



Organic Chemistry

Hydrocarbons

Grade 12 advanced

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Student`s name:

Class:

هذه المذكرة لاتنقى عن الكتاب المدرسي وليست بهدف البيع او الربح

تمنيتي لجميع الطلبة والطالبات بالتفوق والنجاح

Section 1: introduction to hydrocarbons

Main idea: hydrocarbons are carbon-containing organic compounds that provide a source of energy and raw material

CHEM 4YOU:
the gasoline and diesel fuel that are used in cars, trucks and buses are hydrocarbons

items	Definition
Organic chemistry	Is the branch of chemistry study many organic compound that contain carbon atoms
Organic compound	Any compound have carbon atom except carbon oxides and carbonate
hydrocarbons	The simplest organic compounds which contain only the elements carbon and hydrogen
Saturated hydrocarbons	Hydrocarbon having only single bonds
Un Saturated hydrocarbons	A hydrocarbons that has at least one double or triple bond between carbon atoms
Fractional distillation (fractionation)	That method used to separate raw petroleum (crude oil) into simpler components or fractions which involves condense at different temperature and it is done in fractionating tower
cracking	That process which heavier fractions are converted into gasoline by breaking their large molecules into smaller molecules
Octane number	Used to give antiknock rating of fuel (mixture from iso octane and heptane) Ocane number of iso octane =100% Octane number of heptane=0%

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➤ Organic compounds:

- ✓ Chemists referred to the compounds which produced by living things as organic compounds because
- ✓ Once Daltons atomic theory was accepted chemists began to understand that compounds including those made by living organisms consisted of arrangements of atoms bonded together in certain combination

➤ Vitalism (vital theory):

- ✓ According to vitalism organisms possessed a mysterious "vital force" enabling them to assemble carbon compounds

➤ Disproving vitalism:

- ✓ Friedrich Wohler was the first scientist to realize that he had produced an organic compound called urea by synthesis in laboratory
- ✓ Eventually the idea that the synthesis of organic compound required a vital force was discredited and scientists realized they could synthesize organic compounds in the laboratory

Organic chemistry:

- ✓ Organic compounds that are compounds have carbon atoms except of carbon oxides, carbides and carbonates

Carbon atom is

- ✓ an element in group 14
- ✓ electron configuration $1S^2, 2S^2, 2P^2$,
- ✓ Shares its electrons and forms **four covalent bonds**
- ✓ Bonded to H atoms or atoms of other elements that are near carbon in the periodic table -especially N, O, S, P and the halogens

Organic compounds are millions and various ?why ?

Because the electronic configuration of carbon atom make it :

- ✓ Can Bonded to another carbon or another element making single or double or triple bond
- ✓ Can bonded to other carbon atoms and form chains from 2 to thousands of carbon atoms in length
- ✓ It forms a complex, branched chain structures, ring structures and even cakelike structures

14
Carbon 6 C 12.011
Silicon 14 Si 28.086
Germanium 32 Ge 72.61
Tin 50 Sn 118.710
Lead 82 Pb 207.2

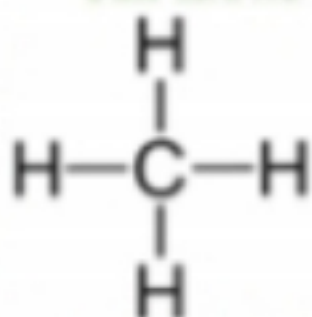


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➤ Hydrocarbons :

- ✓ Are the simplest organic compounds
- ✓ Contain only the elements of C and H
- ✓ The simplest hydrocarbon molecule CH_4 methane
- ✓ Methane CH_4 : excellent fuel and is the main component of natural gas

❖ Models and hydrocarbons :

- ✓ Chemists represent organic molecules in a variety of **four ways** :
- ✓ Keep in mind as you look at the models that the atoms are held closely together by electron -sharing bonds

	Molecular formula	Structural formula	Ball-stick model	Space-filling model
Model	CH_4			
Advantage	Represent kind and number of atoms in the molecule	Shows the general arrangements of atoms in the molecule	Demonstrates the geometry the molecule clearly	Give a more realistic picture of what molecule would look like if you could see it
disadvantage	Give no information about the geometry of the molecule	Not show the exact three dimensional geometry		

