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Introduction to organic chemistry

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The subjects of organic chemistry are carbon-based (has the C–H bond)

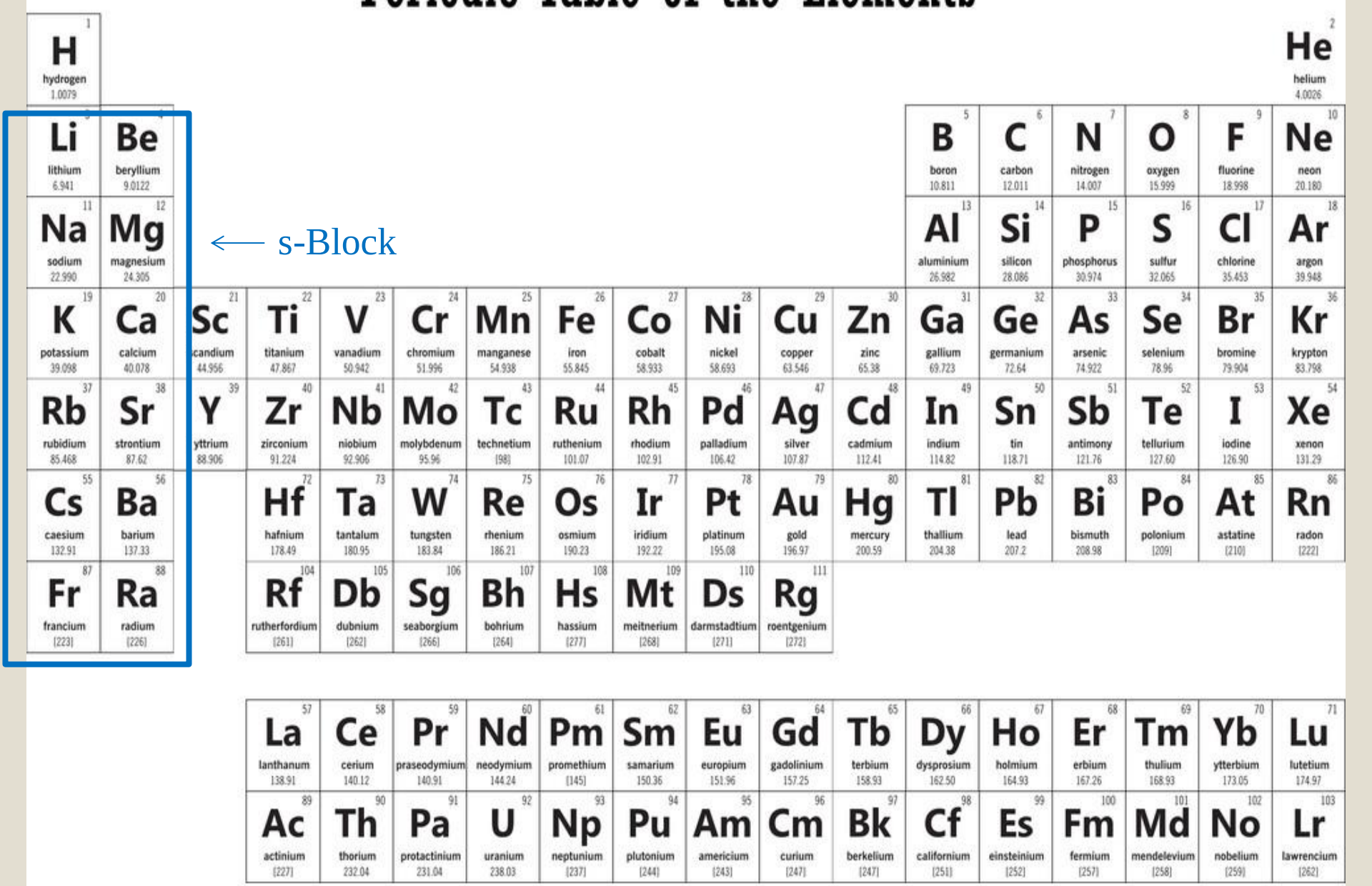
What is studied in organic chemistry?

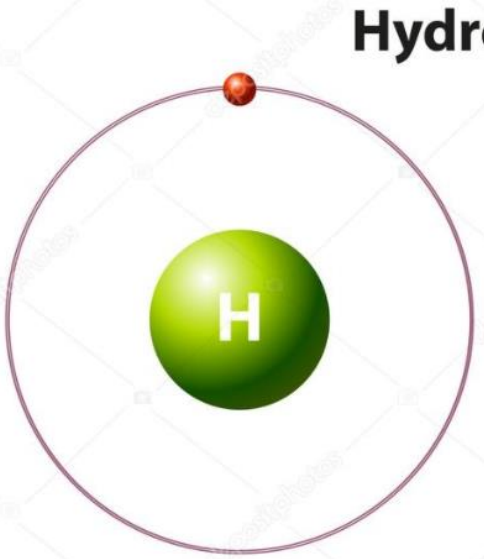
Can we build a wall between organic and inorganic chemistry?

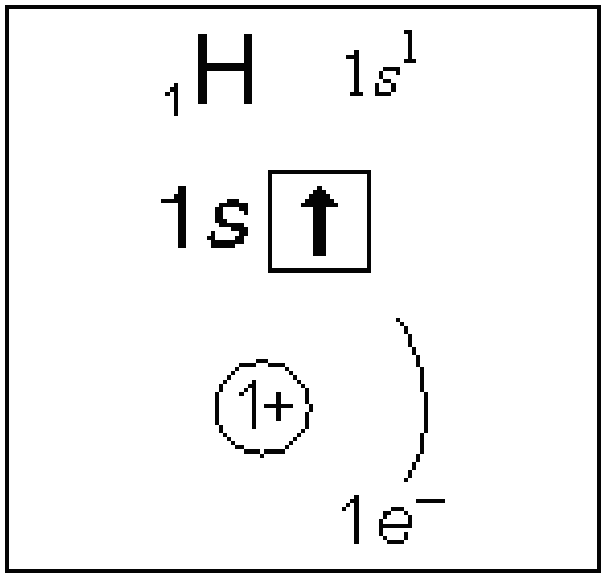
- Chemical elements that are necessary for the construction and life of cells and organisms are called **biogenic elements**. All living systems are based on six elements: carbon **C**, hydrogen **H**, oxygen **O**, nitrogen **N**, phosphorus **P**, and sulfur **S**, which are called **organogens** (97% of them).

- In addition, vital **macroelements** also include s-elements of the third (sodium, magnesium) and fourth (potassium, calcium) periods, and p-elements of the third period (chlorine).

Periodic Table of the Elements







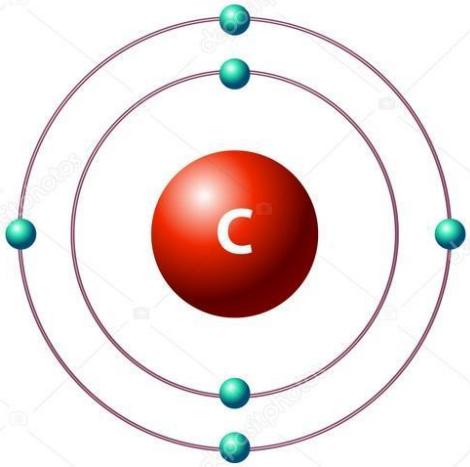
Electron Configuration of Hydrogen

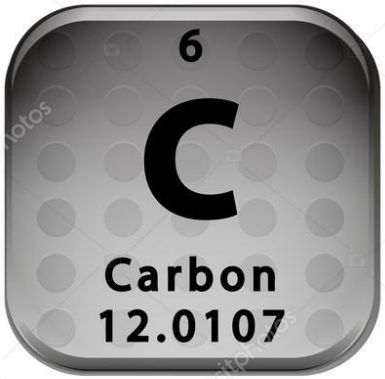
Energy Level

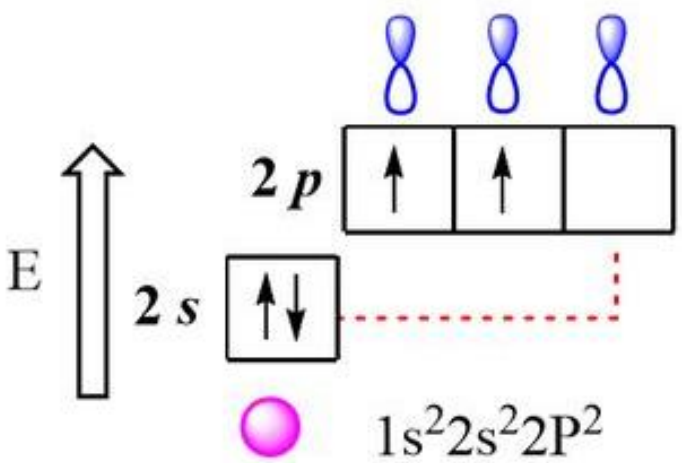
1 — Number of Electrons in This Orbital (Subshell)

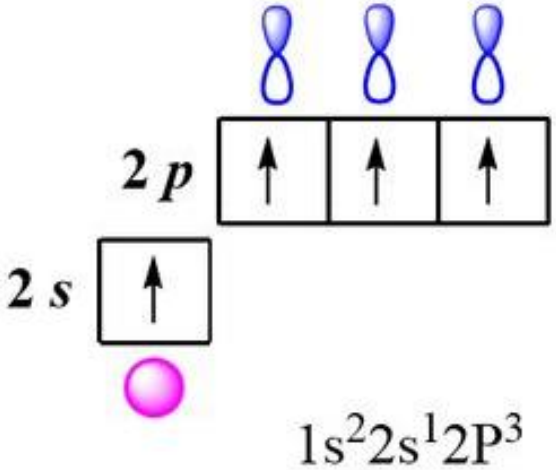
1s — Type of Orbital (Subshell)

