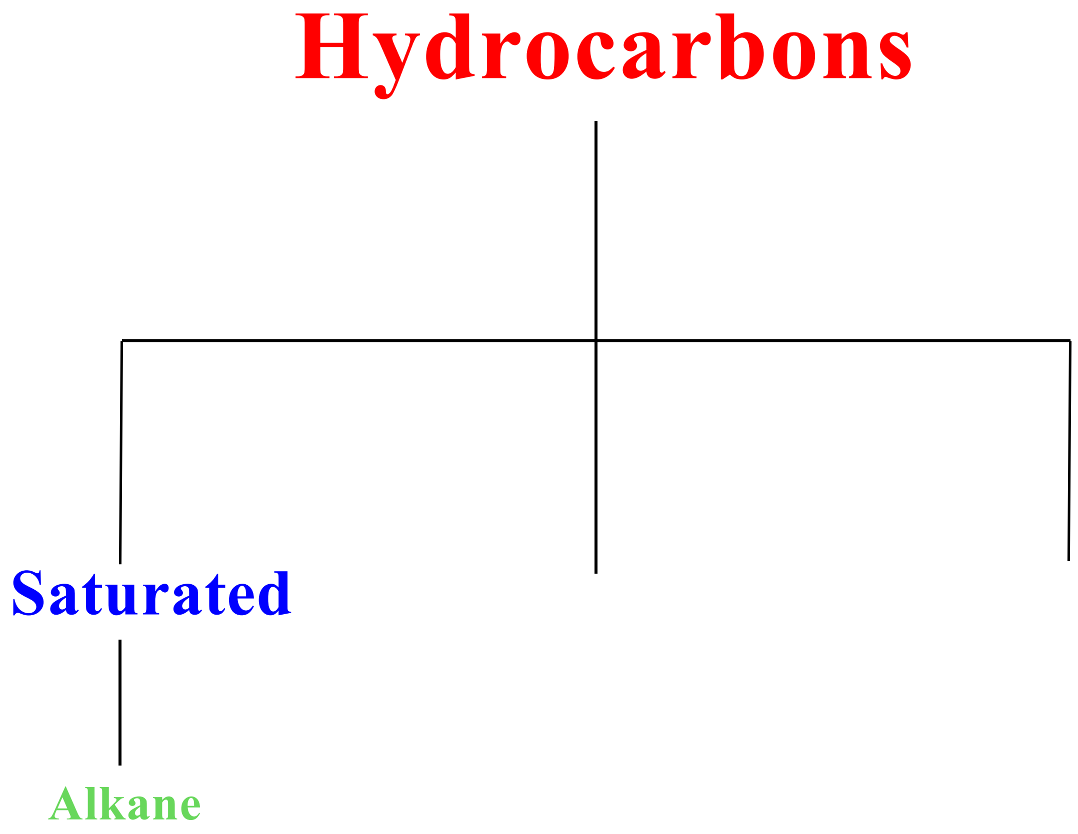
Hydrocarbons

by

Mohammed Adnan Abid

Hydrocarbons

Saturated hydrocarbons



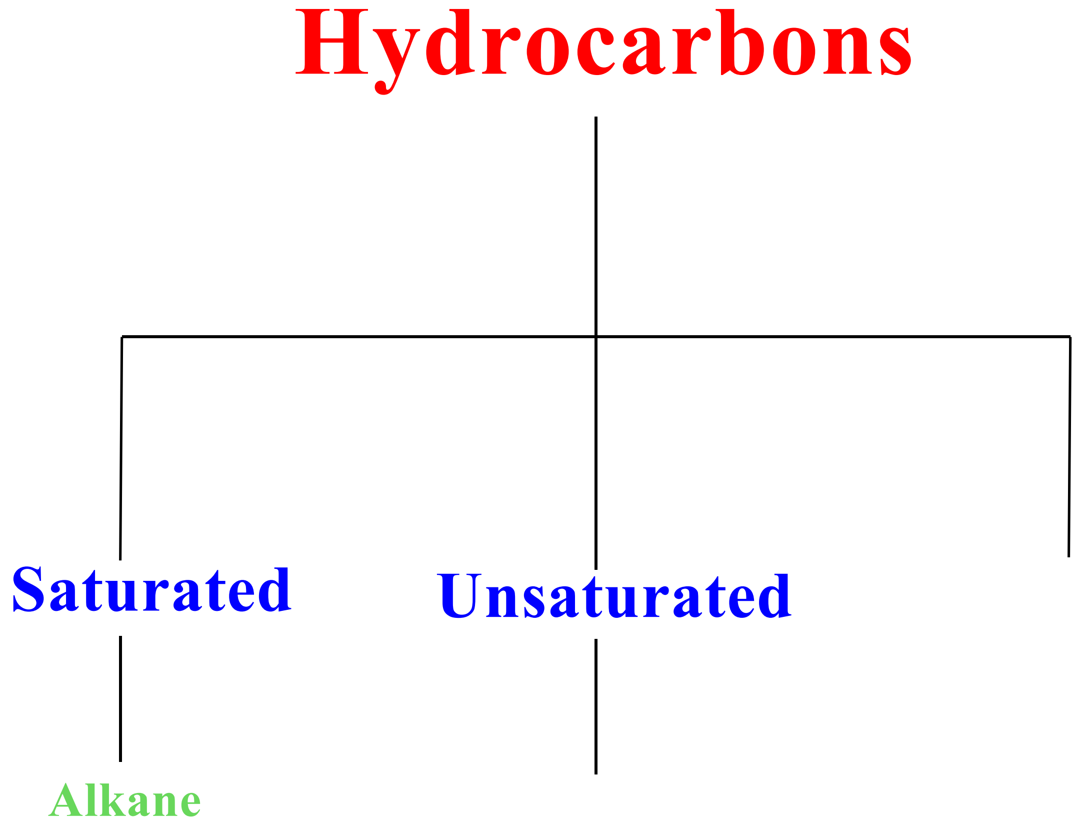
Hydrocarbons

Saturated

Alkane

Hydrocarbons

Unsaturated hydrocarbons



Hydrocarbons

Saturated

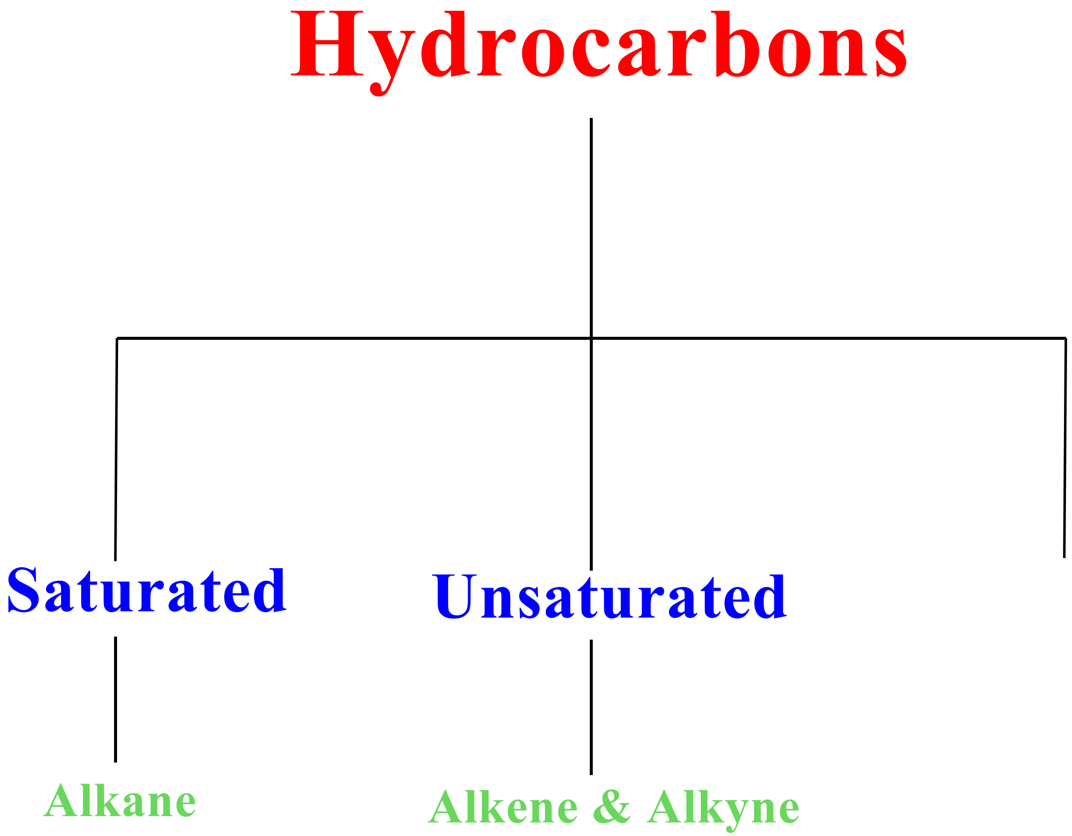
Unsaturated

Alkane

Hydrocarbons

Unsaturated hydrocarbons

Alkene and Alkyne



Hydrocarbons

Saturated

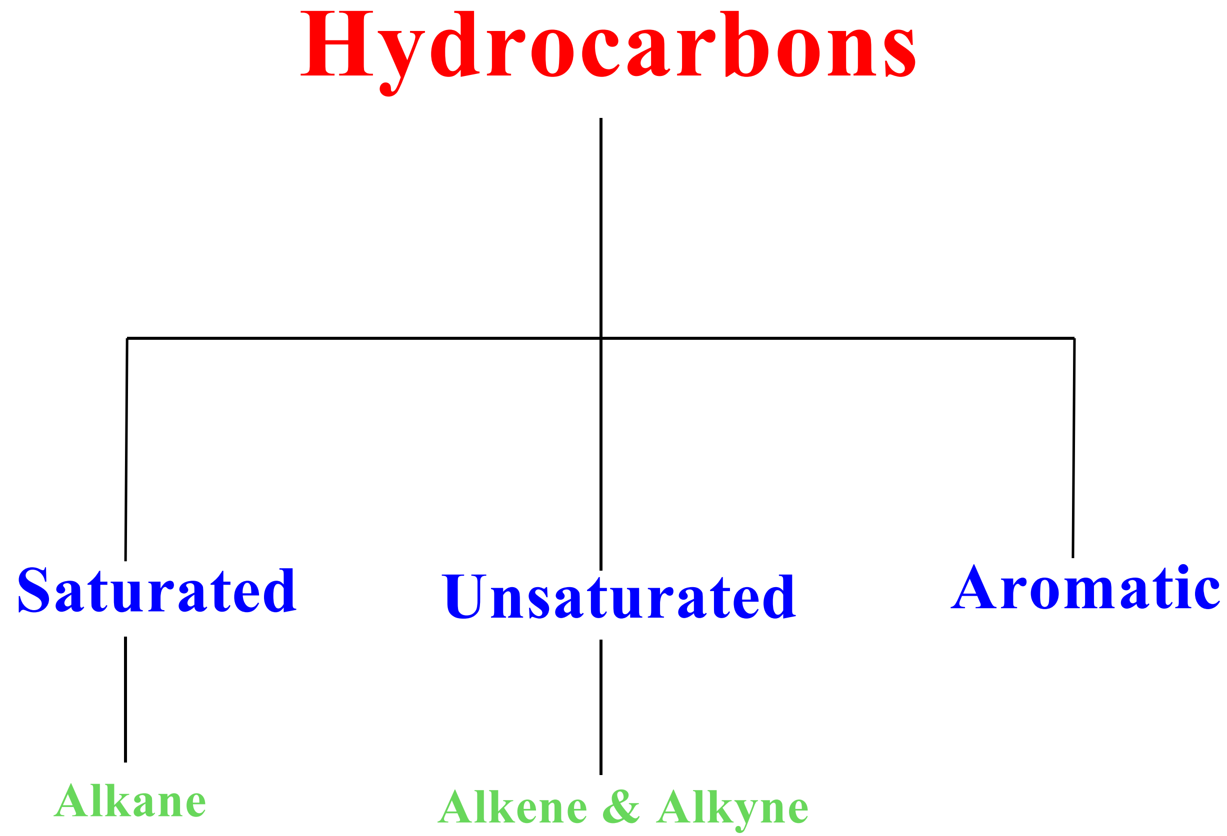
Unsaturated

Alkane

Alkene & Alkyne

Hydrocarbons

Aromatic hydrocarbons



Hydrocarbons

Saturated
Unsaturated
Aromatic

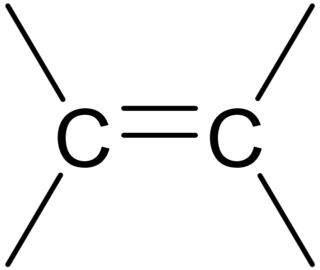
Alkane
Alkene & Alkyne

Hydrocarbons

Unsaturated hydrocarbons

Alkene

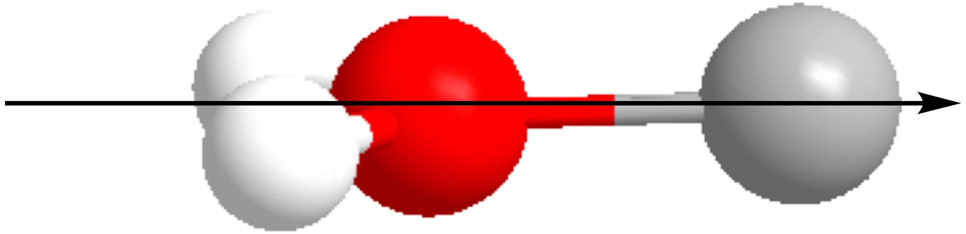
An **alkene** is a hydrocarbon with one or more carbon-carbon double covalent bonds. The simplest alkene is composed of two carbon atoms and is called ethene (shown below). Each carbon is bonded to two hydrogen atoms, in addition to the double bond between them.