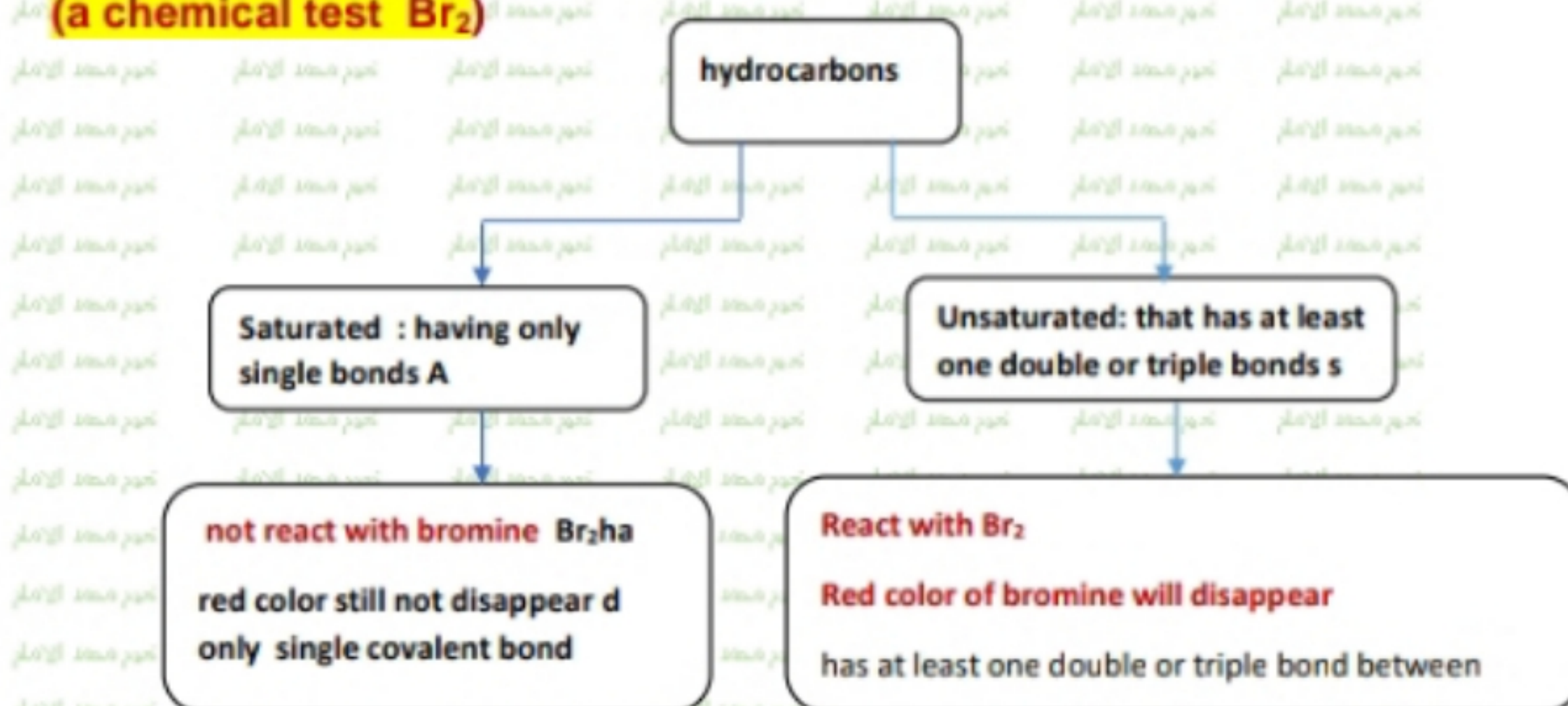
➤ Multiple carbon -carbon bonds :

- ✓ Carbon atoms can bond to each other by single covalent bond (one shared pair) or by double bond (2 shared pairs) and triple covalent bonds (three shared pairs)

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Classified hydrocarbons according to kind of covalent bond

(a chemical test Br_2)



➤ Refining hydrocarbons :

- ✓ Many hydrocarbons are obtained from a fossil fuel called petroleum and natural gas .

➤ Formation of petroleum :

- 1- Is formed from the remains of microorganisms that lived in earth's oceans millions of years ago
- 2- Over time the remains formed thick layers of mudlike deposits on the ocean floor
- 3- Heat from earth's interior and the tremendous pressure of overlying sediments transformed this mud into oil rich shale and natural gas
- 4- The petroleum ran out of the shale and collected in pools deep in earth's crust

➤ Formation of the natural gas

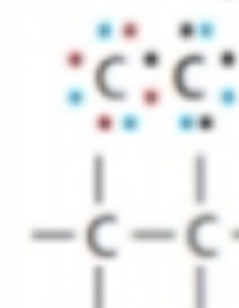
is formed at the same time and in the same way as petroleum is usually found with petroleum deposits
is composed primarily of methane and small amounts of other hydrocarbons that have from 2C to 5C atom

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➤ fractional distillation (fractionation)