Carbon





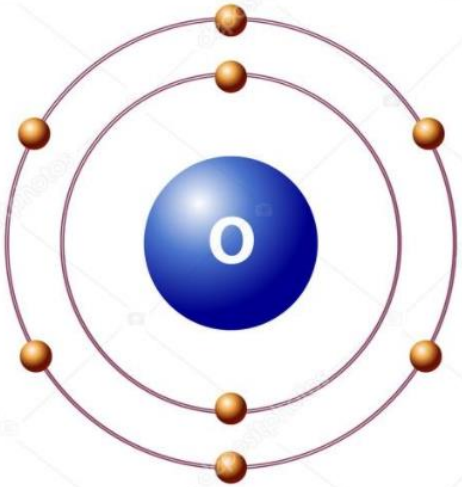


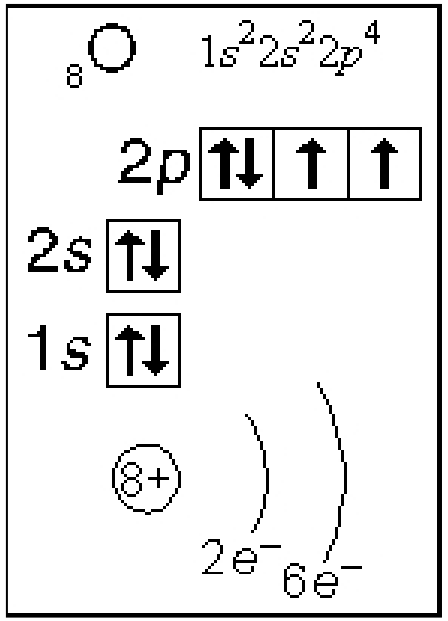


ground state for carbon

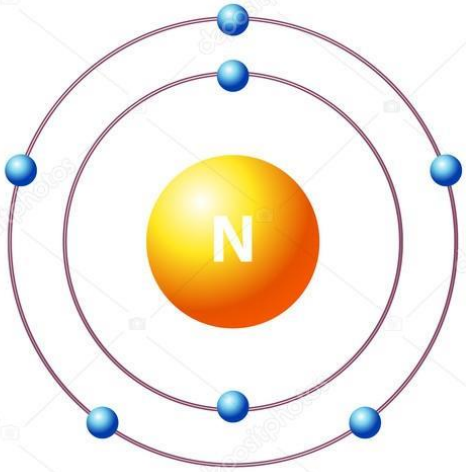
excited state for carbon

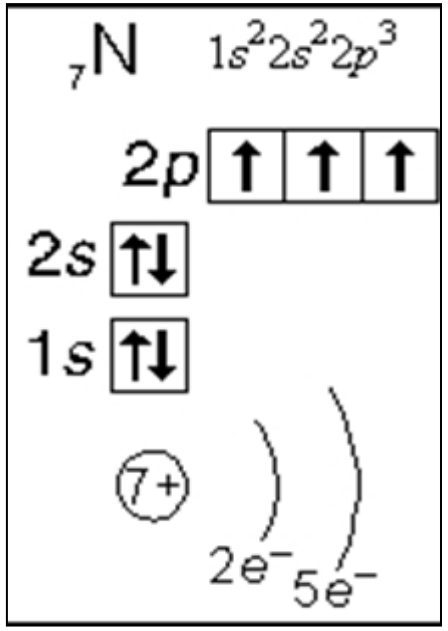
Oxygen

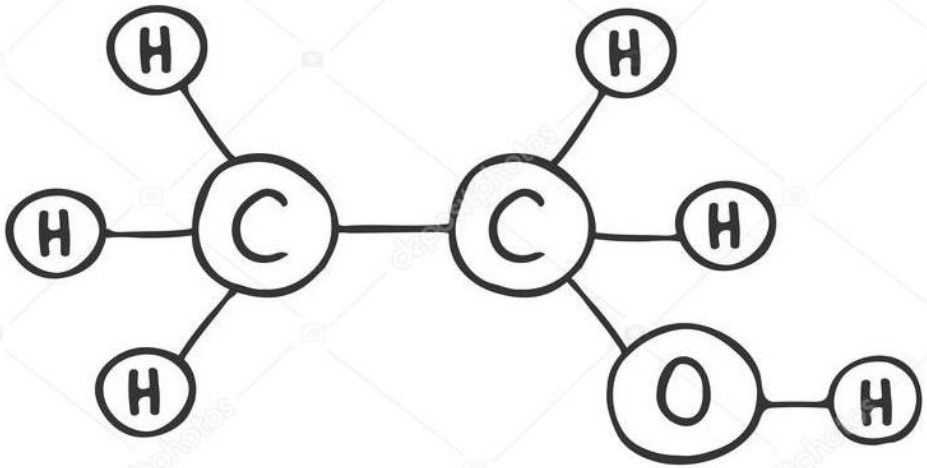




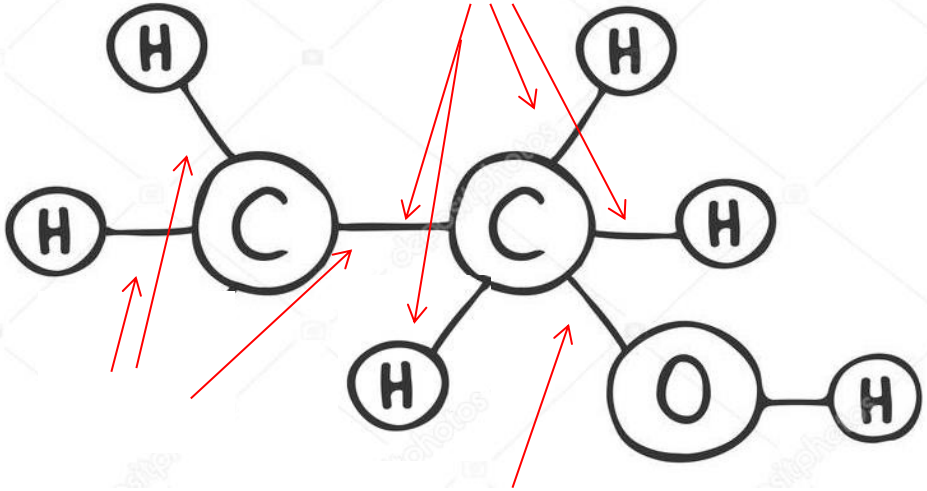
Nitrogen



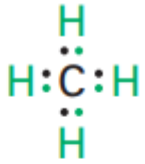


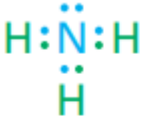


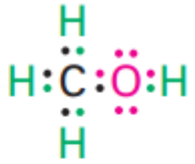
ETHANOL



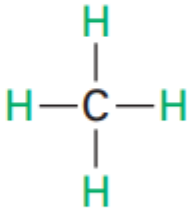
Electron-dot structures (Lewis structures)

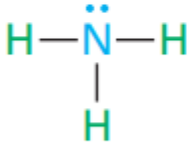


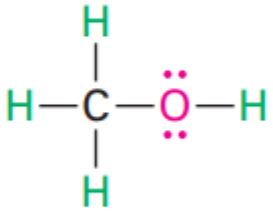




Line-bond structures (Kekulé structures)







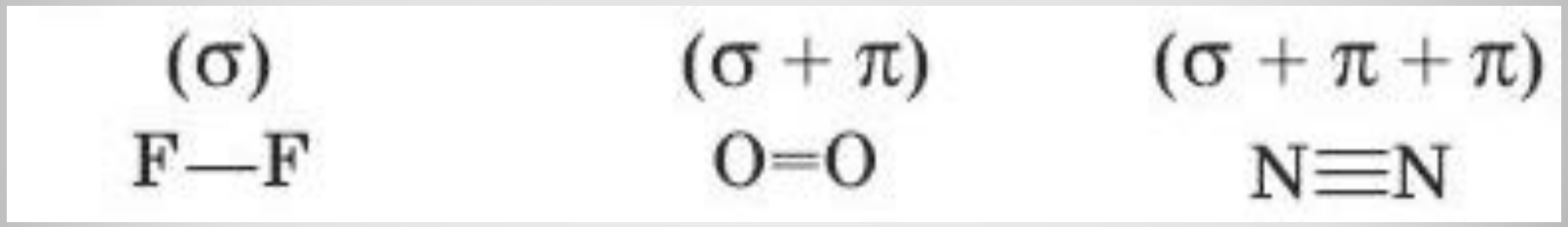
Methane (CH_4)

Ammonia (NH_3)

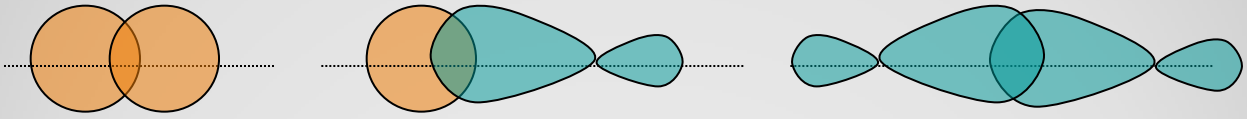
Water (H_2O)

Methanol (CH_3OH)

- **Bond multiplicity** is the number of electron pairs socialized by neighboring atoms as a result of the formation of a covalent bond.
- In ethane, $H_3C–CH_3$ bond between carbon atoms is single, in ethylene, $H_2C=CH_2$ - double, in acetylene, $HC\equiv CH$ - triple.



- **The σ-bond** is formed when the atomic orbitals overlap axially and has an axis of symmetry that coincides with the line connecting the nuclei. The maximum electron density lies on this axis. All single bonds are **σ-bonds.**



s – s

H – H

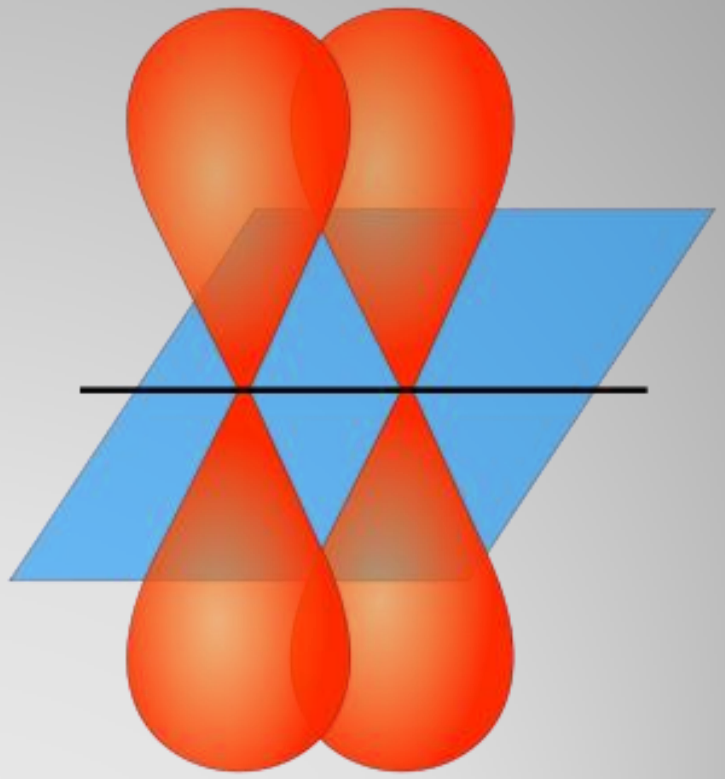
s – σ

H – C
H – N
H – O

σ – σ

C – C
C – N
C – O

The π-bond is formed when the p-orbitals overlap laterally and has a plane of symmetry passing through the line connecting the atomic nucleus



$(\sigma + \pi)$ $(\sigma + \pi + \pi)$

$O{=}O$ $N{\equiv}N$

Isomerism

Isomers are molecules with identical molecular formulae — that is, same number of atoms of each element — but distinct arrangements of atoms in space. Isomerism is existence or possibility of isomers.

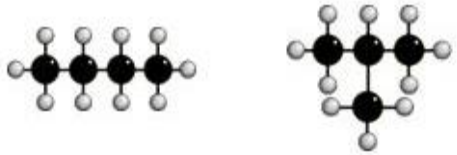
- **Use handouts.**
- **Read the text "Isomerism“ WB1, p. 15; WB2 p. 15. How many types of this phenomenon can be distinguished?**

TYPES OF ISOMERISM

STRUCTURAL ISOMERISM

Same molecular formula but different structural formulae

- **CHAIN ISOMERISM**



- **POSITION ISOMERISM**

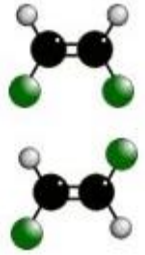
- **FUNCTIONAL GROUP ISOMERISM**

STEREOISOMERISM

Same molecular formula but atoms occupy different positions in space.

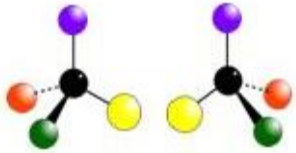
- **GEOMETRICAL ISOMERISM**

Occurs due to the restricted rotation of C=C double bonds... two forms - CIS and TRANS



- **OPTICAL ISOMERISM**

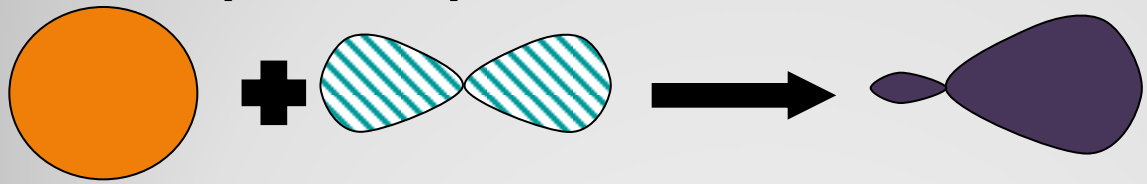
Occurs when molecules have a chiral centre. Get two non-superimposable mirror images.



- Use handouts.
- ~~Read the text "Isomerism". How many types of this phenomenon can be distinguished?~~
- Do task 1 (practice) WB1, p. 15
- Read the text "Optical isomerism" WB2 p. 15
- Do task 1, 2, 3, 4 (a, b) WB2 p. 15(!mark)

Hybridization

- **HYBRIDIZATION** is the mixing of atomic orbitals of different shapes and energies (within the valence level) with the formation of atomic orbitals of the same shape and energy.
- When s-AO and p-AO are mixed, hybrid atomic orbitals (σ - AO) are formed:

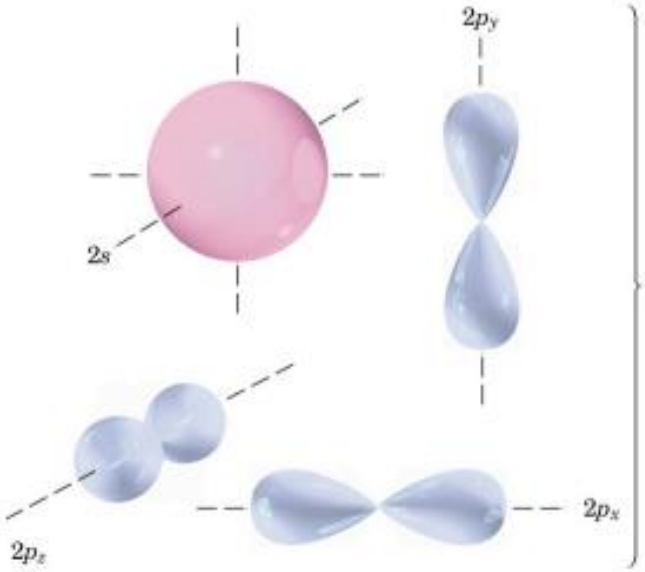


s - AO p - AO σ – AO (hybrid)

(!video)

sp^3 Hybridized Orbitals = 1 part s-orbital + 3 parts p-orbitals

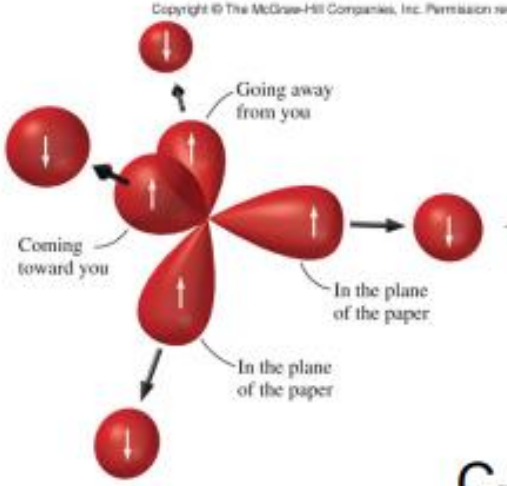
(Figure 2.9, p. 66)