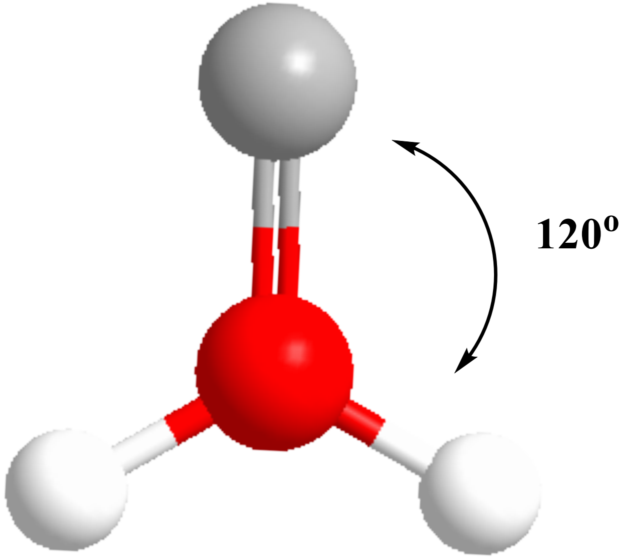


Hydrocarbons

Alkene

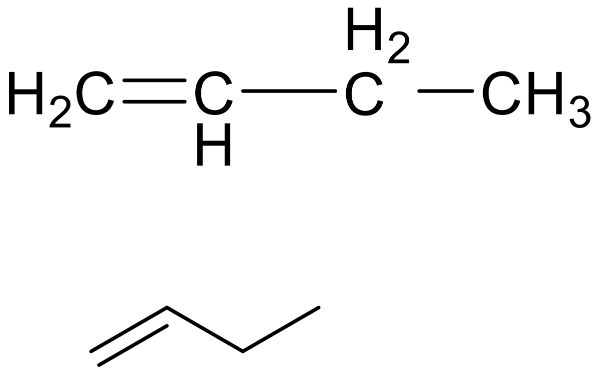
- The hybridization of each carbon atom is sp^2 with trigonal planar geometry. All the atoms of the molecule lay in one plane. The general formula for alkenes with one double bond is C_nH_{2n}





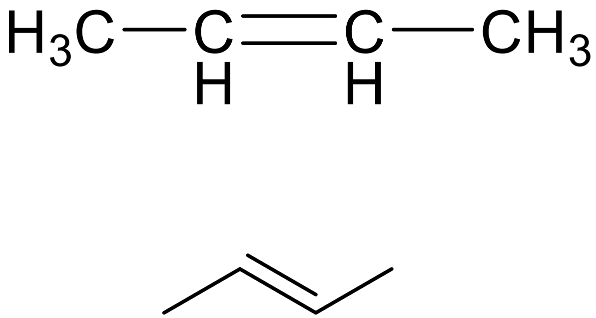
Hydrocarbons

- An **unsaturated hydrocarbon** is a hydrocarbon that contains less than the maximum number of hydrogen atoms that can possibly bond with the number of carbon atoms present.
- The location of the carbon-carbon double bond can vary. The 4-carbon alkene generic name is butene. Since the double bond can be located in more than one place, we have for example 1-butene and 2-butene:



$H_2C{=}CH{-}CH_2{-}CH_3$

1-butene

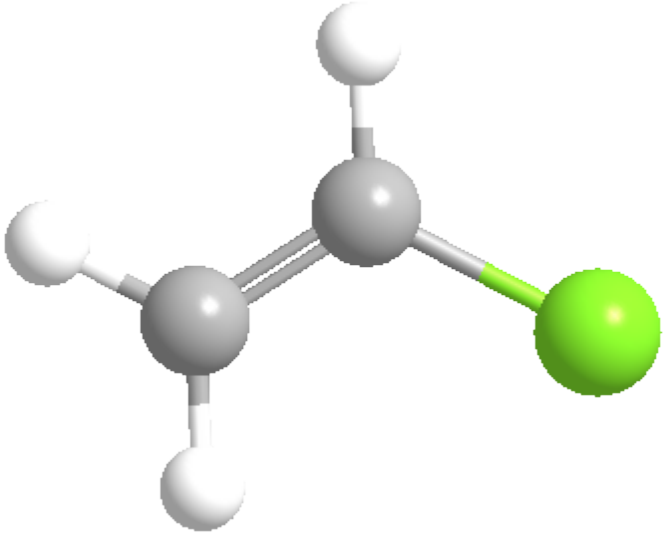


$H_3C{-}CH{=}CH{-}CH_3$

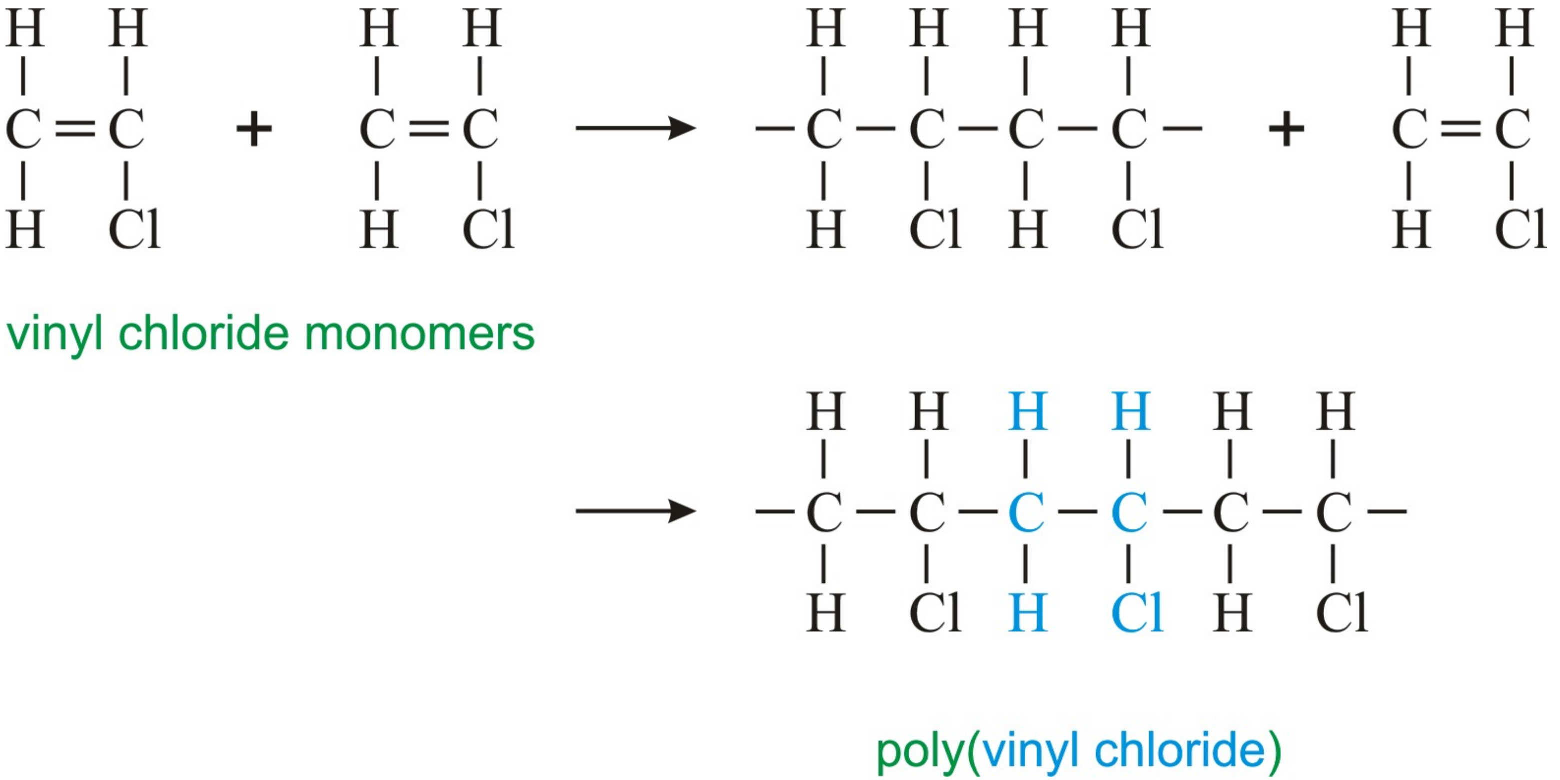
2-butene

Hydrocarbons

- Polymerization of vinyl chloride gives polyvinyl chloride, or PVC, more than 27 million tons of which is used globally each year to produce pipes, floor tiles, siding for houses, gutters.



Vinyl chloride



Hydrocarbons

Alkynes

- An **alkyne** is a hydrocarbon with one or more carbon-carbon triple covalent bonds. The simplest alkyne consists of two carbon atoms and is called ethyne (common name: acetylene).

$$H-C\equiv C-H$$

- The ethyne molecule is linear, with sp hybridization for each carbon atom. The general formula of alkynes with one triple bond is C_nH_{2n-2}. Alkynes are also unsaturated hydrocarbons.

Hydrocarbons

To sum

- An alkane is a hydrocarbon with one carbon-carbon covalent bonds with general formula C_nH_{2n+2}.
- An alkene is a hydrocarbon with one or more carbon-carbon double covalent bonds with general formula C_nH_{2n}.
- An alkyne is a hydrocarbon with one or more carbon-carbon triple covalent bonds with general formula C_nH_{2n-2}.
- An unsaturated hydrocarbon is a hydrocarbon that contains less than the maximum number of hydrogen atoms that can possibly bond with the number of carbon atoms present.

Hydrocarbons

Nomenclature of hydrocarbons (Alkanes)

After the classification of alkanes, the new approach has been developed to name them according to a global system. This system has been agreed upon by chemists, known as the systematic nomenclature.

Systematic name: is known as abbreviated as IUPAC, which is present the first letters of the words International Union of Pure and Applied Chemistry.

Hydrocarbons

Nomenclature of hydrocarbons

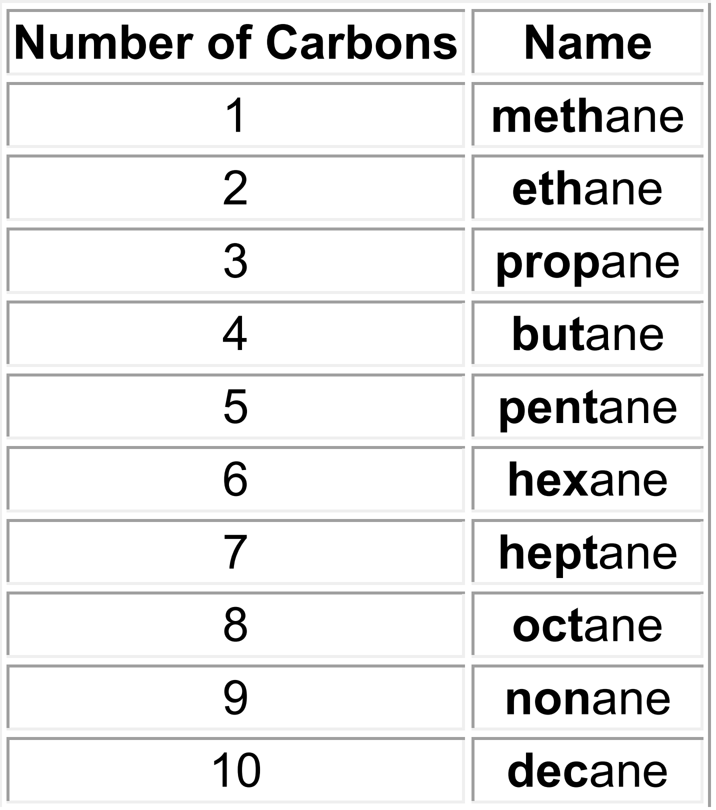
saturated hydrocarbons(Alkanes)

In order to name organic compounds you must first memorize a few basic names. These names are listed within the discussion of naming alkanes. In general, the base part of the name reflects the **number** of carbons in what you have assigned to be the **parent chain**. The **suffix** of the name reflects the type(s) of functional group(s) present on (or within) the parent chain. Other groups which are attached to the parent chain are called **substituents.**

Hydrocarbons

- The names of the straight chain saturated hydrocarbons for up to a 10 carbon chain are shown below. The names of the substituents formed by the removal of one hydrogen from the end of the chain is obtained by changing the suffix -**ane** to -**yl**.

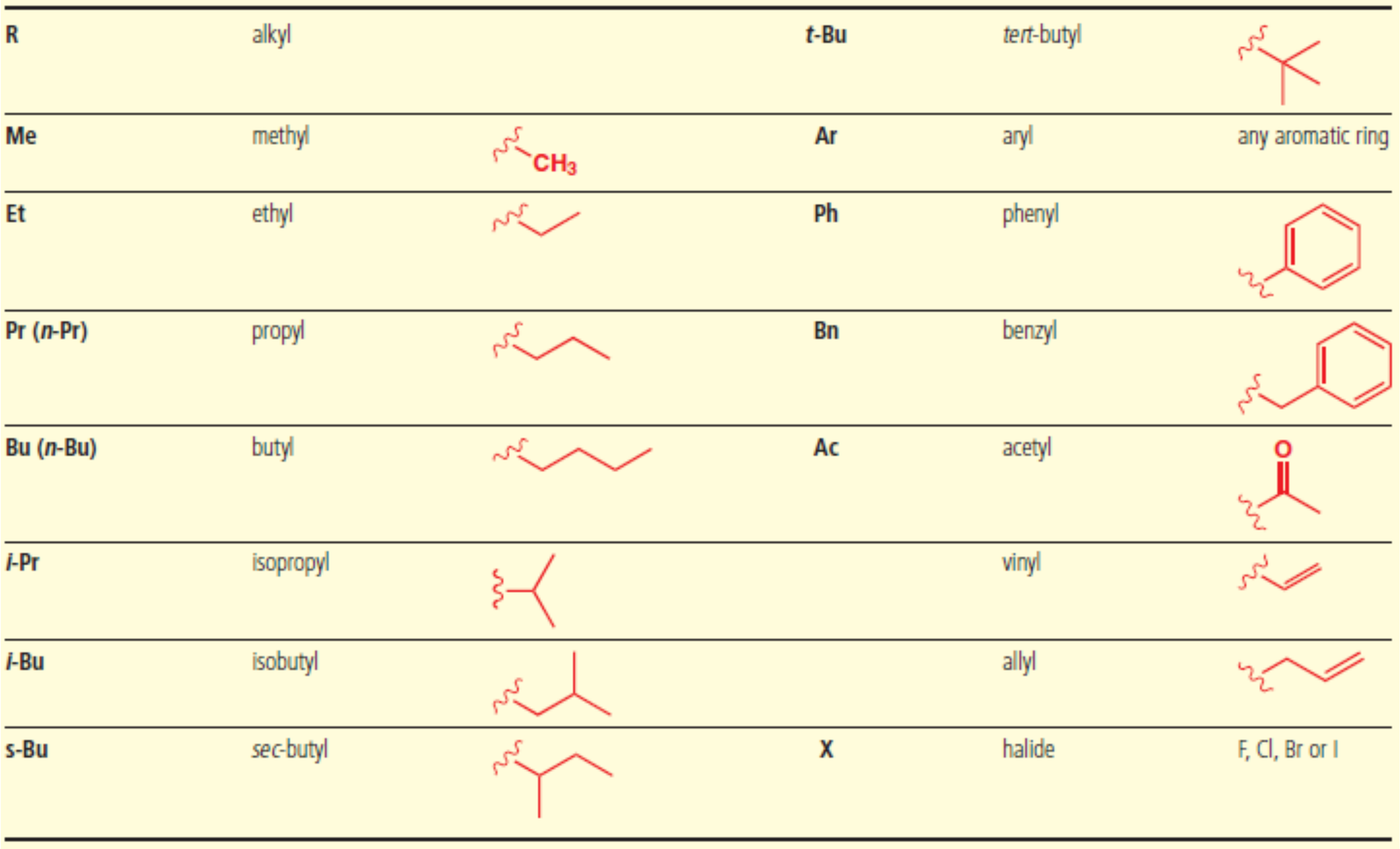
$$\underset{\textbf{alkane}}{C_nH_{2n+2}} \xrightarrow{-\,H} \underset{\textbf{alkyl}}{C_nH_{2n+1}}$$



Number of Carbons	Name
1	**meth**ane
2	**eth**ane
3	**prop**ane
4	**but**ane
5	**pent**ane
6	**hex**ane
7	**hept**ane
8	**oct**ane
9	**non**ane
10	**dec**ane

Hydrocarbons

There are a few common branched substituents which you should memorize. These are shown below.