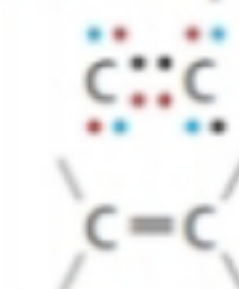
- ✓ Fractional distillation is a process used to separate raw petroleum (crude oil) into simpler components or fractions
- ✓ The raw petroleum sometimes called **crude oil** (why?)
Because Petroleum is a complex mixture containing more than a thousand different compounds
- ✓ Crude oil has little practical use and become more useful to humans when separated into simpler components or fractions
- ✓ Fractional distillation is done in a **fractionating tower**
- ✓ The temperature inside the fractionating tower is controlled so that it remains near 400°C at the bottom
- ✓ The condensation temperature (boiling point) generally decrease as molecular mass decreases
- ✓ Where the petroleum is boiling and gradually decrease toward the top
- ✓ **At the top of the tower** : the components have low boiling point , lower density, lower molecular mass ,lower viscosity and higher volatile
- ✓ Gasoline and gaseous products have low b.p and are drawn off in the cooler regions near the top of the tower
- ✓ Oils and greases having much higher boiling points stay near the bottom of the tower and are drawn off there

One shared pair



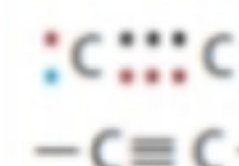
Single covalent bond

Two shared pairs



Double covalent bond

Three shared pairs



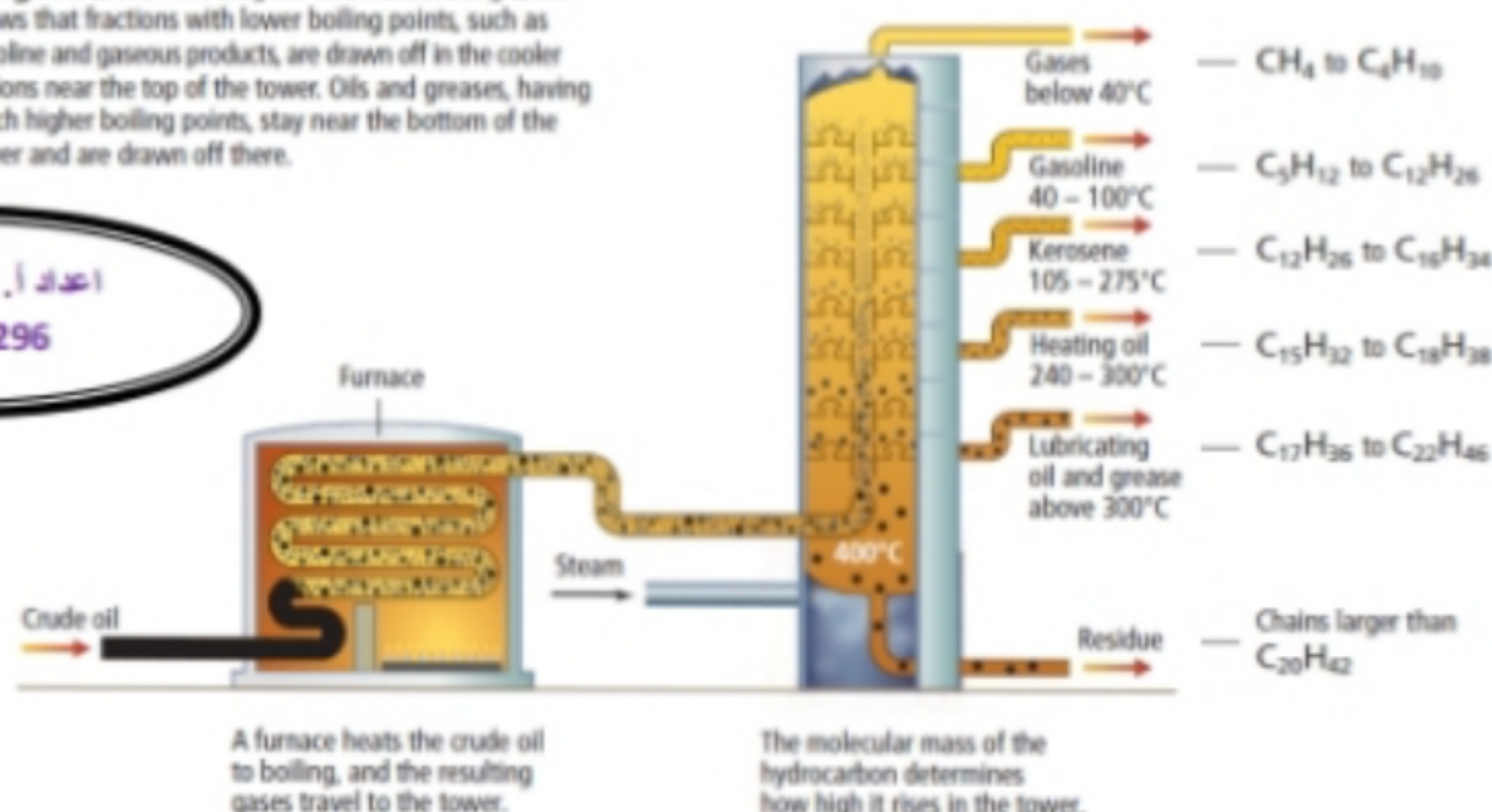
Triple covalent bond

• and • = carbon electrons
• = electron from another atom

➤ Basic scientific of fractional distillation :

- ✓ Each components of petroleum different in boiling point
- ✓ and they condense at a different temperature

■ **Figure 21.6** This diagram of a fractionating tower shows that fractions with lower boiling points, such as gasoline and gaseous products, are drawn off in the cooler regions near the top of the tower. Oils and greases, having much higher boiling points, stay near the bottom of the tower and are drawn off there.



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➤ **cracking :**

- ✓ Is a process in which heavier fractions are converted to gasoline by breaking their large molecules into smaller molecules

Conditions of cracking :

- ✓ Is done in the **absence of oxygen**
- ✓ And in the **presence of a catalyst**

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Don't yield fractions in same proportions they are needed fore example distillation seldom yield the amount of gasoline desired however it yields more of the heavier oils than the market demands

➤ **Rating gasoline :**

- ✓ Gasoline is not a pure substance but rather a mixture of hydrocarbons
- ✓ **Gasoline have 5 to 12 carbon atoms**
- ✓ The gasoline fraction that is distilled from petroleum is modified by adjusting its composition and adding substances to improve its performance in todays automobile engines and to reduce pollution from car exhaust
- ✓ It is critical that the gasoline air mixture in the cylinder of an automobile engine ignite at exactly the right instant and burn evenly
- ✓ If it ignites too early or too late much energy will be wasted , fuel efficiency will drop and the engine will wear out prematurely