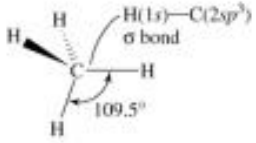


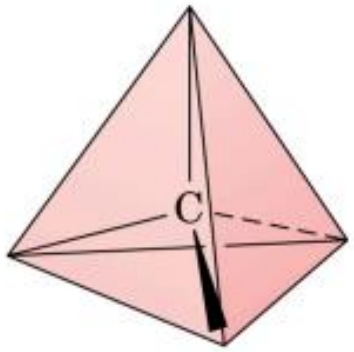
Hybridization

Four tetrahedral sp^3 orbitals

An sp^3 orbital



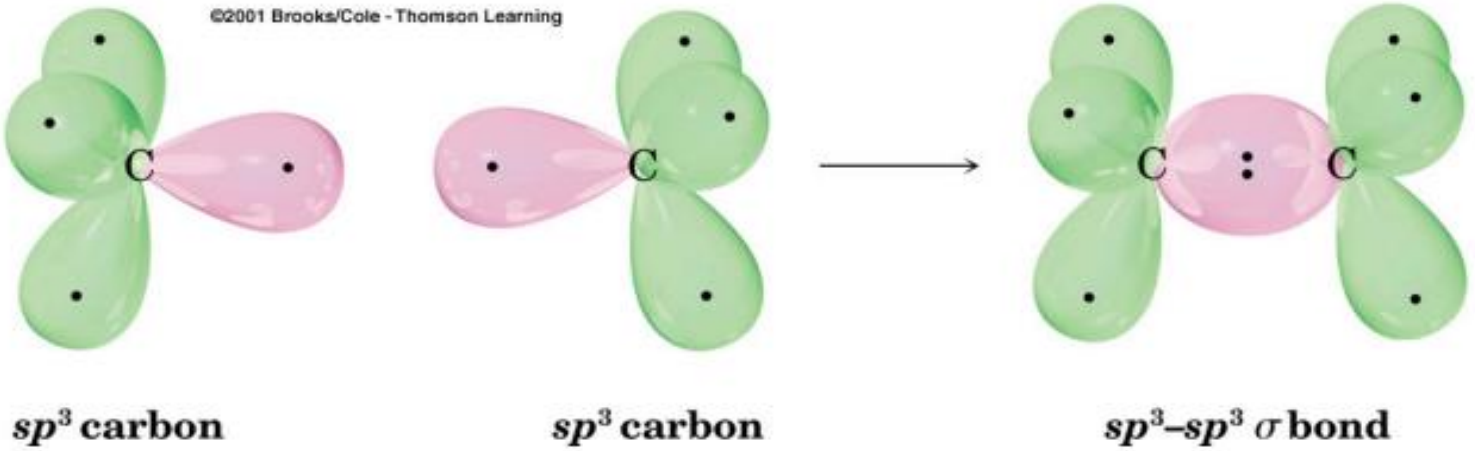




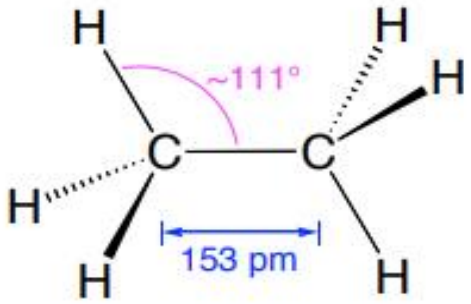
C-H bond strength = 435 KJ/mol

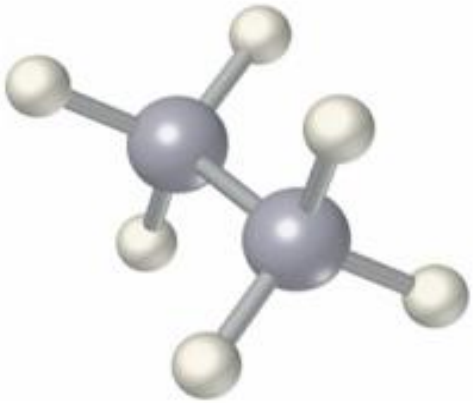
sp^3 hybridized orbital are more directional allowing for greater orbital overlap and strong bonds compared to unhybridized orbitals

2.7: Bonding in Ethane



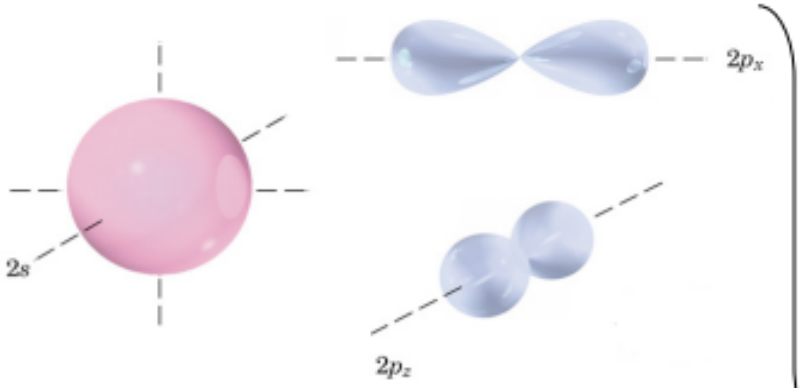
***sp*³ carbon** ***sp*³ carbon** ***sp*³–*sp*³ σ bond**





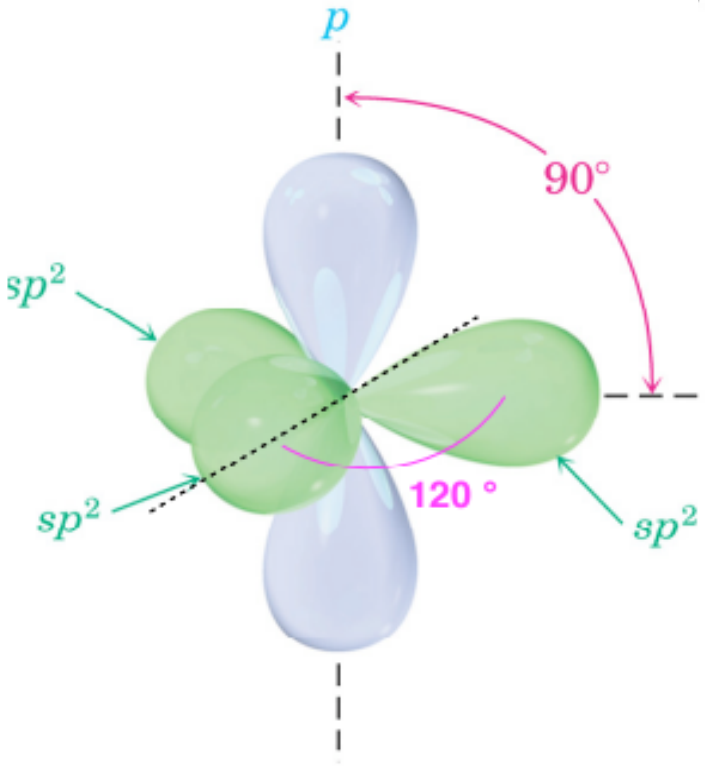
$\Delta H°_{C\text{-}C} = 376$ KJ/mol

sp^2 Hybridization and Bonding in Ethylene



hybridize one s-orbital
and two p-orbitals

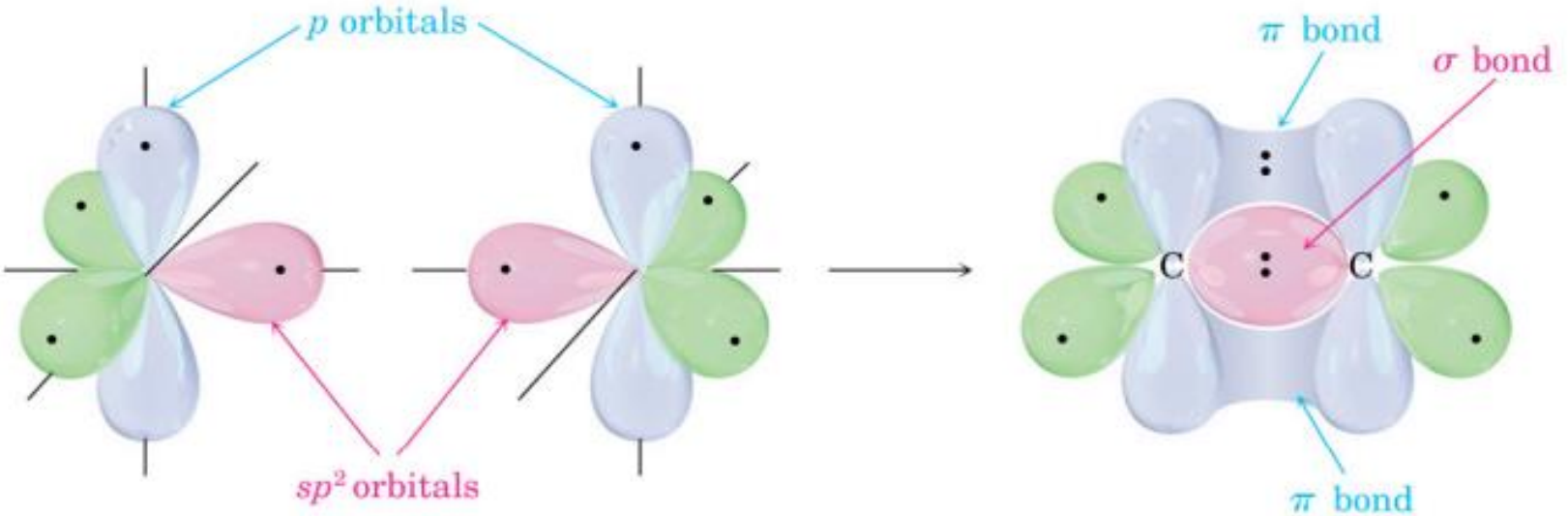
leave one p-orbital
unhybridized

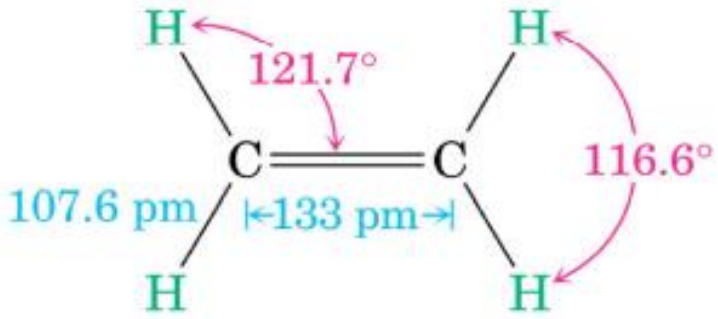


Side view

Three sp^2 hybrid orbitals and
one unhybridized p-orbital

C=C double bonds- ethylene (C_2H_4)



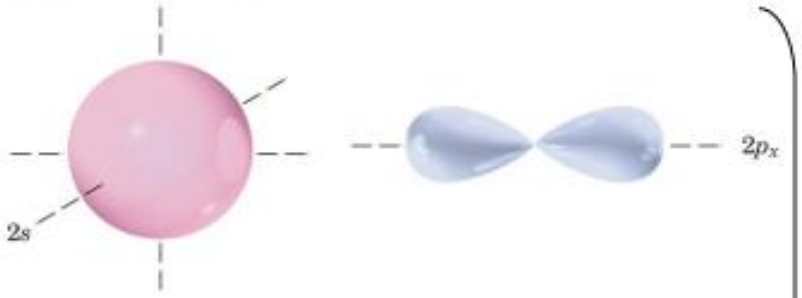


$\Delta H_{C=C}^{\circ}$ = 611 KJ/mol

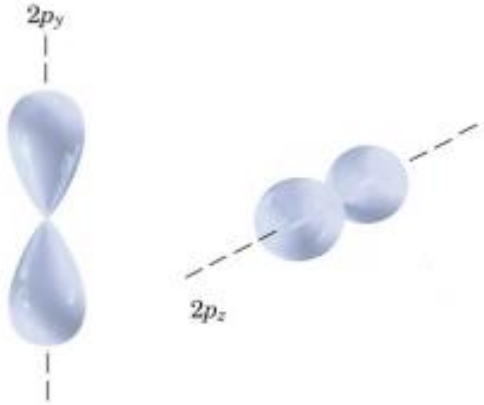
ΔH_{C-C}° = 376 KJ/mol

$\Delta H_{\pi\text{-bond}}^{\circ}$ = 235 KJ/mol

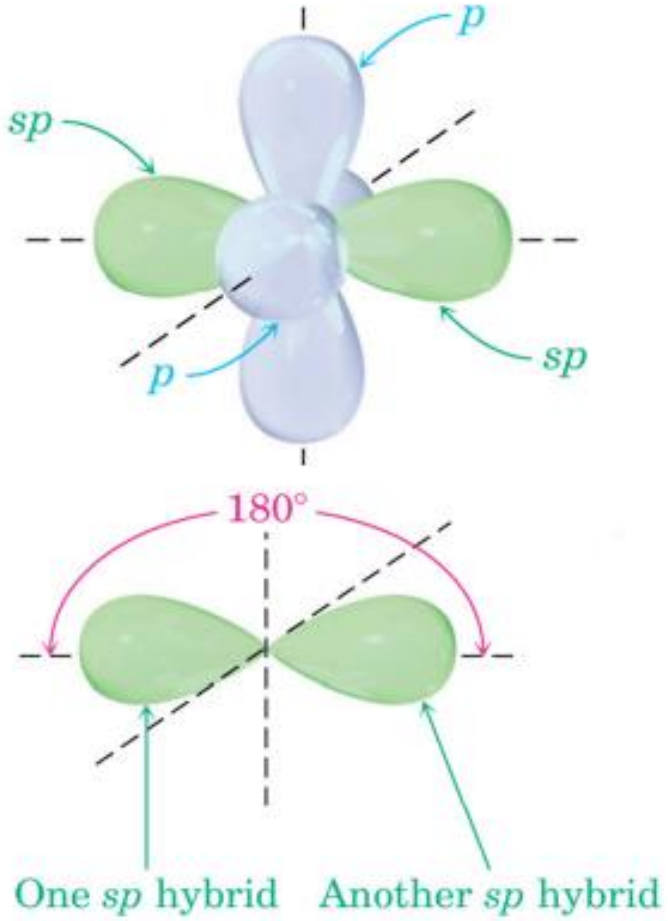
sp Hybridization and Bonding in Acetylene