R	alkyl		***t*-Bu**	*tert*-butyl	
Me	methyl	CH_3	**Ar**	aryl	any aromatic ring
Et	ethyl		**Ph**	phenyl	
Pr (*n*-Pr)	propyl		**Bn**	benzyl	
Bu (*n*-Bu)	butyl		**Ac**	acetyl	O
***i*-Pr**	isopropyl			vinyl	
***i*-Bu**	isobutyl			allyl	
s-Bu	*sec*-butyl		**X**	halide	F, Cl, Br or I

Hydrocarbons

- Here is a simple list of rules to follow. Some examples are given at the end of the list:

1. Identify the longest carbon chain. This chain is called the parent chain.
2. Identify all of the substituents (groups appending from the parent chain).
3. Number the carbons of the parent chain from the end that gives the substituents the lowest numbers. When comparing a series of numbers, the series that is the "lowest" is the one which contains the lowest number at the occasion of the first difference. If two or more side chains are in equivalent positions, assign the lowest number to the one which will come first in the name.

Hydrocarbons

4. If the same substituent occurs more than once, the location of each point on which the substituent occurs is given. In addition, the number of times the substituent group occurs is indicated by a prefix (di, tri, tetra, etc.).
5. If there are two or more different substituents they are listed in alphabetical order using the base name (ignore the prefixes). The only prefix which **is** used when putting the substituents in alphabetical order is **iso** as in isopropyl or isobutyl. The prefixes sec- and tert- are not used in determining alphabetical order except when compared with each other.

Hydrocarbons

6. If chains of equal length are competing for selection as the parent chain, then the choice goes in series to:
   a) the chain which has the greatest number of side chains.
   b) the chain whose substituents have the lowest- numbers.
   c) the chain having the greatest number of carbon atoms in the smaller side chain.
   d)the chain having the least branched side chains.
7. A cyclic (ring) hydrocarbon is designated by the prefix **cyclo-** which appears directly in front of the base name.

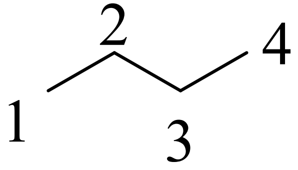
Hydrocarbons

- When the alkyl group attached to carbon atom which attaches to one carbon atom, it is call primary carbon and it presents as (1°).
- When the alkyl group attached to carbon atom which attaches to two carbon atoms, it is call secondary (sec) carbon and it presents as (2°).
- When the alkyl group attached to carbon atom which attaches to three carbon atoms, it is call tertiary (tert) carbon and it presents as (3°). Also, the quaternary (4°).

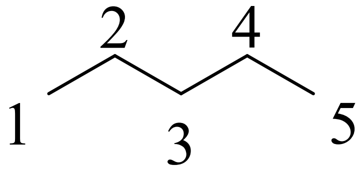
Hydrocarbons

Some examples of alkanes nomenclature

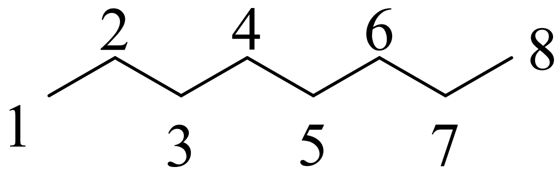
- Identify the longest carbon chain, this chain is called the parent chain, any others are called alkyl groups.
-