- ✓ Early ignition causes a rattling or pinging noise called **knocking**
- ✓ Several factors determine which octane rating a car needs including
 - How much the piston compresses the air-fuel mixture
 - The altitude at which the car is driven

Notes

- As the united states entered the machine age and its population increased the demand for petroleum products
- Edwin drake drilled the first oil well in the U.S.A in Pennsylvania in 1859
- When tomasEdison introduced the electric light inventors feared that industry was doomed however the invention of automobile revived the industry on a massive scale

Section 2: alkanes

Main idea : alkanes are hydrocarbons that contain only single bond

Chemistry for you : natural gas and propane are the two most common gases used in many applications and both are alkanes

Item	Definition
Alkanes	Are hydrocarbons that have only single bonds between atoms
A homologous series	A series of compounds that differ from one another by a repeating unit (CH_2)
Parent chain	The longest continuous chain of carbon atoms
Substituent groups (Alkyl group R-)	All side branches that group appear to substitute for a hydrogen atom in the straight chain and the ending in the alkane (ane) is replaced with (yl)
Cyclic hydrocarbons	An organic compound that contains a hydrocarbon ring
Cyclo alkanes	Cyclic hydrocarbons that contain only single bonds
Skeletal structure	That formula that represent covalent bonds between carbon atoms without hydrogen
Condensed structural formula	Like a structural formula but save space by not showing how the hydrogen atoms branch off from the carbon atoms and the lines between carbon atoms have been eliminated to save space

➤ Simple alkanes :

Molecular Formula	Structural Formula	Ball-and-Stick Model	Space-Filling Model
Ethane (C_2H_6)	$\begin{array}{c} \text{H} & \text{H} \\ & \\ \text{H}-\text{C}- & \text{C}-\text{H} \\ & \\ \text{H} & \text{H} \end{array}$		
Propane (C_3H_8)	$\begin{array}{c} \text{H} & \text{H} & \text{H} \\ & & \\ \text{H}-\text{C}- & \text{C}- & \text{C}-\text{H} \\ & & \\ \text{H} & \text{H} & \text{H} \end{array}$		
Butane (C_4H_{10})	$\begin{array}{c} \text{H} & \text{H} & \text{H} & \text{H} \\ & & & \\ \text{H}-\text{C}- & \text{C}- & \text{C}- & \text{C}-\text{H} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array}$		

➤ Straight –chain alkanes

✓ The smallest member of a series of hydrocarbons known as alkanes is methane CH_4

✓ The general formula of alkanes is $\text{C}_n\text{H}_{2n+2}$

✓ Alkanes with 5 carbons or more in a chain have names that use a **prefix** derived from the greek or latin word for the number of carbones in each chain



Example : pentane has 5 carbon just as a pentagon have 5 sides, and octane has 8 carbon just as an octopus has 8 tentacles

✓ A **homologous series** has a fixed numerical relationship among the number of atoms ($\text{C}_n\text{H}_{2n+2}$) where n: is equal to the number of carbon atoms in alkane.