hybridize one s-orbital
and one p-orbitals

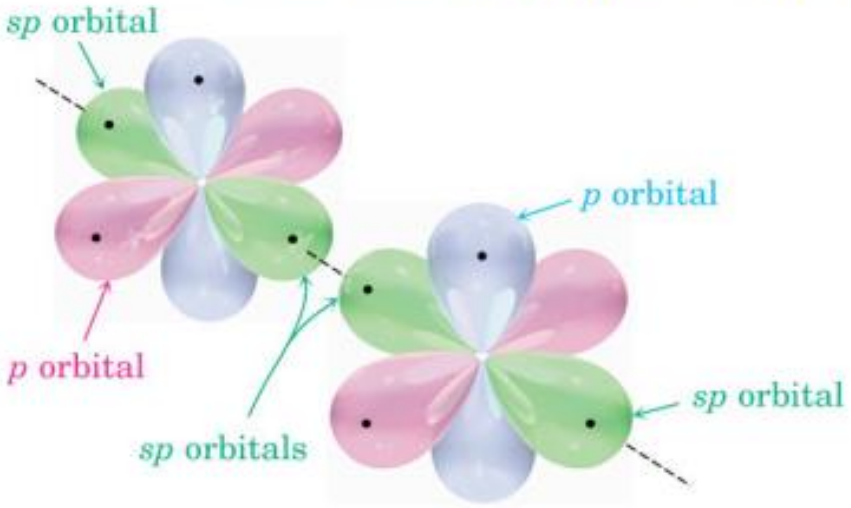


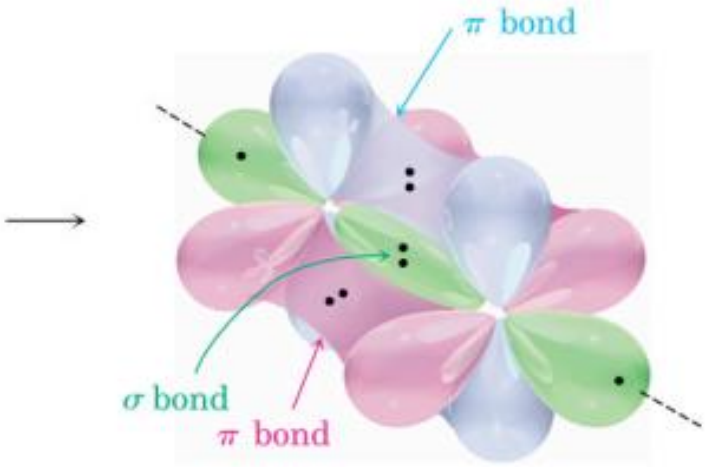
leave two p-orbital
unhybridized



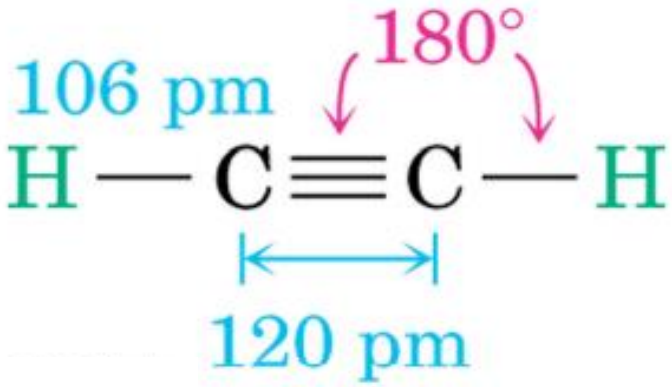
two sp hybrid orbitals and
two unhybridized p-orbital

C≡C triple bonds- acetylene (C_2H_2)
one C-C σ-bond and two C-C π-bonds





Carbon–carbon triple bond

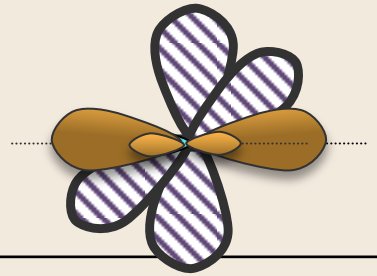
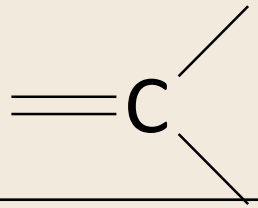
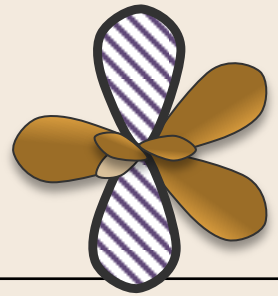
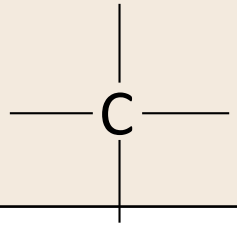
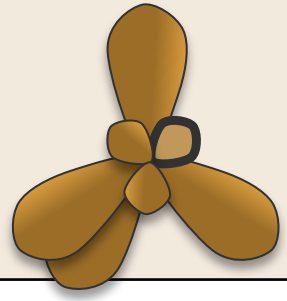


$\Delta H_{C\equiv C}^{\circ}$ = 835 KJ/mol

$\Delta H_{C\text{-}C}^{\circ}$ = 376 KJ/mol

$\Delta H_{1st\ \pi\text{-bond}}^{\circ}$ = 235 KJ/mol

$\Delta H_{2nd\ \pi\text{-bond}}^{\circ}$ = 224 KJ/mol

Type of Hybridization	Formula	Carbon skeleton structure	view
sp	1s + 1p = 2sp	linear (180°) 	
sp^2	1s + 2p = $3sp^2$	flat triangle (120°) 	
sp^3	1s + 3p = $4sp^3$	tetrahedral (109°) 	

(!mark)

TYPES OF HYBRIDIZATION OF ATOMIC ORBITALS

Determine the hybridization of each carbon atom in the following molecules:

(!mark)

(a) H_3C-CH_3

(b) $H_3C-CH=CH_2$

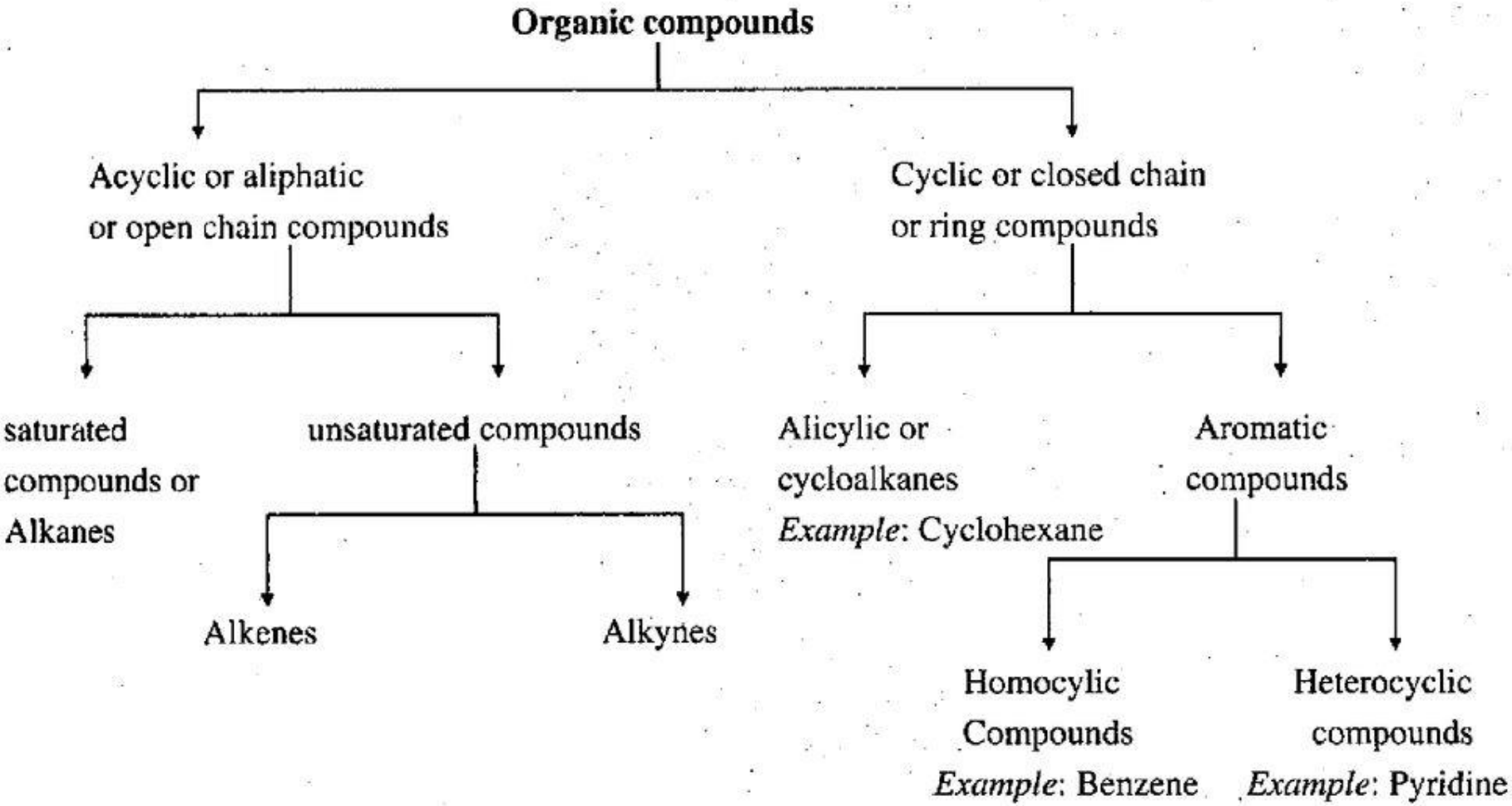
(c) $CH_3-C\equiv C-CH_2OH$

(d) $CH_3CH=O$

(e) CH_3COOH

Classification of organic compounds

Schematic representation for the classification of organic compounds



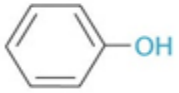
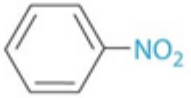
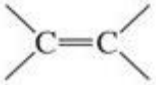
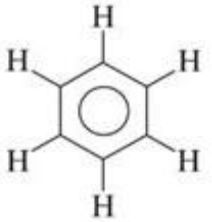
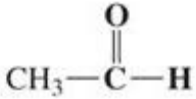
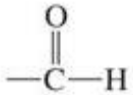
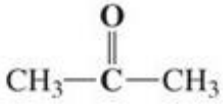
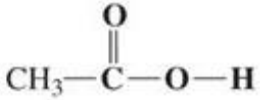
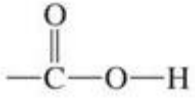
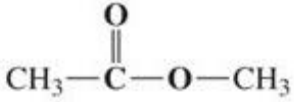
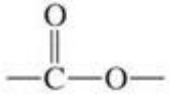
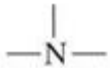
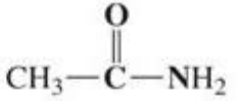
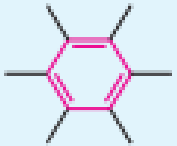
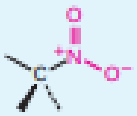
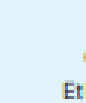
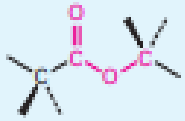
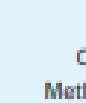
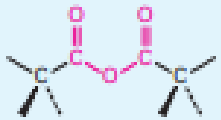
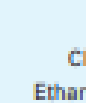
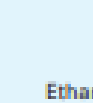
Class	General Formula	Example	Common Name (Systematic Name)	Common Suffix/Prefix (Systematic)
Hydrocarbons (УГЛЕВОДОРОДЫ)				
Alkanes (Алканы)	RH	CH_3CH_3	ethane (этан)	-ane (-ан)
Alkenes (Алкены)	$RR'C{=}CR''R'''$	$H_2C{=}CH_2$	ethylene (этилен) (ethene) (этен)	-ene (-ен)
Alkynes (Алкины)	$RC{\equiv}CR'$	$HC{\equiv}CH$	acetylene (ацетилен) (ethyne) (этин)	(-yne) (-ин)
Arenes (Арены)	ArH^a		benzene (бензол)	-ene (-бензол)
Oxygen-Containing Compounds (КИСЛОРОДСОДЕРЖАЩИЕ СОЕДИНЕНИЯ)				
Alcohols (Спирты)	ROH^a	CH_3CH_2OH	ethyl alcohol (ethanol) (этанол)	-ol (-ол)
Phenols (Фенолы)	$ArOH^b$		phenol (фенол)	-ol (-ол)
Ethers (Простые эфиры)	ROR′	$H_3CH_2COCH_2CH_3$	diethyl ether (диэтиловый эфир)	ether (-эфир)
Aldehydes (Альдегиды)	RCHO		acetaldehyde (ethanal) (этаналь)	-aldehyde (-al) (-аль)
Ketones (Кетоны)	$RR'C{=}O$		acetone (2-propanone) (пропанон)	-one (-он)
Carboxylic acids (Карбоновые кислоты)	RCO_2H		acetic acid (ethanoic acid) (этановая	-ic acid (-oic acid) (-овая кислота
Nitrogen-Containing Compounds (АЗОТСОДЕРЖАЩИЕ СОЕДИНЕНИЯ)				
Amines (Амины)	RNH_2, RNHR′, RNR′R″	$CH_3CH_2NH_2$	ethylamine (этиламин)	-amine (-амин)
Nitriles (Нитрилы)	$RC{\equiv}N$	$H_3CC{\equiv}N$	acetonitrile (ацетонитрил)	-nitrile (-нитрил)
Nitro compounds (Нитро соединения)	$ArNO_2{}^a$		nitrobenzene (нитробензол)	nitro- (нитро-)