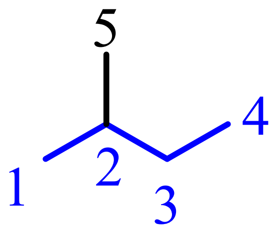
n-butane

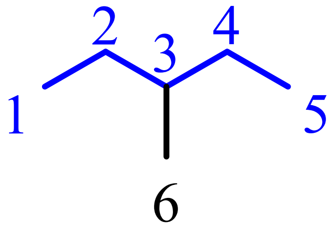


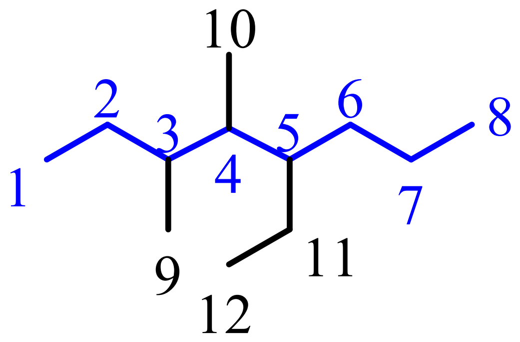
n-pentane



n-octane

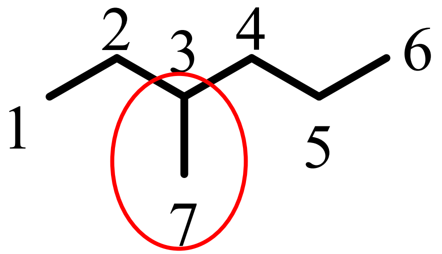




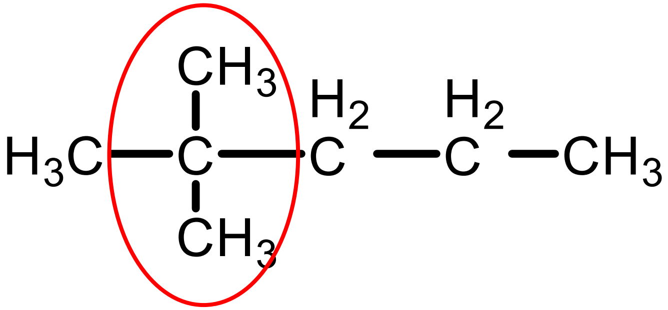


Hydrocarbons

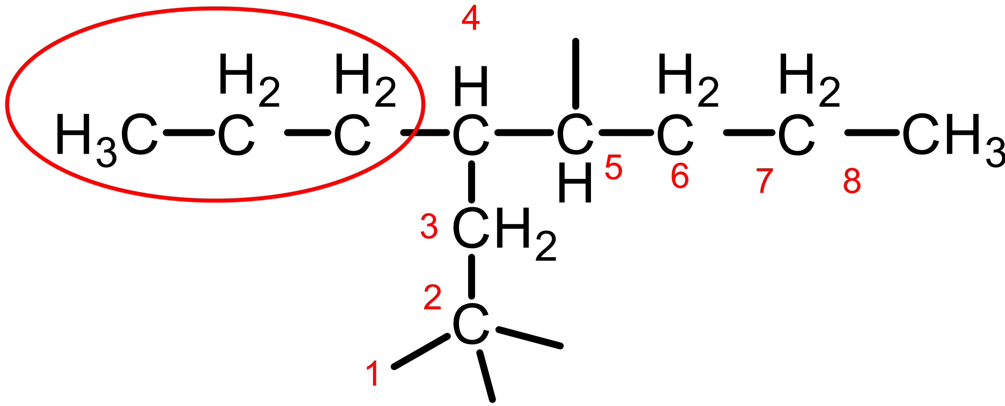
- Examples



3-methylhexane

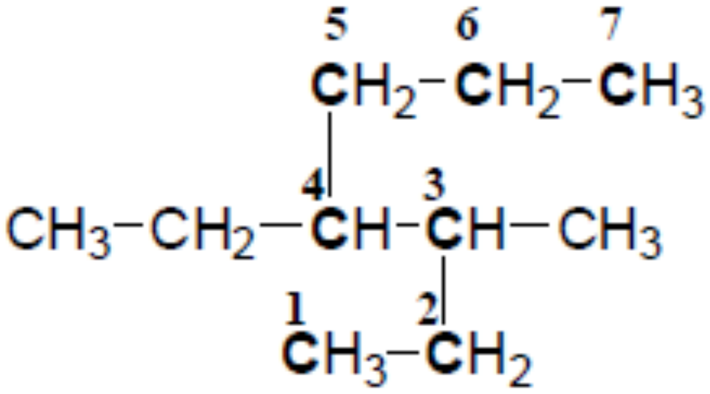


2,2-dimethylpentane

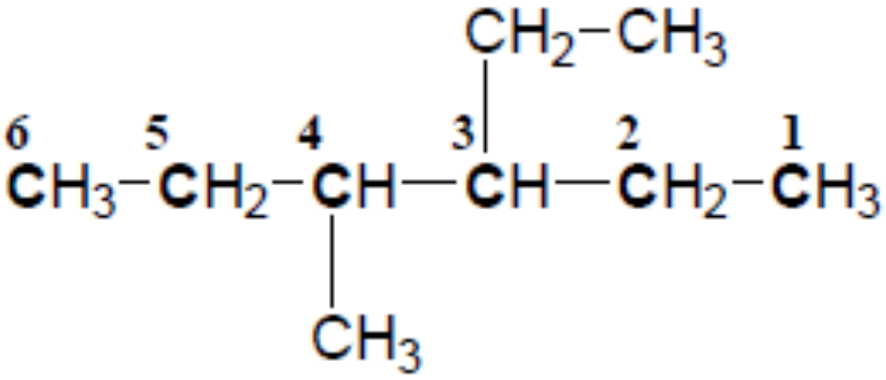


2,2,5-trimethyl-4-propyloctane

Hydrocarbons



4-Ethyl-3-methyl heptane

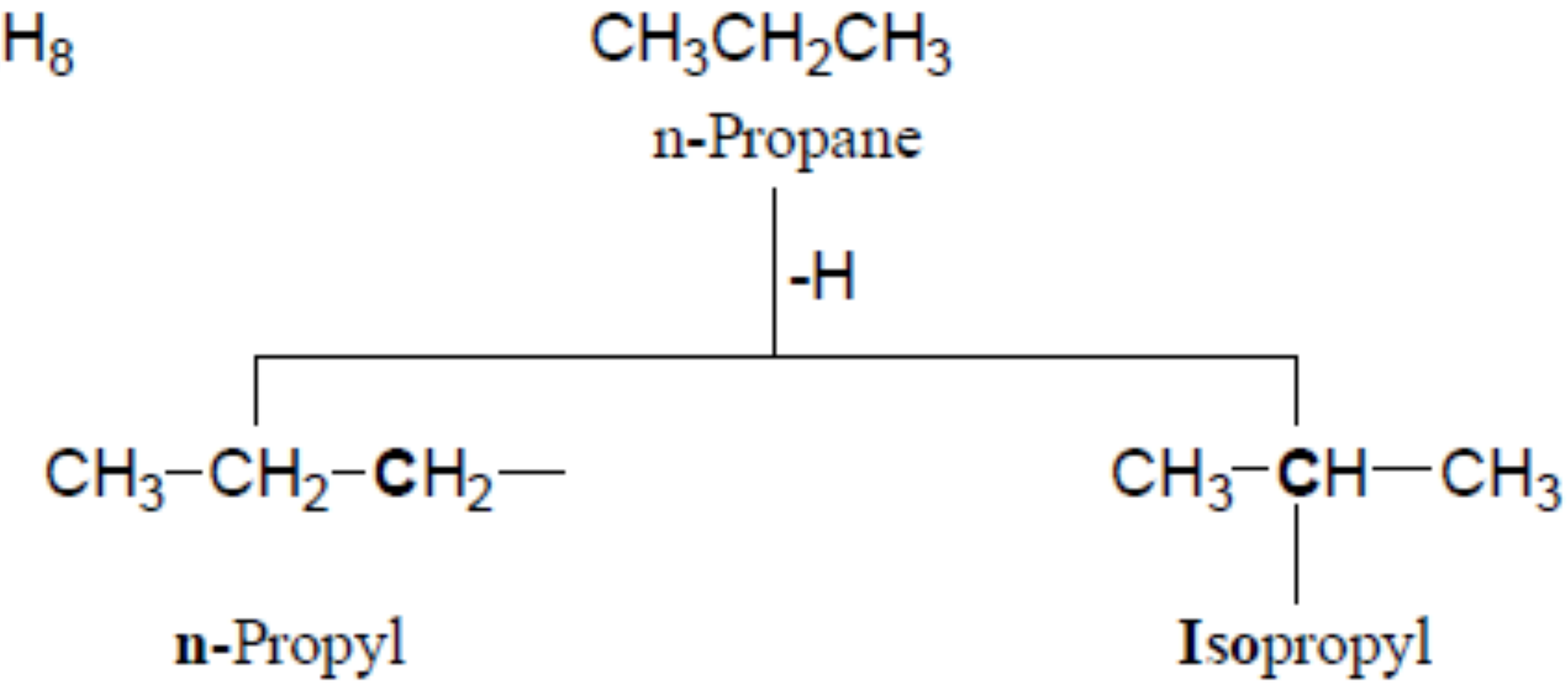


3-Ethyl- 4-methyl hexane

To be continued…….

Hydrocarbons

C_3 : C_3H_8



$CH_3CH_2CH_3$

n-Propane

-H

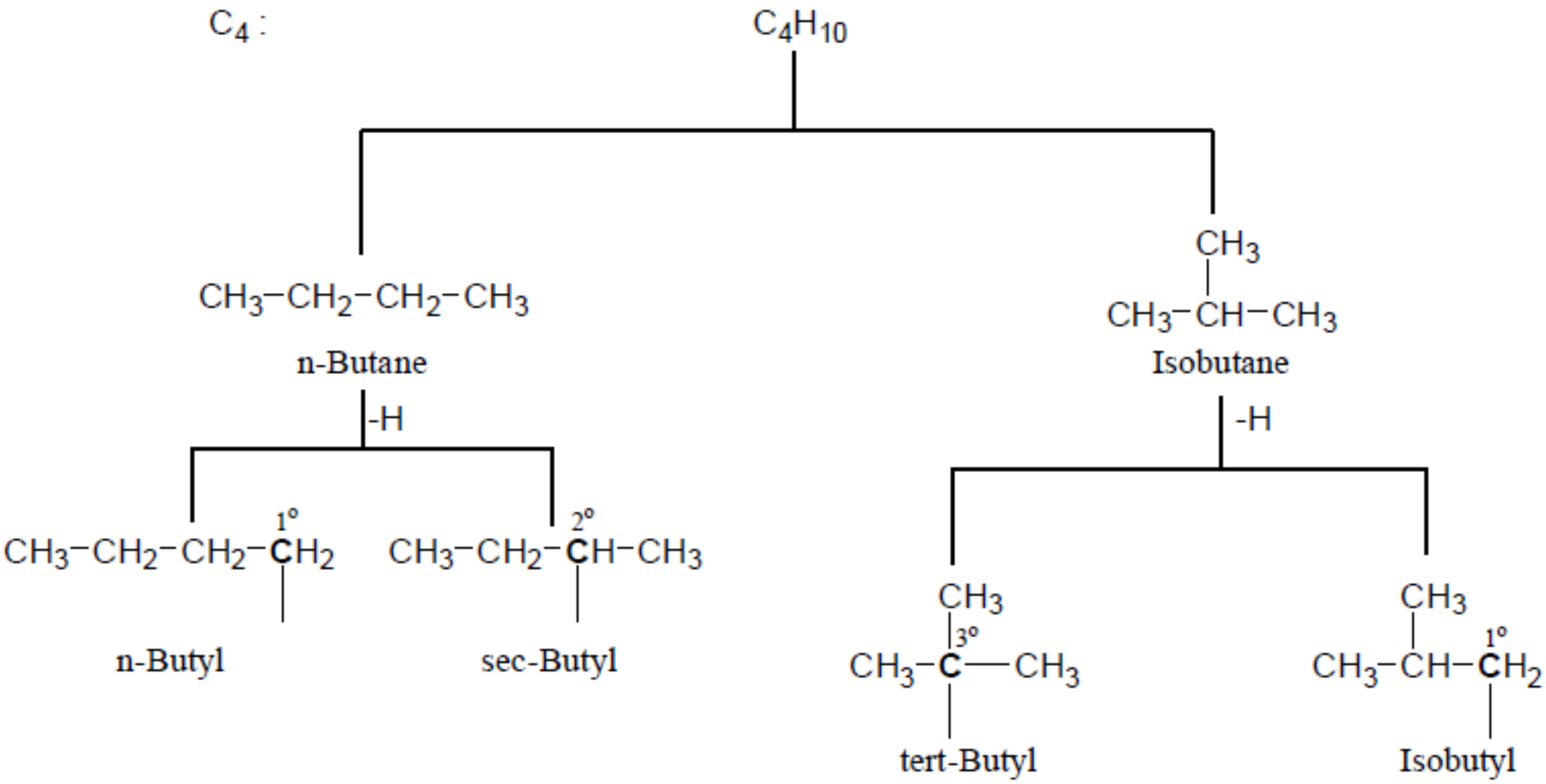
$CH_3-CH_2-\mathbf{C}H_2-$

n-Propyl

$CH_3-\mathbf{C}H-CH_3$

Isopropyl

Hydrocarbons



C_4 :