Name	Molecular Formula	Condensed Structural Formula
Methane	CH_4	CH_4
Ethane	C_2H_6	CH_3CH_3
Propane	C_3H_8	$\text{CH}_3\text{CH}_2\text{CH}_3$
Butane	C_4H_{10}	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$
Pentane	C_5H_{12}	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
Hexane	C_6H_{14}	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
Heptane	C_7H_{16}	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$
Octane	C_8H_{18}	$\text{CH}_3(\text{CH}_2)_6\text{CH}_3$
Nonane	C_9H_{20}	$\text{CH}_3(\text{CH}_2)_7\text{CH}_3$
Decane	$\text{C}_{10}\text{H}_{22}$	$\text{CH}_3(\text{CH}_2)_8\text{CH}_3$

➤ Common alkyl groups :

Name	Methyl	Ethyl	Propyl	Isopropyl	Butyl
Condensed structural formula	CH_3-	CH_3CH_2-	$\text{CH}_3\text{CH}_2\text{CH}_2-$	CH_3CHCH_3 	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2-$
Structural formula	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \end{array}$	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \end{array}$	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \end{array}$	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ -\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array}$	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \end{array}$

Alkanes	
Straight chain	Branched chain
<p>Example : butane</p> <p>Uses : used in lighters and in troches</p>  <p>Butane Molecular formula: C_4H_{10}</p>	<p>Example: Iso butane(2-methyl butane)</p> <p>Uses :</p> <ul style="list-style-type: none"> ✓ used as both an environmentally-safe refrigerant ✓ a propellant in products such as shaving gel  <p>Isobutane Molecular formula: C_4H_{10}</p>
<ul style="list-style-type: none"> ✓ Have the same molecular formula C_4H_{10} ✓ Different in chemical and physical properties ✓ Used as raw materials for many chemical processes. 	



the same of molecular formula for a straight chain and branched chain illustrates a basic principle of organic chemistry

- ✓ The order and the arrangement of atoms in an organic molecule determine its identity
- ✓ The name of organic compound must also accurately describe the molecular structure of the compound

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➤ Naming branched – chain alkanes :

To name organic structures chemists use the following systematic rules approved by the international union of pure and applied chemistry (IUPAC)

Step1: count the number of carbon atoms in the longest continuous chain

Step2: number each carbon in the parent chain

Step3: name each alkyl group substituent

Step4: if the same alkyl group occurs more than once as a branch on the parent structure, use a prefix (di-, tri-, tetra-, ... and so on) before its name to indicate how many times it appears

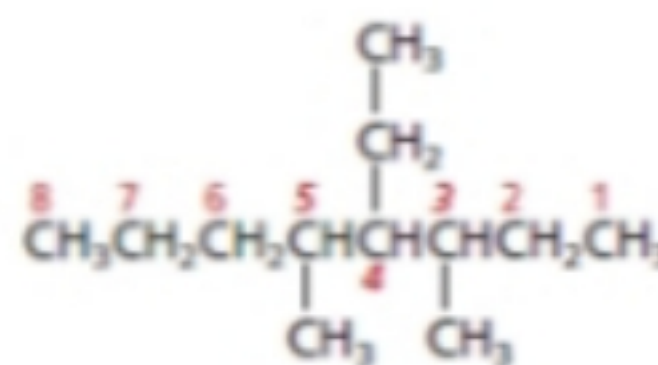
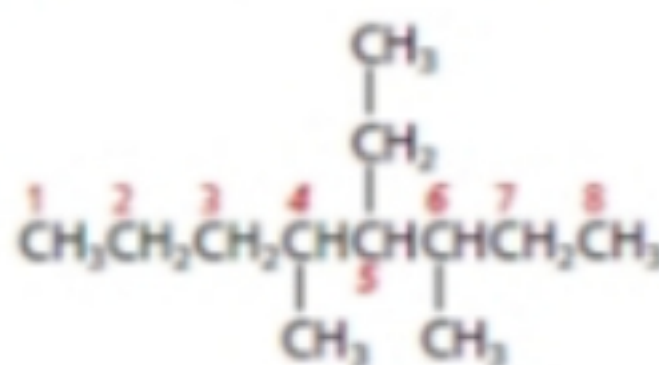
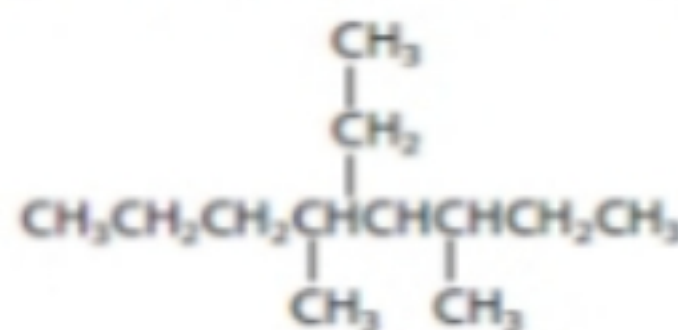
Step5: when different alkyl groups are attached to the same parent structure place their names in alphabetical order