TABLE 11.9 Classification of Organic Compounds

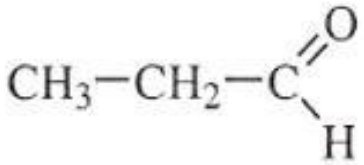
Class	Example	Functional Group	Characteristic
Alkene	$H_2C{=}CH_2$		Carbon–carbon double bond
Alkyne	$HC{\equiv}CH$	$-C{\equiv}C-$	Carbon–carbon triple bond
Aromatic			Benzene ring (six carbon atoms and six hydrogen atoms)
Haloalkane	$CH_3{-}\mathbf{Cl}$	—F, —Cl, —Br, —I	One or more halogen atoms
Alcohol	$CH_3{-}CH_2{-}\mathbf{OH}$	—OH	Hydroxyl group (—OH)
Ether	$CH_3{-}\mathbf{O}{-}CH_3$	—O—	Oxygen atom bonded to two carbons
Thiol	$CH_3{-}\mathbf{SH}$	—SH	Thiol group (—SH)
Aldehyde			Carbonyl group (carbon–oxygen double bond) with —H
Ketone			Carbonyl group (carbon–oxygen double bond) between carbon atoms
Carboxylic acid			Carboxyl group (carbon–oxygen double bond and —OH)
Ester			Carboxyl group with —H replaced by a carbon
Amine	$CH_3{-}\mathbf{NH_2}$		Nitrogen atom with one or more carbon groups
Amide			Carbonyl group bonded to nitrogen

Structures of Some Common Functional Groups

Name	Structure*	Name ending	Example
Alkene (double bond)		*-ene*	$H_2C{=}CH_2$ Ethene
Alkyne (triple bond)		*-yne*	$HC{\equiv}CH$ Ethyne
Arene (aromatic ring)		None	 Benzene
Halide	 (X = F, Cl, Br, I)	None	CH_3Cl Chloromethane
Alcohol		*-ol*	CH_3OH Methanol
Ether		*ether*	CH_3OCH_3 Dimethyl ether
Monophosphate		*phosphate*	$CH_3OPO_3^{2-}$ Methyl phosphate
Amine		*-amine*	CH_3NH_2 Methylamine
Imine (Schiff base)		None	 Acetone imine
Nitrile		*-nitrile*	$CH_3C{\equiv}N$ Ethanenitrile
Nitro		None	CH_3NO_2 Nitromethane
Thiol		*-thiol*	CH_3SH Methanethiol

Name	Structure*	Name ending	Example
Sulfide		*sulfide*	CH_3SCH_3 Dimethyl sulfide
Disulfide		*disulfide*	CH_3SSCH_3 Dimethyl disulfide
Carbonyl			
Aldehyde		*-al*	Ethanal
Ketone		*-one*	Propanone
Carboxylic acid		*-oic acid*	 Ethanoic acid
Ester		*-oate*	 Methyl ethanoate
Amide		*-amide*	Ethanamide
Carboxylic acid anhydride		*-oic anhydride*	 Ethanoic anhydride
Carboxylic acid chloride		*-oyl chloride*	 Ethanoyl chloride

Determine the class and C-chain type of organic compounds

а) 

б) CH_3-CH_2-Br

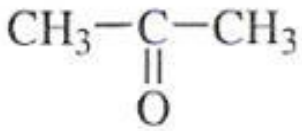
в) CH_3-CH_2-OH

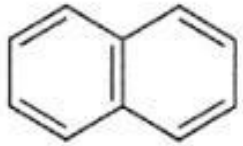
г) $CH_3-CH=CH-CH_3$

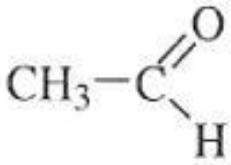
д) $CH_3-C\equiv C-CH_3$

е) $CH_3-CH_2-NH_2$

ж) $CH_3-CH_2-O-CH_2-CH_3$

з) 

и) 

к) 

(!mark)

Nomenclature of organic compounds

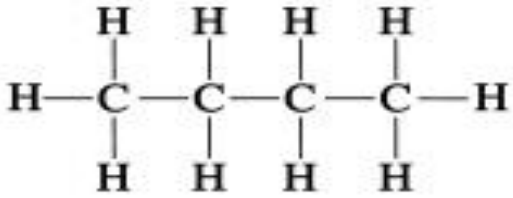
IUPAC

Summary of Formulas

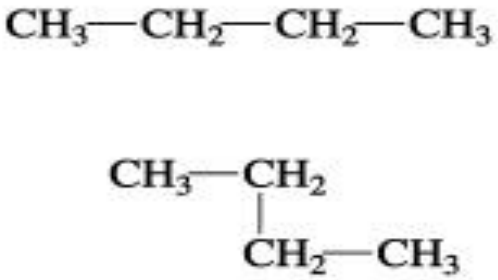
Table 12.3 Some Structural Formulas and Conformations for Butane C_4H_{10}

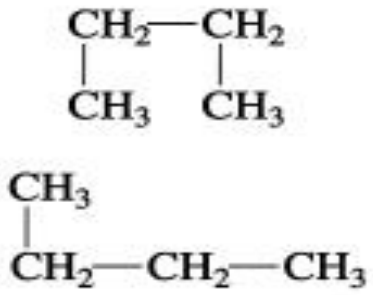
Molecular formula

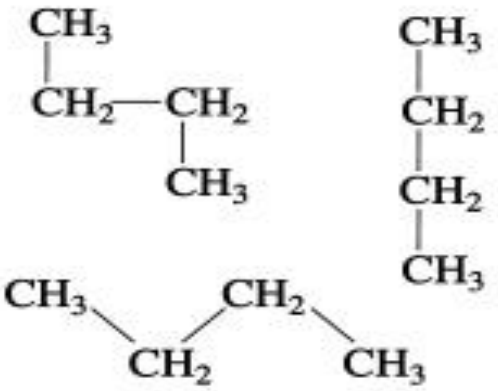
Expanded structural formula



Condensed structural formulas







Line-bond formula

IUPAC System of Naming Alkanes

- The **IUPAC** (International Union of Pure and Applied Chemistry) establishes the rules for naming organic compounds.
- **Alkanes** are named with ***–ane*** endings.
- The first four alkanes are *meth**ane**, eth**ane**, prop**ane** and but**ane**.*
- The names of longer carbon chains use Greek prefixes such as *pent-* for 5 C atoms and *hex-* for 6 C atoms.

Table 12.1 IUPAC Names for the First Ten Continuous-Chain Alkanes

Number of Carbon Atoms	Prefix	Name	Molecular Formula	Condensed Structural Formula
1	Meth	Methane	CH_4	CH_4
2	Eth	Ethane	C_2H_6	$CH_3—CH_3$
3	Prop	Propane	C_3H_8	$CH_3—CH_2—CH_3$
4	But	Butane	C_4H_{10}	$CH_3—CH_2—CH_2—CH_3$
5	Pent	Pentane	C_5H_{12}	$CH_3—CH_2—CH_2—CH_2—CH_3$
6	Hex	Hexane	C_6H_{14}	$CH_3—CH_2—CH_2—CH_2—CH_2—CH_3$
7	Hept	Heptane	C_7H_{16}	$CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$
8	Oct	Octane	C_8H_{18}	$CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$
9	Non	Nonane	C_9H_{20}	$CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$
10	Dec	Decane	$C_{10}H_{22}$	$CH_3—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_2—CH_3$

Learning Check

A. Give the name of each compound:

1) $CH_3—CH_3$

2) $CH_3—CH_2—CH_3$

3) $CH_3—CH_2—CH_2—CH_2—CH_2—CH_3$

B. Write the condensed structural formula of

pentane.

Solution

A. Give the name of each compound:

1) $CH_3—CH_3$ ethane

2) $CH_3—CH_2—CH_3$ propane

3) $CH_3—CH_2—CH_2—CH_2—CH_2—CH_3$ hexane

B. Write the condensed structural formula of pentane.

$CH_3—CH_2—CH_2—CH_2—CH_3$

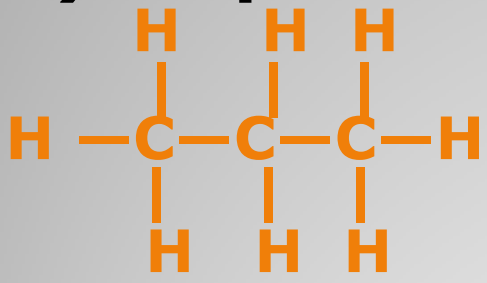
Learning Check

For propane, write the:

1) **Molecular formula**
2) **Expanded structural formula**
3) **Condensed structural formula (two conformations)**
4) **Line-bond formula**

Solution

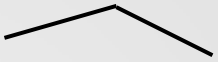
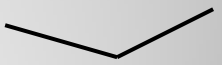
1) **Molecular formula** C_3H_8
2) **Expanded structural formula**



3) **Condensed structural formula (two conformations)**

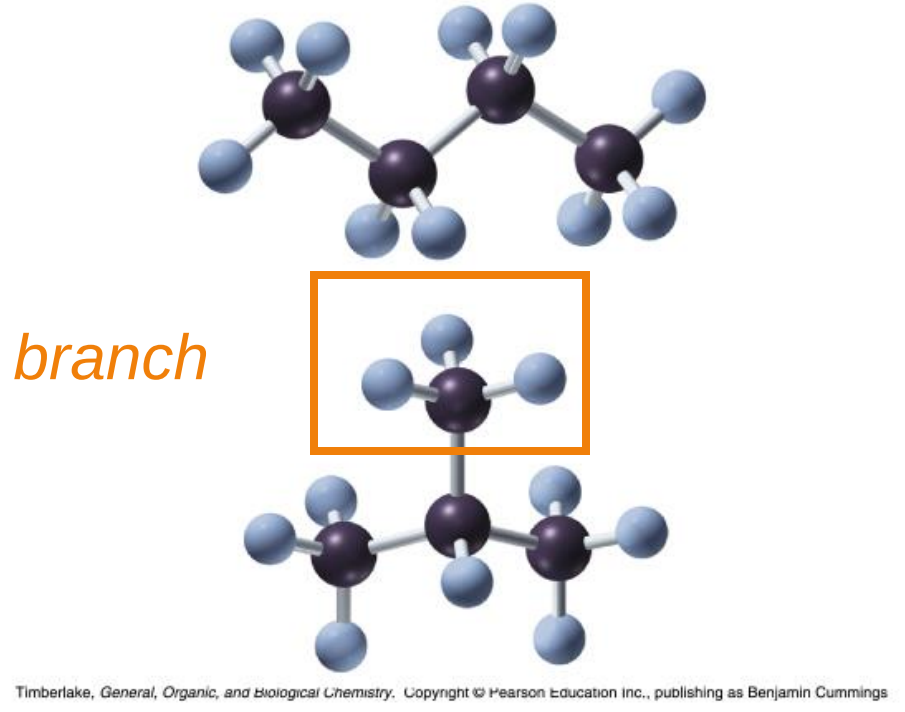
$CH_3—CH_2—CH_3$

$CH_3—CH(CH_3)$

4) **Line-bond formula**  **or** 

Branched-Chain Alkanes

- **In a branched-chain alkane, a side group called a branch or a substituent is attached to a carbon chain.**



Timberlake, *General, Organic, and Biological Chemistry.* Copyright © Pearson Education Inc., publishing as Benjamin Cummings

Alkyl Groups

An alkyl group:

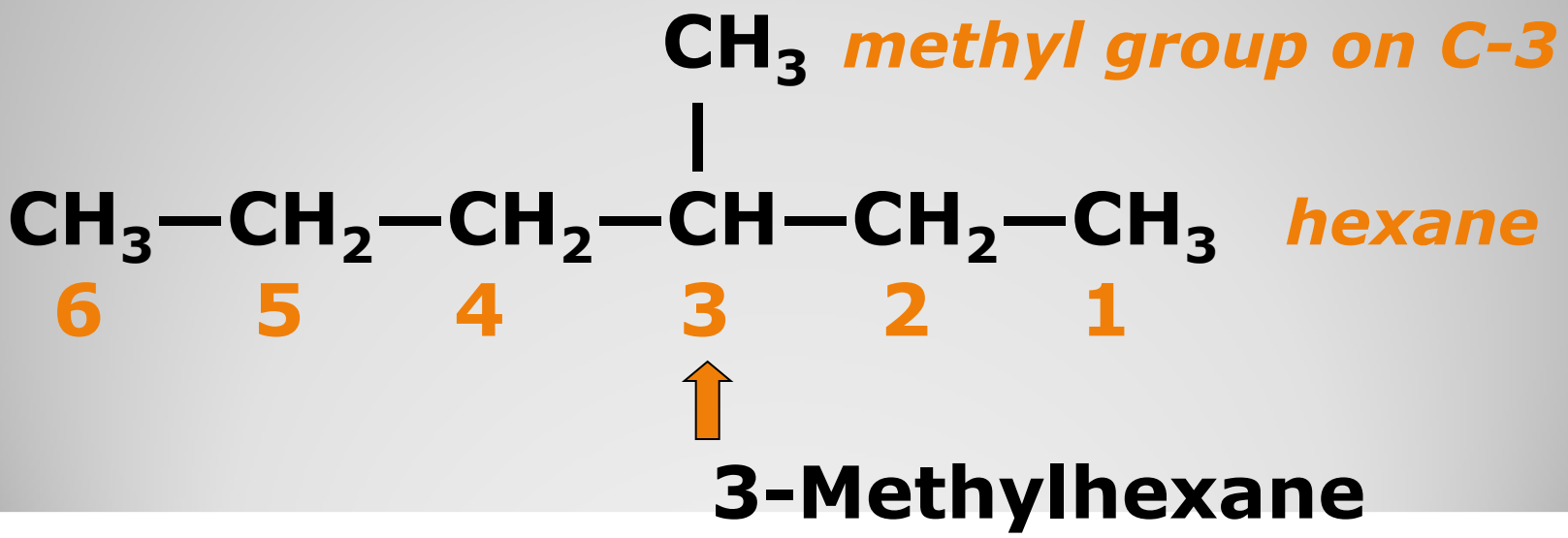
- Is composed of one or more carbon atoms attached to a carbon chain.
- Is derived from the corresponding alkane by removing one hydrogen.
- Is named by replacing the *–ane* ending of the corresponding alkane with *–yl*.
- Derived from methane is ***methyl*** and from ethane is ***ethyl*****.**

Table 12.5 Names and Formulas of Some Common Alkyl Groups

Alkane	Name of Alkane	Corresponding Alkyl Group	Name of Alkyl Group
One carbon			
CH_4	Methane	CH_3-	Methyl
Two carbons			
CH_3-CH_3	Ethane	CH_3-CH_2-	Ethyl
Three carbons			
$CH_3-CH_2-CH_3$	Propane	$CH_3-CH_2-CH_2-$	Propyl
		$CH_3-CH(CH_3)-$	Isopropyl
Four carbons			
$CH_3-CH_2-CH_2-CH_3$	Butane	$CH_3-CH_2-CH_2-CH_2-$	Butyl
		$CH_3-CH(CH_2-CH_3)-$	*sec*-Butyl (secondary butyl)
$CH_3-CH(CH_3)-CH_3$	Isobutane	$CH_3-CH(CH_3)-CH_2-$	Isobutyl
		$CH_3-C(CH_3)_2-$	*tert*-Butyl or *t*-butyl (tertiary butyl)

Naming Branched-Chain Alkanes

The names of branched-chain alkanes indicate the groups bonded to the longest carbon chain.



Naming Summary

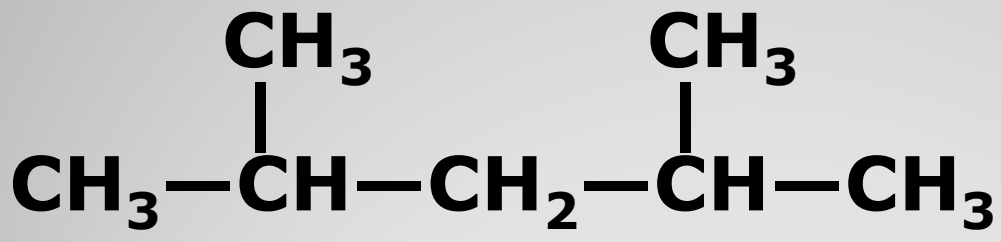
In the IUPAC system:

- The longest chain is named as the main chain.
- Any carbon branches use their alkyl names.
- Each branch is numbered by counting the main chain from the end nearest the first side group.
- Branches are listed in alphabetical order.

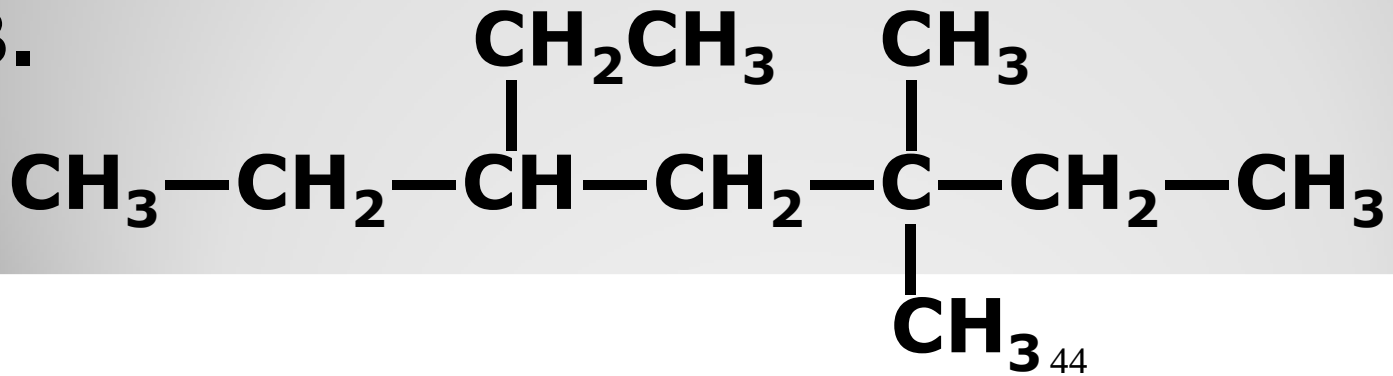
Learning Check

Give the IUPAC name for each alkane.

A.

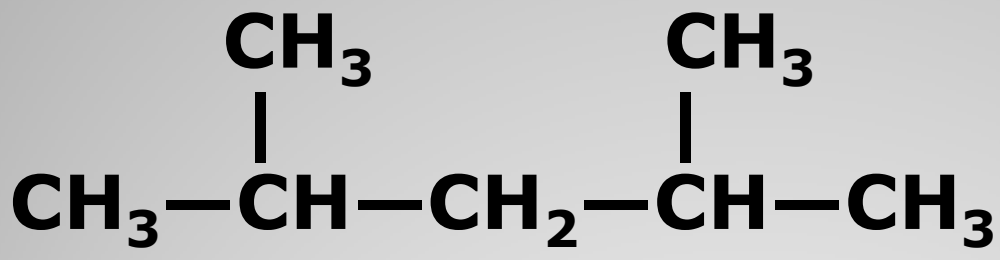


B.



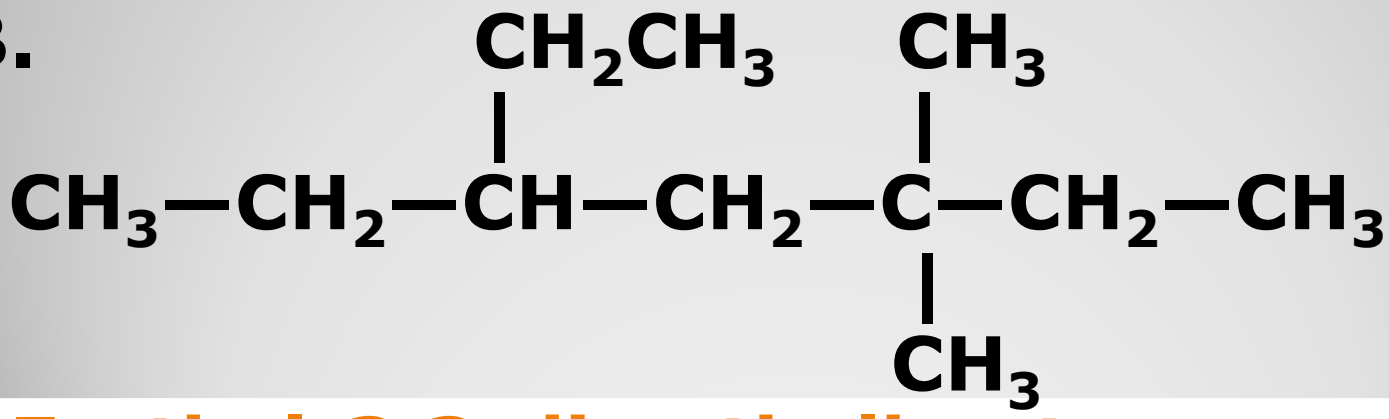
Solution

A.



2,4-dimethylpentane

B.



5-ethyl-3,3-dimethylheptane

What Is In A Name?

The structural formula is drawn from the IUPAC name.

2, 4-dimethylhexane

2, 4 **dimethyl** **hexane**

Location of main chain branches

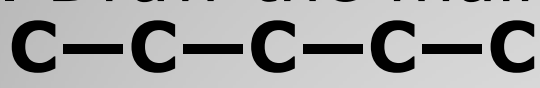
Two CH_3-groups

6 carbons

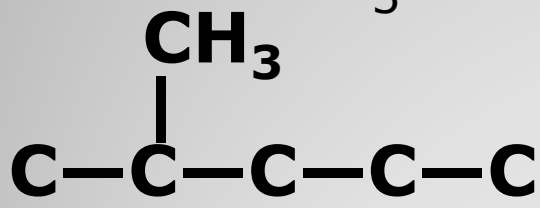
Drawing Structural Formulas

Draw the condensed formula of
2-methylpentane

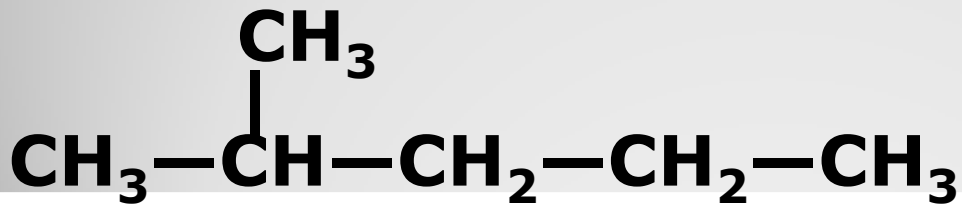
1. Draw the main chain of 5 carbon atoms.



2. Add a CH_3 branch to C-2 on the main chain.



3. Add hydrogen atoms to give 4 bonds to each C.



Learning Check

Draw the condensed structural formula for

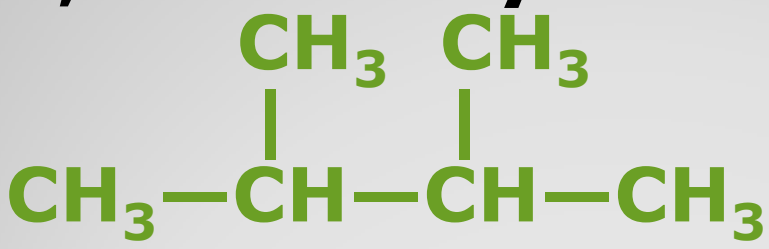
A. 2, 3-dimethylbutane

B. 2, 3, 4-trimethylpentane

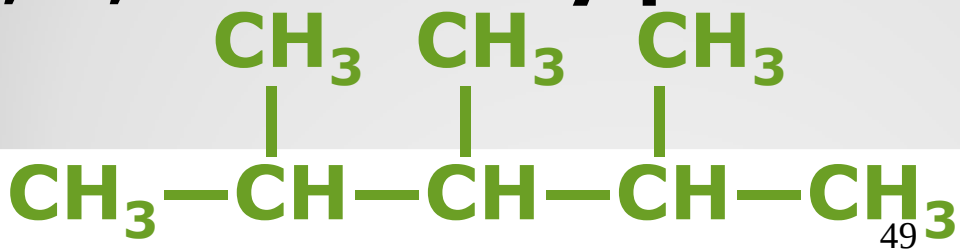
Solution

Write the condensed structural formula for

A. 2, 3-dimethylbutane



B. 2, 3, 4-trimethylpentane



Other cases

- How to give an IUPAC name for **unsaturated** hydrocarbons?
- What if is there a **functional group**?