C_4H_{10}

$CH_3-CH_2-CH_2-CH_3$

n-Butane

-H

$CH_3-CH_2-CH_2-\overset{1°}{\mathbf{C}}H_2-$

n-Butyl

$CH_3-CH_2-\overset{2°}{\mathbf{C}}H-CH_3$

sec-Butyl

$CH_3-\overset{\overset{CH_3}{|}}{C}H-CH_3$

Isobutane

-H

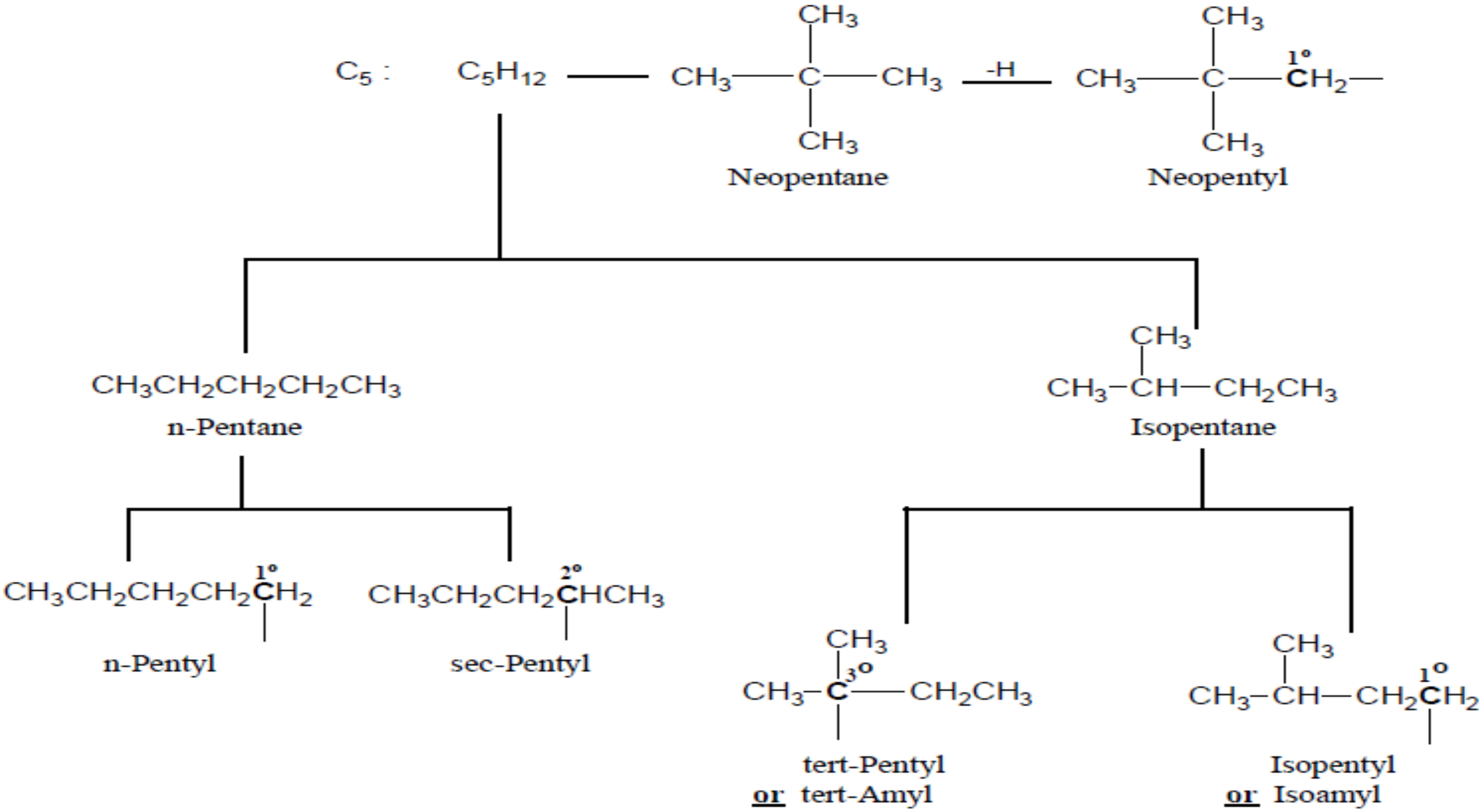
$CH_3-\overset{\overset{CH_3}{|}}{\underset{|}{\mathbf{C}}}-CH_3$ (3°)

tert-Butyl

$CH_3-\overset{\overset{CH_3}{|}}{C}H-\overset{1°}{\mathbf{C}}H_2-$

Isobutyl

Hydrocarbons



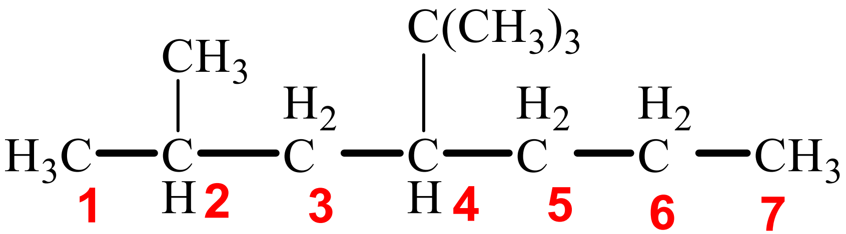
Hydrocarbons

NEO Terminal *tert*-butyl group

neopentyl

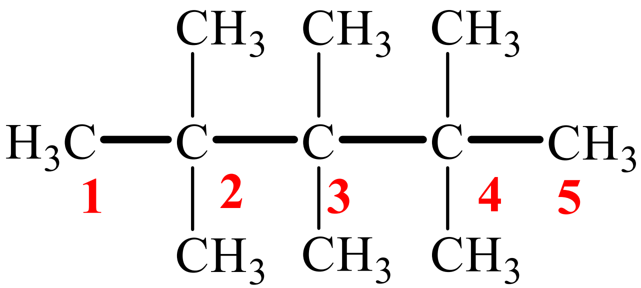
neoheptyl

Hydrocarbons



$H_3C-CH(CH_3)-CH_2-CH(C(CH_3)_3)-CH_2-CH_2-CH_3$

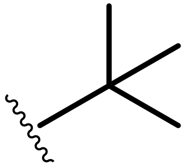
4-*tert*-butyl-2-methylheptane



$H_3C-C(CH_3)_2-C(CH_3)_2-C(CH_3)_2-CH_3$

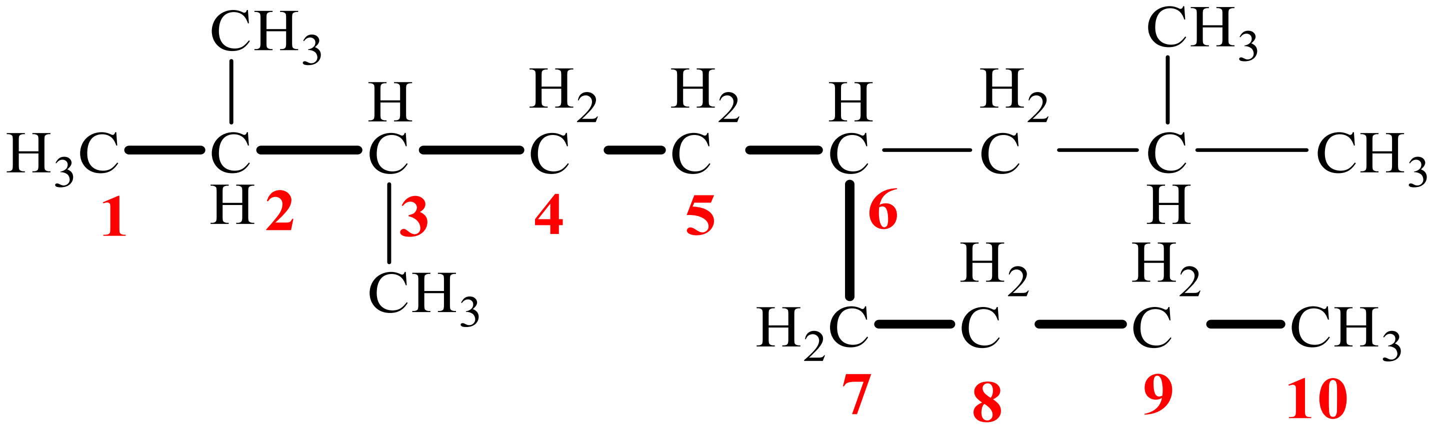
2,2,3,3,4,4-hexamethylpentane

tert-butyl ($C(CH_3)_3$ =

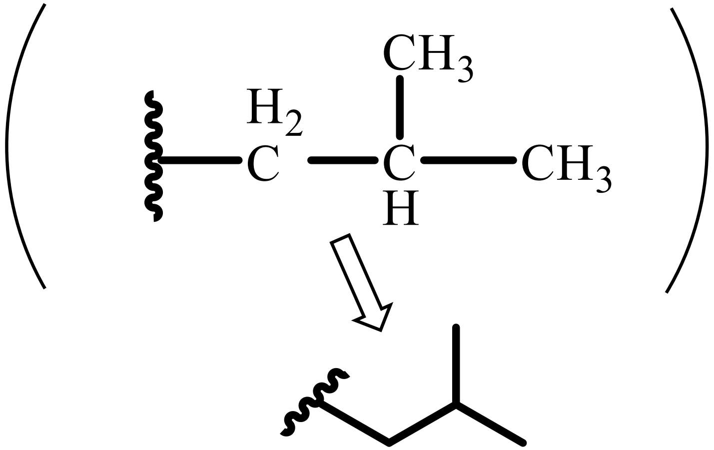


)