And don't consider the prefixes (di-, tri-, ...) when determining alphabetical order

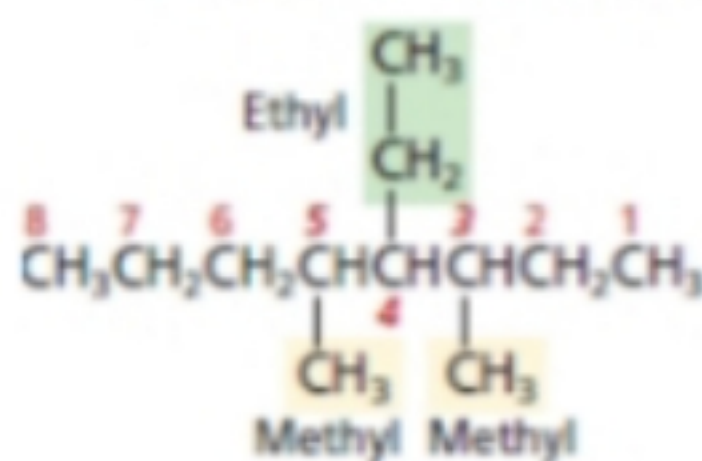
Step6: write the entire name, using hyphens to separate numbers from words and commas to separate numbers

Example:

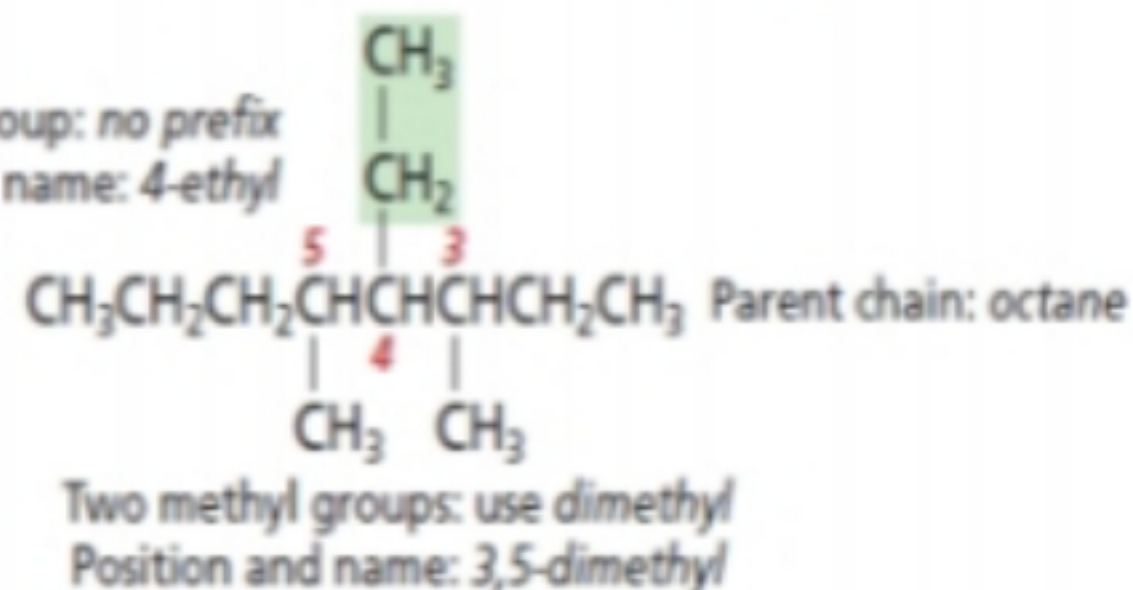
Name the alkane shown:



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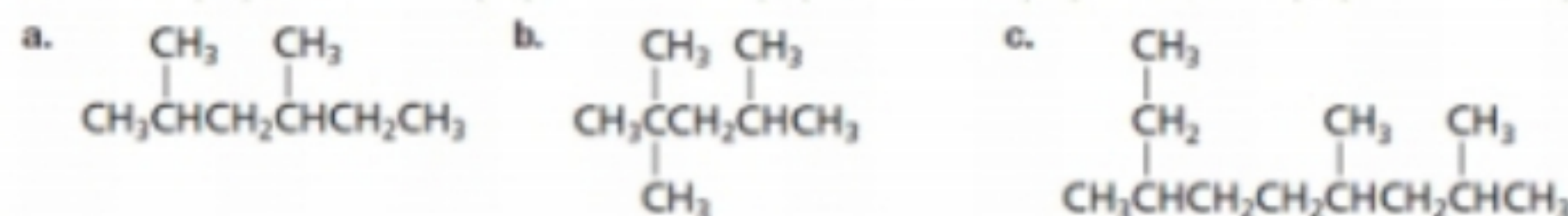
One ethyl group: no prefix
Position and name: 4-ethyl



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Applications

1- Use the IUPAC rules to name the following structures



2- Draw the structures of the following branched-chain alkanes :

2,3-di methyl-5-propyl decane

3,4,5-tri ethyl octane

Cycloalkanes

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✓ The simplest compound in cycloalkanes is **cyclopropane**

✓ General formula of cycloalkanes is **C_nH_{2n}**

✓ Cycloalkanes have **2 fewer hydrogen** atoms than straight-chain alkane (why?)

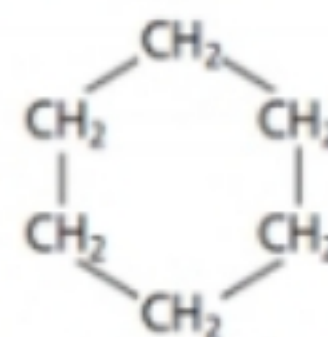
because a valence electron from each of 2 carbon atoms is now forming a carbon-carbon bond rather than a carbon-hydrogen bond

✓ Cycloalkanes can be represented in several ways:

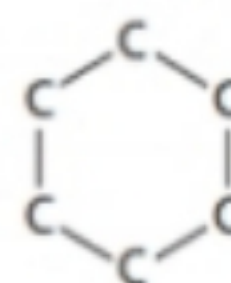
• Condensed structural formula

• Skeletal structure : H atoms are not shown in formula

• Line structure : show only the C-C bonds with carbon atoms understood to be at each vertex of the structure



Condensed structural formula



Skeletal structure



Line structure

Naming substituted cycloalkanes :

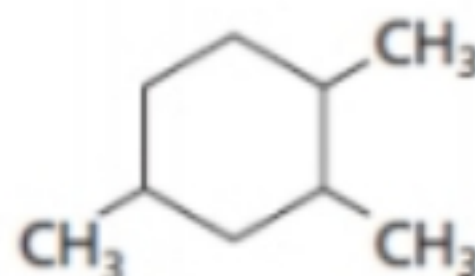
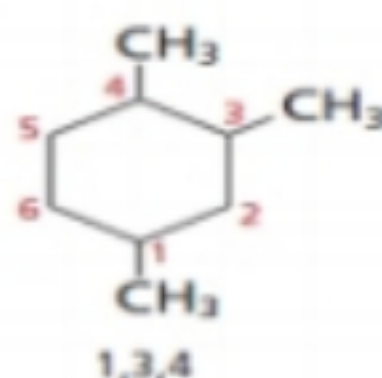
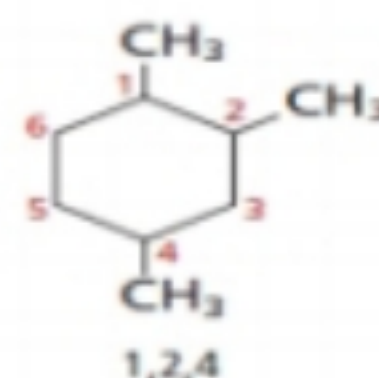
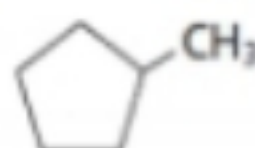
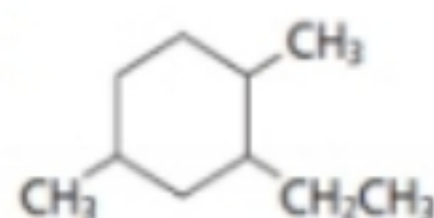
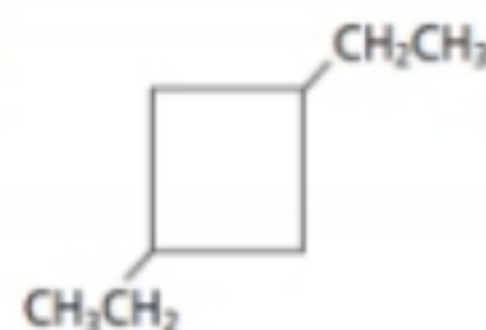
✓ Substituted cycloalkanes are named by following the same IUPAC rules used for straight-chain alkanes but with a few modifications