- **Location!**

Haloalkanes

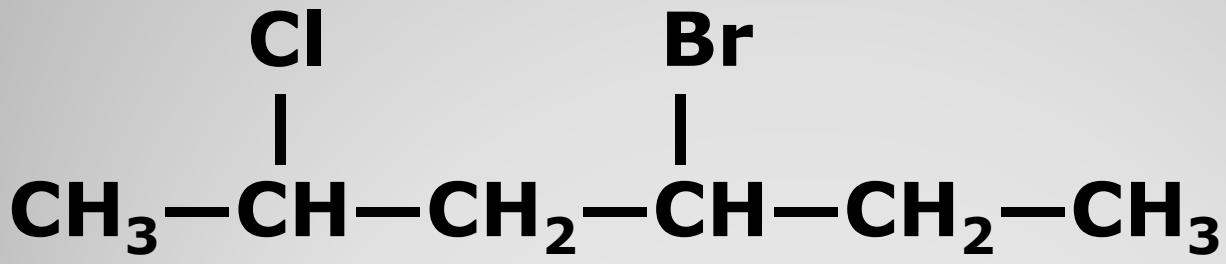
- In a **haloalkane,** one or more H atoms in an alkane is replaced by a halogen atom.
- Haloalkanes containing one halogen are named **alkyl halides**.
- In IUPAC names, a halogen is named as **fluoro, chloro, bromo, or iodo.**

CH_3Br bromomethane (methyl bromide)

2-chlorobutane (*sec*-butyl chloride)

Substituents

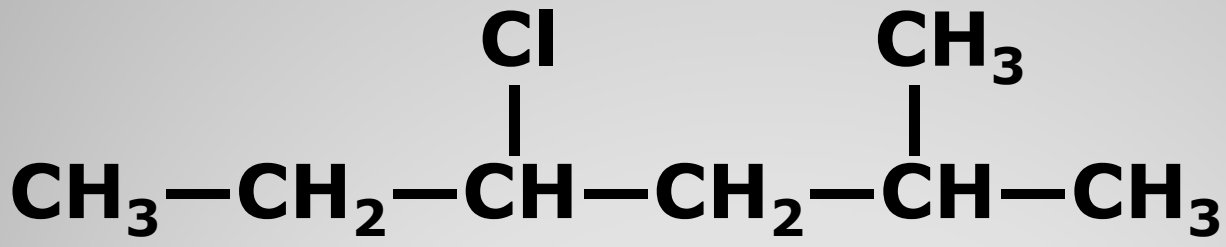
- **Two or more substituents are named in alphabetical order.**



4-bromo-2-chlorohexane

Learning Check

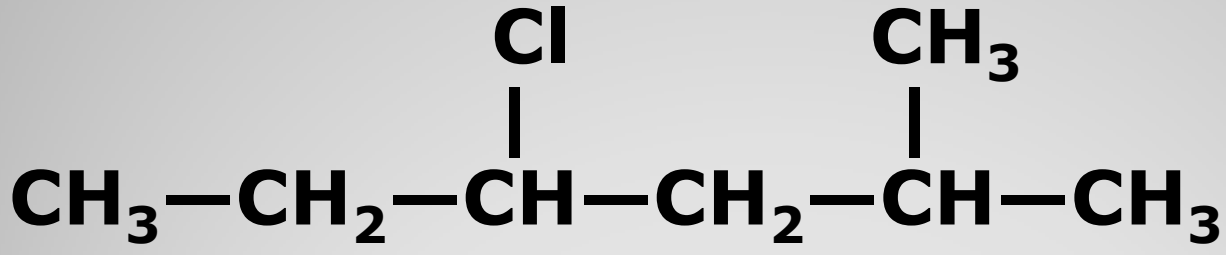
The name of this compound is:



1) 2,4-dimethylhexane
2) 3-chloro-5-methylhexane
3) 4-chloro-2-methylhexane

Solution

The name of this compound is:



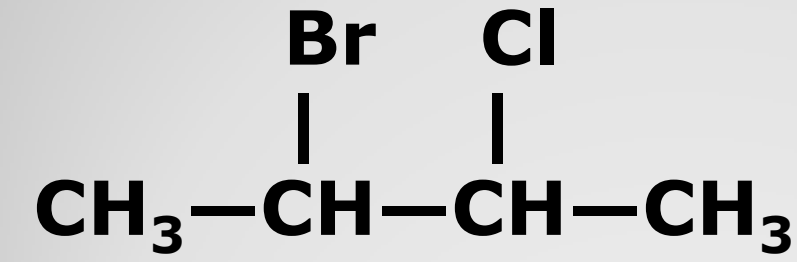
3) 4-chloro-2-methylhexane

Learning Check

Give the IUPAC name for each.

A. $CH_3CH_2—F$

B.

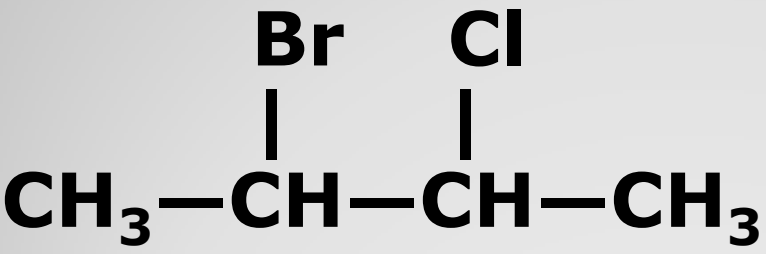


Solution

Give the IUPAC name for each.

A. $CH_3CH_2—F$ **fluoroethane**

B.

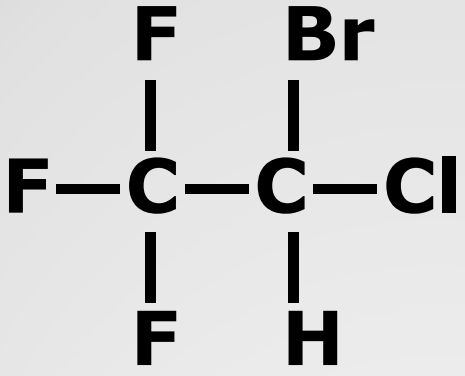


2-bromo-3-chlorobutane

Learning Check

Halothane is widely used as an anesthetic, which is a compound that decreases the ability of the nerve cells to conduct pain.

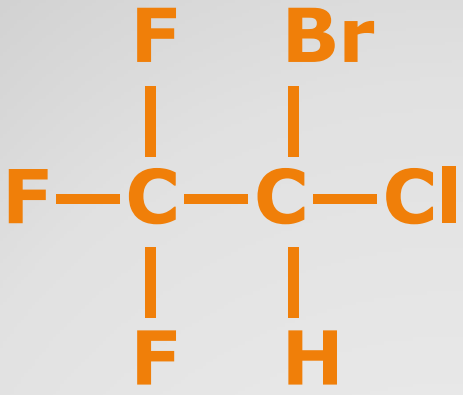
What is the IUPAC name of halothane?



Solution

The IUPAC name is

2-bromo-2-chloro-1,1,1-trifluoroethane



Other cases

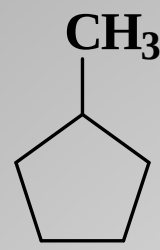
- How to give an IUPAC name for **cyclic chain**?

- **Cyclo!**

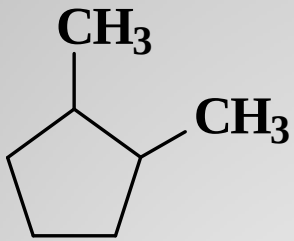
Table 12.6 Formulas of Some Common Cycloalkanes

Condensed Structural Formula	Geometric Formula	Name	
CH_2 $H_2C—CH_2$		Cyclopropane	
$H_2C—CH_2$ $H_2C—CH_2$		Cyclobutane	
CH_2 H_2C CH_2 $H_2C—CH_2$		Cyclopentane	
CH_2 H_2C CH_2 H_2C CH_2 CH_2		Cyclohexane	

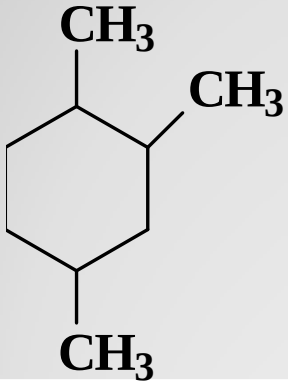
Cycloalkanes with Side Groups



methylcyclopentane

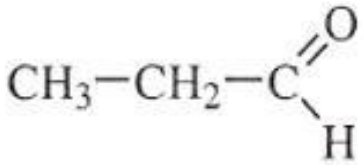


1,2-dimethylcyclopentane



1,2,4-trimethylcyclohexane

Give the IUPAC name

а) 

б) CH_3-CH_2-Br

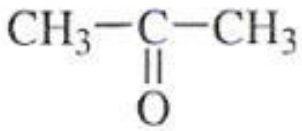
в) CH_3-CH_2-OH

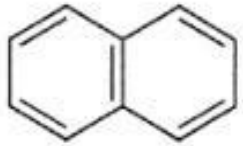
г) $CH_3-CH=CH-CH_3$

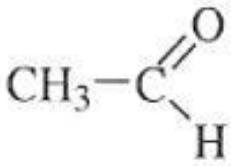
д) $CH_3-C\equiv C-CH_3$

е) $CH_3-CH_2-NH_2$

ж) $CH_3-CH_2-O-CH_2-CH_3$

з) 

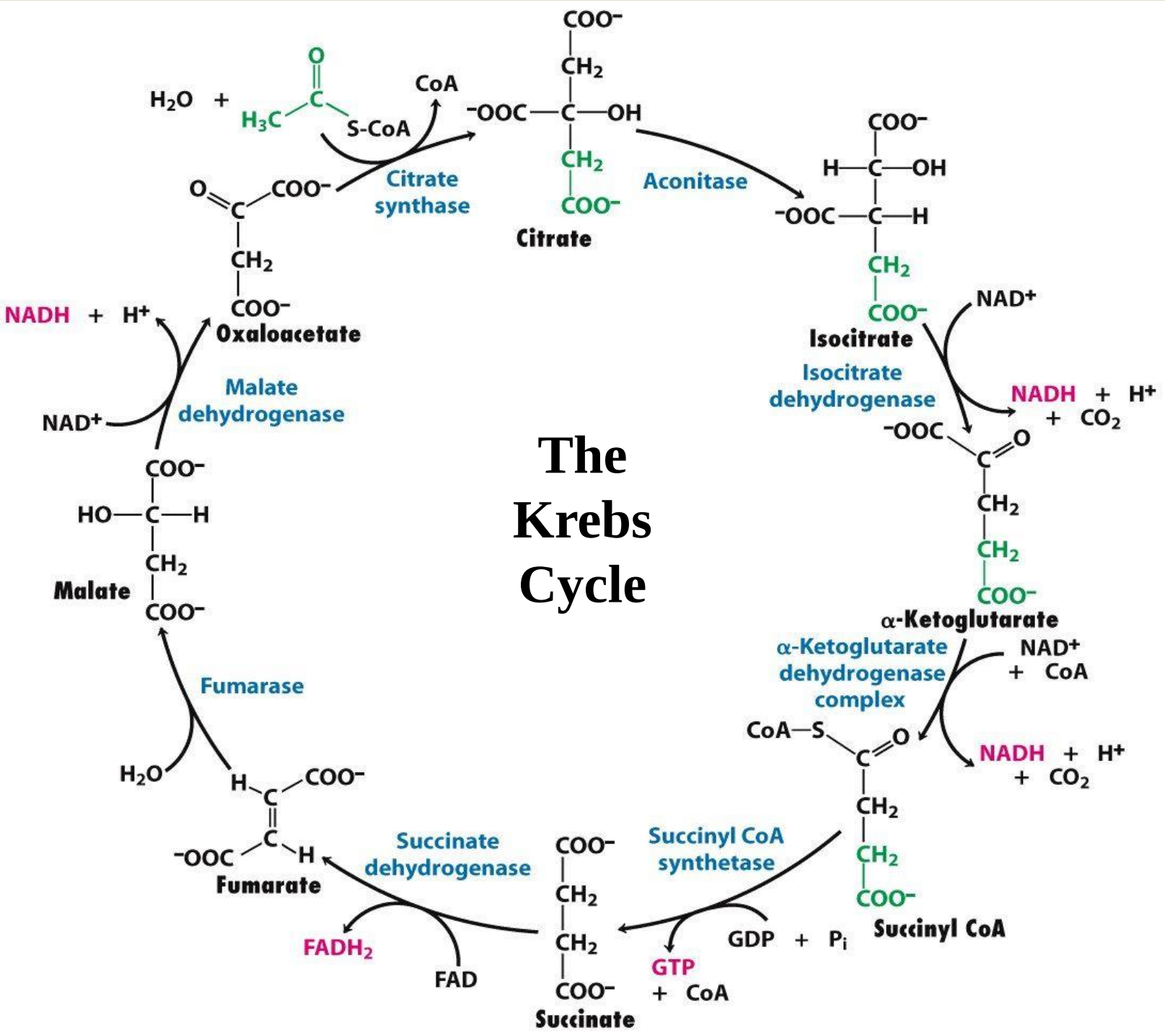
и) 

к) 

(!mark)

HOMEWORK

<u>WB 1</u>. P.12, tasks 1, 2, 4, 5


The Krebs Cycle
Citrate synthase
Aconitase
Isocitrate dehydrogenase
α-Ketoglutarate dehydrogenase complex
Succinyl CoA synthetase
Succinate dehydrogenase
Fumarase
Malate dehydrogenase
Citrate
Isocitrate
α-Ketoglutarate
Succinyl CoA
Succinate
Fumarate
Malate
Oxaloacetate
CoA
S-CoA
NAD+
NADH + H+
+ CO2
GTP
+ CoA
GDP + Pi
FADH2
FAD
H2O

HOMEWORK

1. Prepare for the test (Unit 1 Structure of organic compounds):

- Describe the electronic structure of organogenic atoms, their valence. Valence states of organogenic atoms. The types of hybridization. The main approaches to the classification of organic compounds.
- Isomerism of organic compounds.
- Nomenclature of Organic Compounds (IUPAC).
- Types of reagents, homolysis and heterolysis of covalent bonds, classification of organic reactions by direction and reagent involved. Types of reaction centers in molecules of organic compounds.