Hydrocarbons

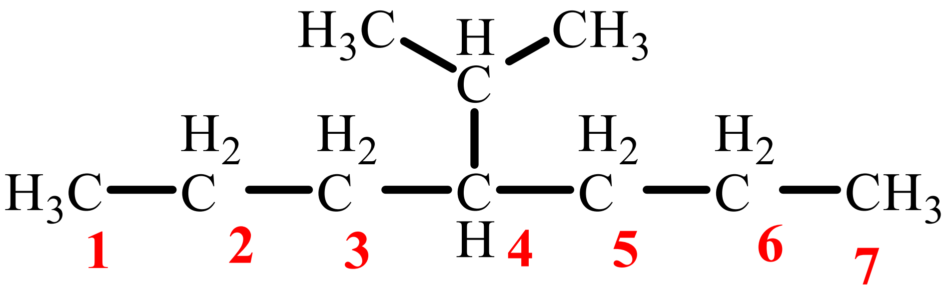


6-isobutyl-2,3-dimethyldecane

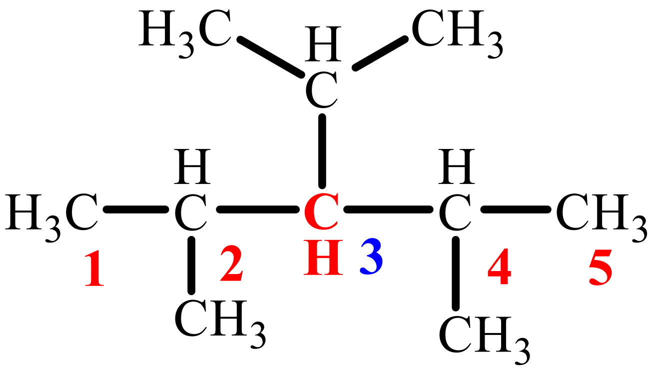


isobutyl

Hydrocarbons

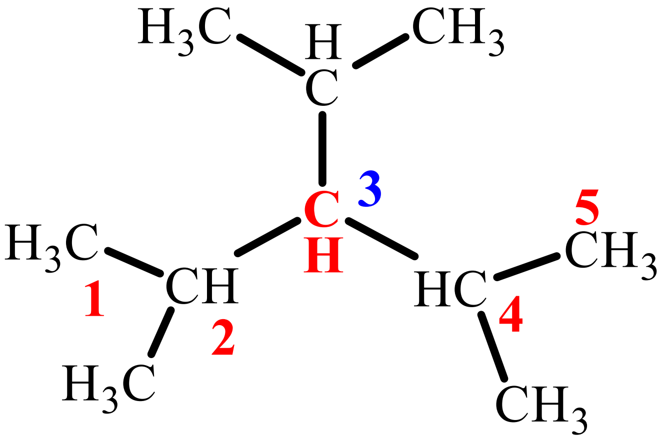


4-isopropylheptane



3-isopropyl-2,4-dimethylpentane

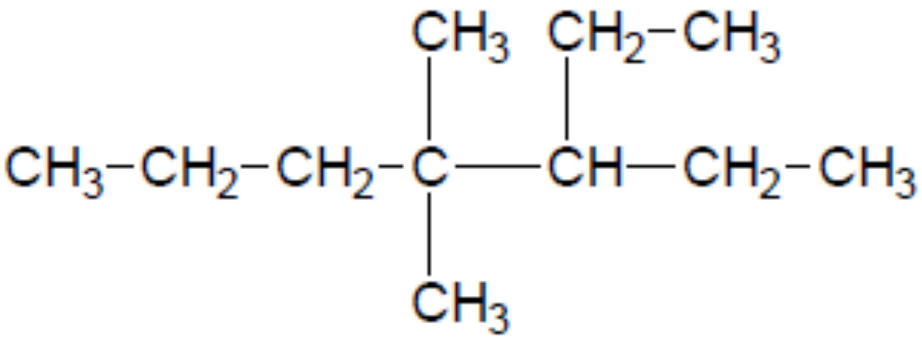
Hydrocarbons



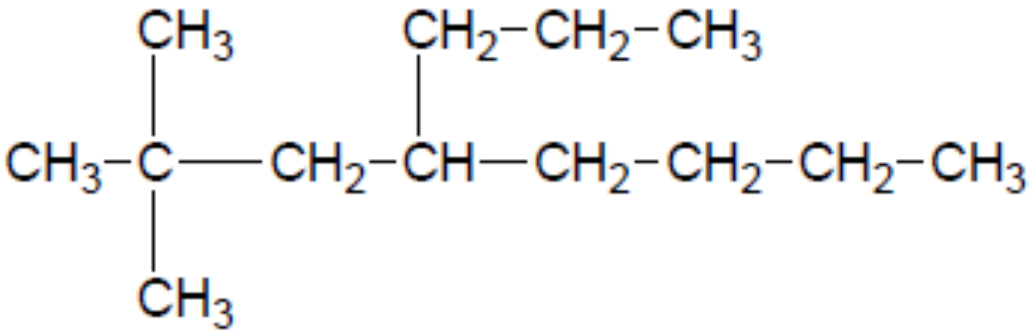
Triisopropyl methane

Hydrocarbons

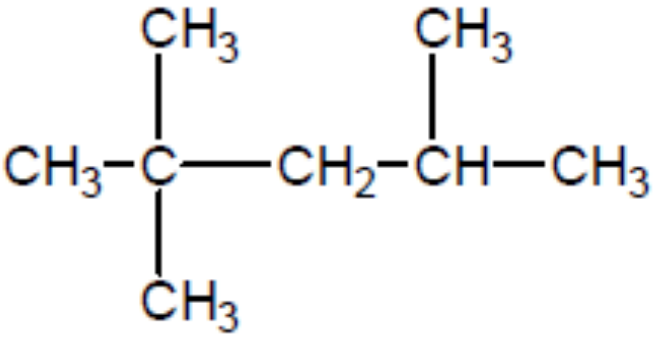
Some examples



$$\mathrm{CH_3-CH_2-CH_2-\overset{\displaystyle CH_3}{\underset{\displaystyle CH_3}{C}}-\overset{\displaystyle CH_2-CH_3}{CH}-CH_2-CH_3}$$



$$\mathrm{CH_3-\overset{\displaystyle CH_3}{\underset{\displaystyle CH_3}{C}}-CH_2-\overset{\displaystyle CH_2-CH_2-CH_3}{CH}-CH_2-CH_2-CH_2-CH_3}$$



$$\mathrm{CH_3-\overset{\displaystyle CH_3}{\underset{\displaystyle CH_3}{C}}-CH_2-\overset{\displaystyle CH_3}{CH}-CH_3}$$

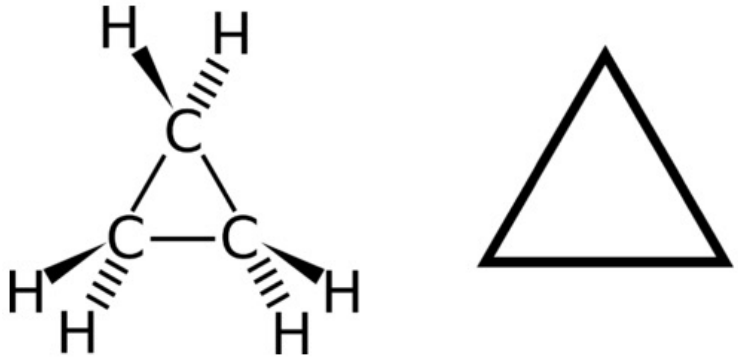
Hydrocarbons

Cyclic hydrocarbons

Have you ever grabbed a piece of meat at a barbecue that was left on the grill a bit too long? Chemically, the charred portion on grilled meat contains cyclic compounds. That is, if you looked at the chemical produced from cooking your meat beyond well-done, you would see that its chemical structure contains **cyclic hydrocarbons**.

Hydrocarbons

A **cyclic hydrocarbon** is a hydrocarbon in which the carbon chain joins to itself in a ring. Many organic compounds found in nature or created in a laboratory contain rings of carbon atoms with distinguishing chemical properties; these compounds are known as cycloalkanes. A cycloalkane is a cyclic hydrocarbon in which all of the carbon-carbon bonds are single bonds. Such other alkanes, cycloalkanes are saturated compounds, they have the general formula C_nH_{2n}. The simplest cycloalkane is cyclopropane, a three-carbon ring.

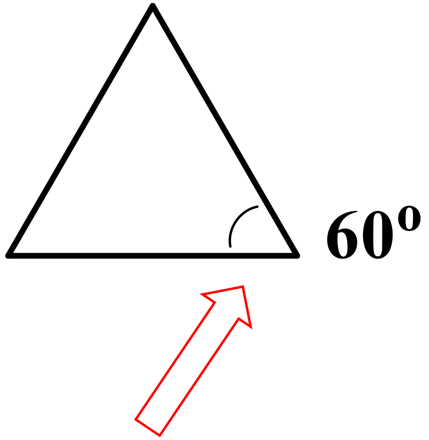


Cyclopropane is the simplest cycloalkane. Its highly strained geometry makes it rather unstable and highly reactive

Hydrocarbons

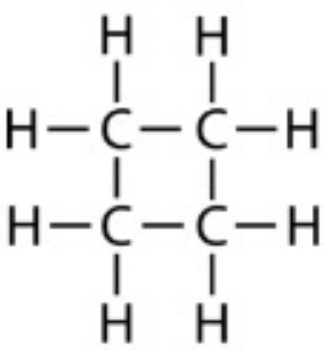
Cyclic hydrocarbons

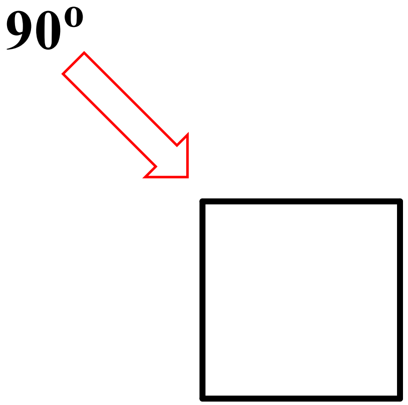
The carbon atoms in cycloalkanes are still sp^3 hybridized, with an ideal bond angle of 109.5°. However, an examination of the cyclopropane structure shows that the triangular structure results in a C−C−C bond angle of 60°.



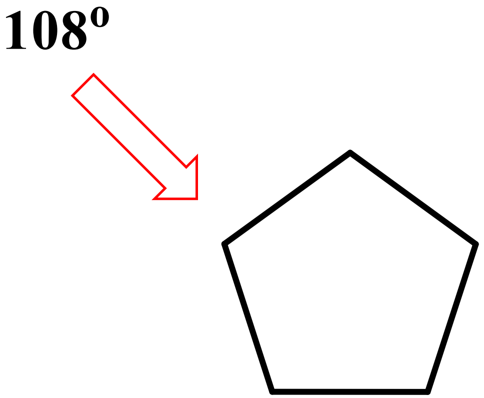
Hydrocarbons

This deviation from the ideal angle is called ring strain and makes cyclopropane a fairly unstable and reactive molecule. Ring strain is decreased for cyclobutane, with a bond angle of 90^{o}, but is still significant. Cyclopentane has a bond angle of about 108^{o}. This minimal ring strain for cyclopentane makes it a more stable compound.