2. STUDY INFORMATION of the lecture

"Alkenes and arenes reactivity"

Types of reactions and reagents in organic chemistry

- **A chemical reaction** is a process accompanied by a change in the distribution of electrons in the outer shells of the atoms of the reacting substances.

Reactivity is the ability of a substance to react chemically and react at a slower or faster rate.

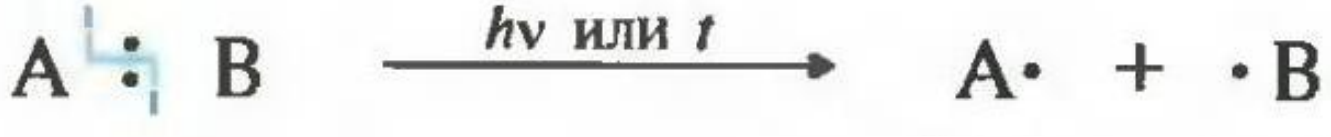
A reaction center is an atom or group of atoms directly involved in a given chemical reaction.

Substrate (reactant) + **Reagent** (reactive particle) = **Reaction products**

Classification of reactions in organic chemistry

By the mechanism of breaking the covalent bond

1. Radical reactions (bond homolysis)

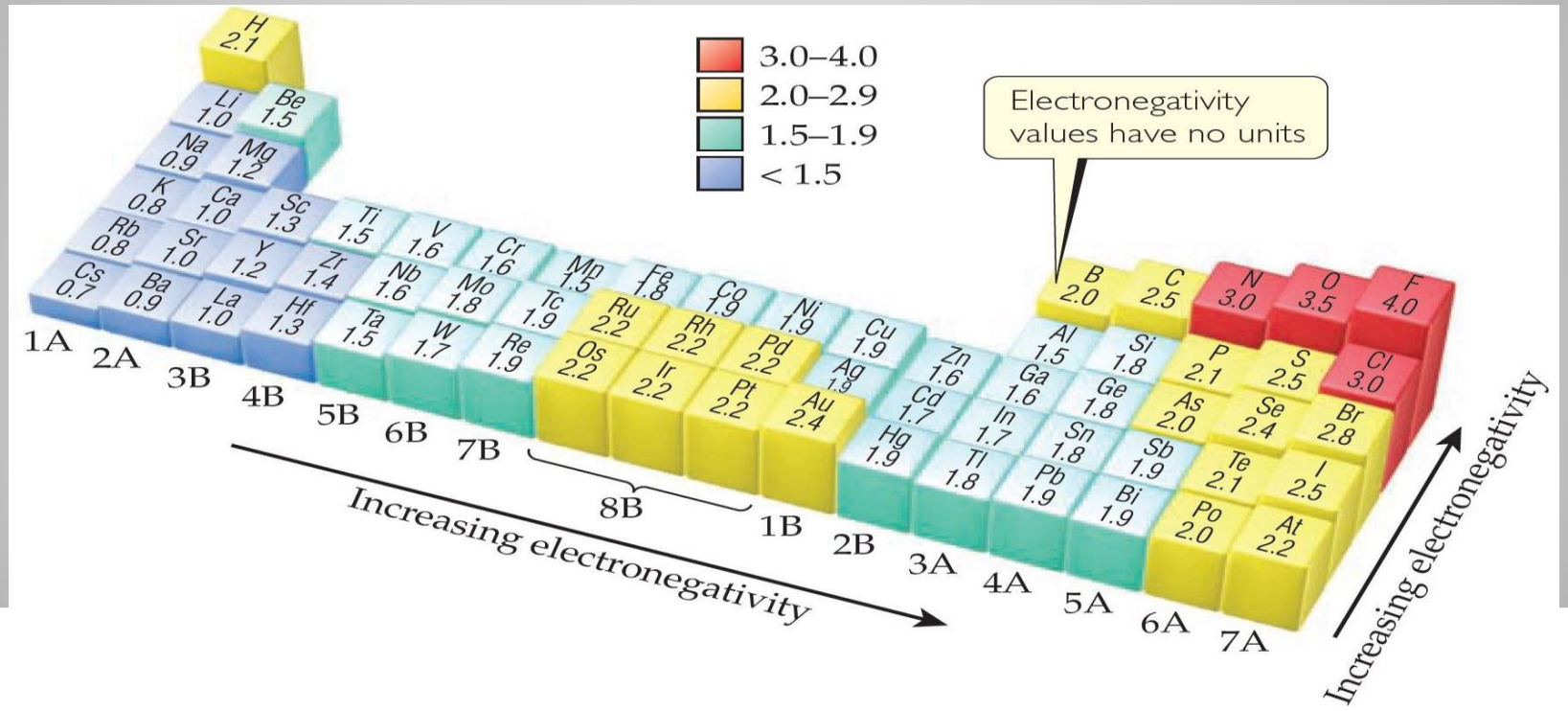


free radicals

2. Ionic reactions (bond heterolysis)

cation anion

- **The polarity of the bond** is due to the uneven distribution of the electron density. The reason for the polarity is differences in the electronegativity of bound atoms.
- **Electronegativity (EO)** is the ability of an atom in a molecule to attract binding electrons. As the difference in electronegativity increases, the bond polarity increases.



Reagents types

Reagent	Definition	Examples
Electrophile E^+, E	A particle that forms a new covalent bond due to the partner's electronic pair.	H^+, Br^+, R_3C^+, SO_3, $AlCl_3$
Nucleophile Nu, Nu^-	Particles forming a new covalent bond with a partner carrying a partial or full positive charge, providing their electron pair.	H^-, Cl^-, OH^-, RO^- NH_3, H_2O, $CH_2{=}CH_2$ (alkenes), C_6H_6 (arenes)

Reagents types

Reagent	Definition	Examples
Acid HA (BH^+)	Neutral molecules or ions capable of donating a hydrogen proton H^+.	HCl, HC≡CH, CH_3COOH, NH_4^+, H_3O^+
Base B, B^-	Neutral molecules or "-" charged particles capable of tearing a proton away from an acid site.	OH^-, RO^- NH_3, H_2O, R-OH, R-NH_2, $CH_2=CH_2$ (alkenes)

Reagents types

Reagent	Definition	Examples
Radical ·R	Free atom or particle with unpaired ē	·Cl, ·Br, ·OH, $\cdot CH_3$
Oxidizer [O]	Neutral molecule or ion that accepts ē	O_2 Fe^{3+}
Reducing agent [H]	Neutral molecule or ion that gives off ē	H_2, Fe^{2+}

Classification of reactions in organic chemistry

1. Substitution reactions (S)

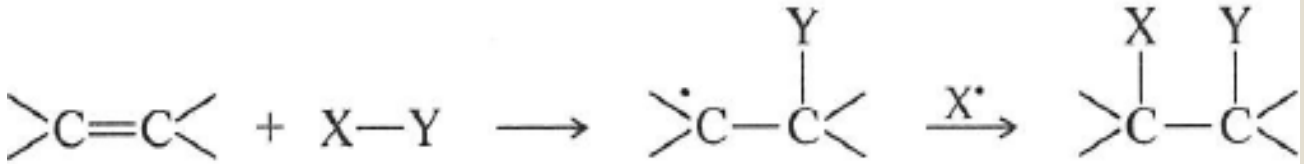
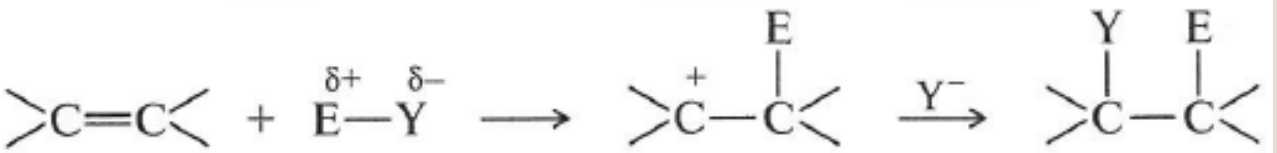
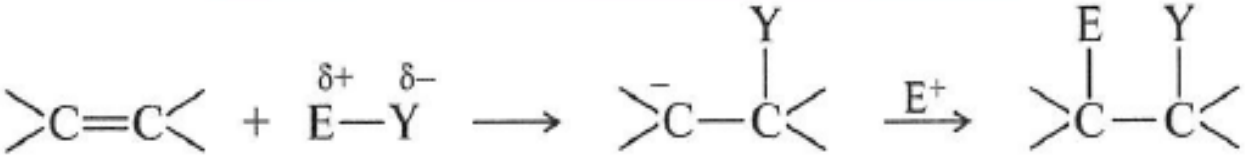
By the direction of reaction

Substitution type	Example in a general form
Radical substitution S_R	
Electrophilic substitution S_E	
Nucleophilic substitution S_N	

Classification of reactions in organic chemistry

2. Addition reactions (A)

By the direction of reaction

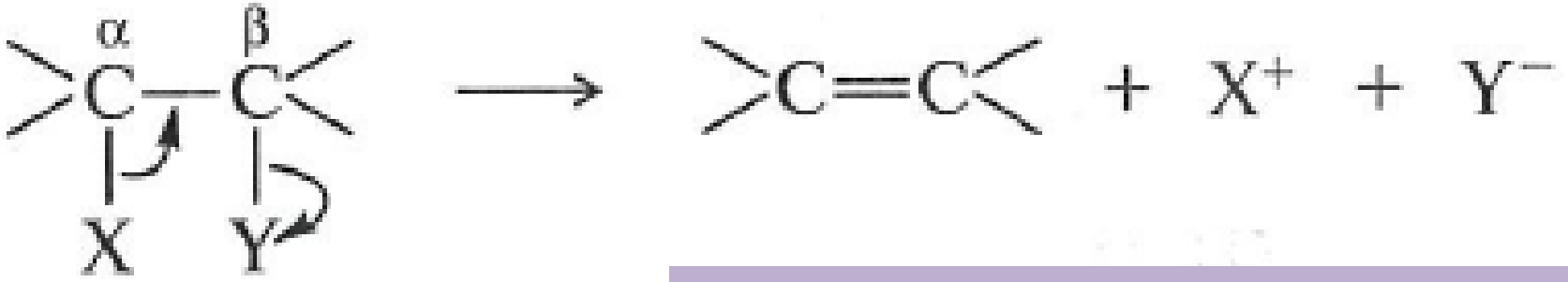
Addition type	Example in a general form
Radical addition A_R	
Electrophilic addition A_E	
Nucleophilic addition A_N	

Classification of reactions in organic chemistry

3. Elimination reactions (E)

By the direction of reaction

Example in a general form



- Groups X and Y can leave sequentially or simultaneously, unite or not unite

Classification of reactions in organic chemistry

4. Regrouping

By the direction of reaction

Regrouping type	Example in a general form
Radical regrouping	
Nucleophilic regrouping	

Classification of reactions in organic chemistry

By the direction of reaction

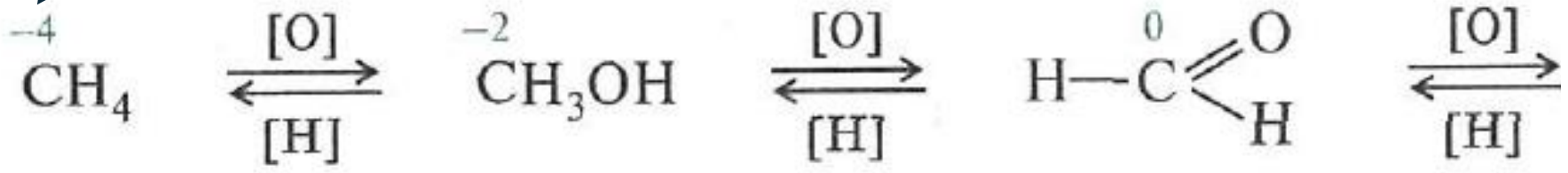
5. Redox reactions

In the course of these reactions, the oxidation state of the carbon atom, which acts as a reaction center, changes.

Oxidation of organic compounds is the process of removing hydrogen to form a multiple bond or a new bond between a carbon atom and a heteroatom. Reduction is the reverse process of oxidation.

Redox series

Minimum oxidation state of carbon

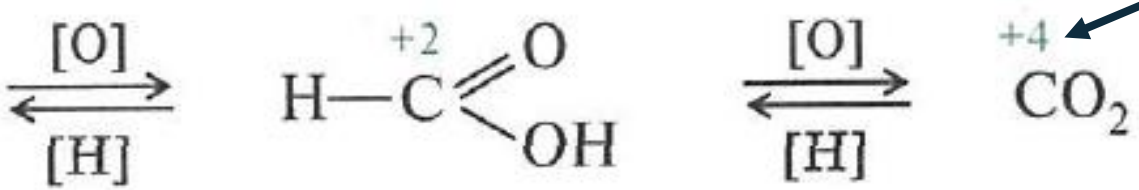


methane

methanol

formaldehyde

Maximum oxidation state of carbon



methanoic acid

carbon dioxide

Classification of reactions in organic chemistry

By the direction of reaction

6. Acid-base interactions

The acid (кислота) is the hydrogen proton donor H^+.

The base (основание) is the acceptor of the hydrogen proton H^+.