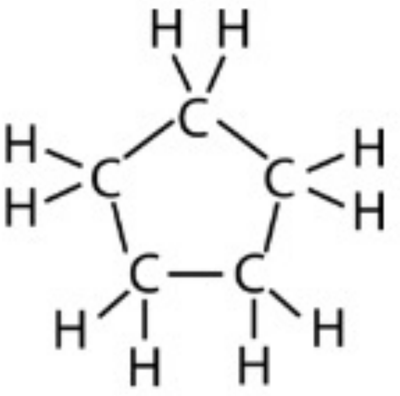




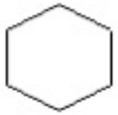
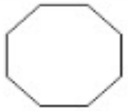
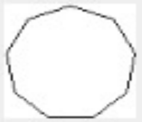
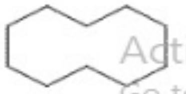
cyclobutane



cyclopentane

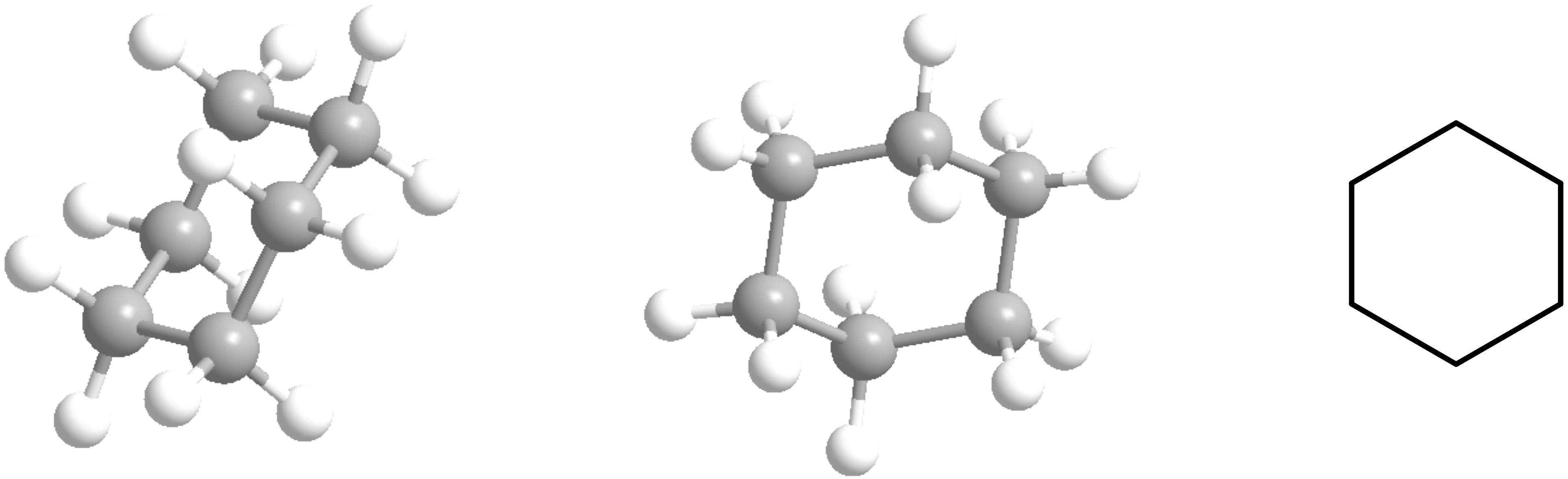


Hydrocarbons

Cycloalkane	Molecular Formula	Basic Structure
Cyclopropane	C_3H_6	
Cyclobutane	C_4H_8	
Cyclopentane	C_5H_{10}	
Cyclohexane	C_6H_{12}	
Cycloheptane	C_7H_{14}	
Cyclooctane	C_8H_{16}	
Cyclononane	C_9H_{18}	
Cyclodecane	$C_{10}H_{20}$	

Hydrocarbons

The general formula as said for a cycloalkane is C_nH_{2n}. Cyclic compounds are not all flat molecules. All of the cycloalkanes, from cyclopentane upwards, exist as "puckered rings". Cyclohexane, for example, has a ring structure that looks like this:



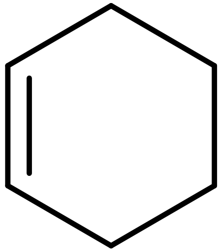
Hydrocarbons

All three of the depictions of cyclohexane are somewhat misleading, because the molecule is not planar. In order to reduce the ring strain and attain a bond angle of approximately 109.5^{o}, the molecule is puckered. The puckering of the ring means that every other carbon atom is above and below the plane. The figure below shows two possibilities for the puckered cyclohexane molecule. Each of the structures is called a conformation. The conformation on the left is called the **chair** conformation, while the one on the right is called the **boat** conformation.

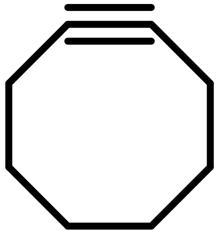
Hydrocarbons

While both conformations reduce the ring strain compared to a planar molecule, the chair is preferred. This is because the chair conformation results in fewer repulsive interactions between the hydrogen atoms.

Larger cycloalkanes also exist, but are less common. Cyclic hydrocarbons may also be unsaturated. A **cycloalkene** is a cyclic hydrocarbon with at least one carbon-carbon double bond. A **cycloalkyne** is a cyclic hydrocarbon with at least one carbon-carbon triple bond. Shown below are the simplified structural formulas for cyclohexene (left) and cyclooctyne (right).



cyclohexene



cyclooctyne

Hydrocarbons

Nomenclature of cyclic alkanes

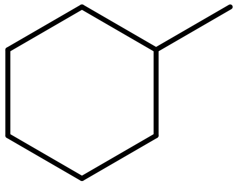
IUPAC Rules for Nomenclature

- Determine the cycloalkane to use as the parent chain. The parent chain is the one with the highest number of carbon atoms. If there are two cycloalkanes, use the cycloalkane with the higher number of carbons as the parent chain.
- If there is an alkyl straight chain that has a greater number of carbons than the cycloalkane, then the alkyl chain must be used as the primary parent chain. Cycloalkane acting as a substituent to an alkyl chain has an ending "-yl" and, therefore, must be named as a cycloalkyl.

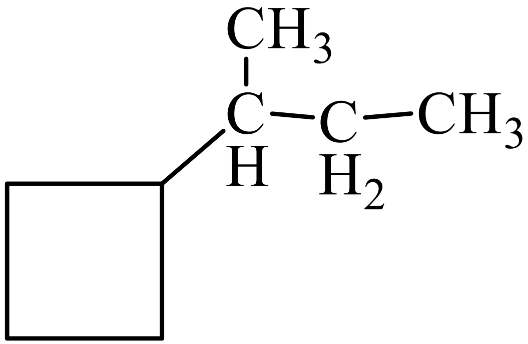
Hydrocarbons

Cycloalkane	**Cycloalkyl**
cyclopropane	cyclopropyl
cyclobutane	cyclobutyl
cyclopentane	cyclopentyl
cyclohexane	cyclohexyl
cycloheptane	cycloheptyl
cyclooctane	cyclooctyl
Cyclononane	cyclononanyl
cyclodecane	cyclodecanyl

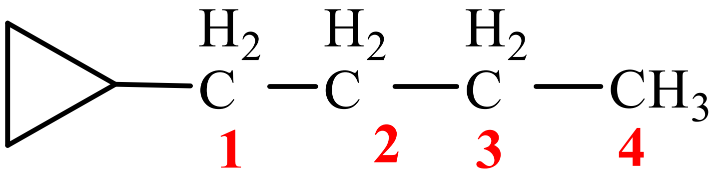
Hydrocarbons



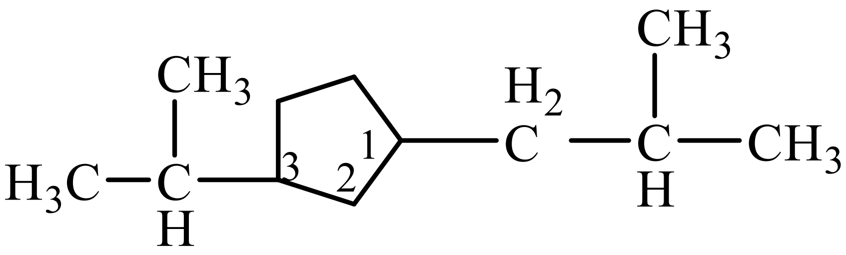
Methylcyclohexane



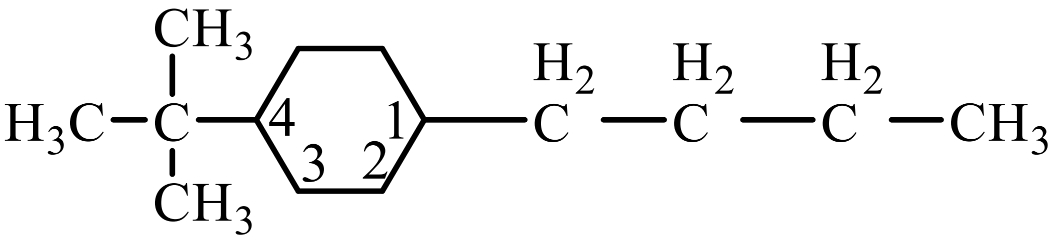
sec-butylcyclobutane



1-Cyclopropane butane



1-isobutyl-3-isopropylcyclopentane



1-*n*-Butyl-4-*tert*-butyl cyclohexane

Hydrocarbons

Summary

- A cyclic hydrocarbon is a hydrocarbon in which the carbon chain joins to itself in a ring.
- A cycloalkane is a cyclic hydrocarbon in which all of the carbon-carbon bonds are single bonds. (Like other alkanes, cycloalkanes are saturated compounds).
- A cycloalkene is a cyclic hydrocarbon with at least one carbon-carbon double bond.
- A cycloalkyne is a cyclic hydrocarbon with at least one carbon-carbon triple bond.
- Names and structures of typical cyclic hydrocarbons are given.

Thank you for attention