✓ With cycloalkanes there is **no need to find the longest chain** because the ring is always considered to be the parent chain

✓ Numbering is started on the carbon that is bonded to the substituent group because a cyclic structure has no ends

✓ When there are 2 or more substituents, the carbons are numbered around the ring in a way that gives the lowest-possible set of numbers for the substituents

✓ If only one group is attached to the ring **no number is necessary**

Example:**Name the cycloalkane shown****A****B****1,2,4-tri methyl cyclohexane****Applications****1- Use the IUPAC rules to name the following structures :****a.****b.****c.****2- Draw the structures of the following branched- chain alkanes :****1-ethyl-3-propylcyclopentane****1,2,2,4-tetramethylcyclohexane**

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Properties of alkanes**Physical properties :****1- Solubility in water :**

✓ Alkanes (such as lubricating oils) and other hydrocarbons are **immiscible** in water, the two liquids separate almost immediately into two phases (why ?)

This separation happens because :

👇 The attractive force between alkane molecules are stronger than the attractive force alkane and water molecules

👇 Alkanes are non-polar molecules applied to rule (like dissolve like) water is polar compound so alkanes not soluble in water

2- Melting point and Boiling point :

- ✓ Water and methane molecules are similar in size and are closed in molecular mass [Water (18amu) , methane (CH_4 :16amu)] although that **the boiling point of water more than methane (why?)**
- ✚ Because the methane molecules is non polar so it have little intermolecular attraction (london dispersion forces) compared to water molecules which are polar and freely form hydrogen bonds
- ✓ **When molar mass of molecules increase the boiling point increase (why?)**
because increasing in molar mass of molecules the intermolecular force between molecules become more and it is need more energy to break it
- ✓ If the organic compounds have the same molecular formula but different in structural formula the **compound have more branches is low boiling point**

3- The structure of a molecules affects

- ✓ The structure of a molecules affects its properties
- ✓ **Water is polar solvent (why?)** because the O-H bonds in a water molecule are polar and water molecule has a bent geometry thus water molecules can form a hydrogen bond to each other as a result the boiling and melting points of water are much higher than those of other substances having similar molecular mass and size
- ✓ **Alkanes are non-polar (why?)** because the all bonds in alkanes between either a carbon atoms C-C also C-H have only a small electronegativity difference and are non polar

Substance and formula	Water (H_2O)	Methane (CH_4)
Molecular mass	18 amu	16 amu
State at room temperature	liquid	gas
Boiling point	100°C	-162°C
Melting point	0°C	-182°C

- 4- **Alkanes and cycloalkanes are good solvents** (as thinners for paints , coatings ,waxes,photocopier toners,adhesives and printer press inks)for other non polar substances **(why?)** because Alkanes and cycloalkanes are nonpolar solvents

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➤ Chemical properties of alkanes :

Alkanes are low reactivity (why?) because :

- a- Atoms in alkanes are connected by **nonpolar bonds** ,have no charge .as aresult they have little attraction for ions or polaler molecules
- b- Can also be attributed to the **relatively strong C-C** and C-H bonds

Main idea : alkenes are hydrocarbons that contain at least one double bond and alkynes are hydrocarbons that contain at least one triple bond

Chemistry for you :

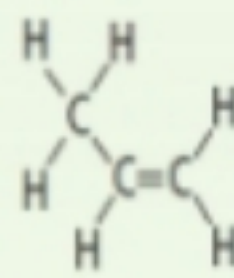
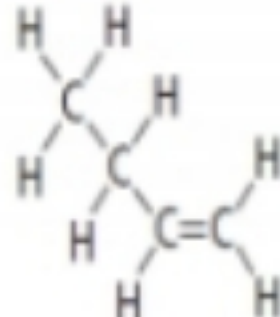
plants produce ethene as a natural ripening hormone . for efficiency in harvesting and transporting produce to market , fruits and vegetables are often picked while unripe and are exposed to ethene so they will ripen at the same time

Item	Definition
Alkenes	That hydrocarbons contain one or more double covalent bonds between carbon atoms in a chain
Alkynes	That hydrocarbons contain one or more triple bonds between carbon atoms in a chain

Alkenes

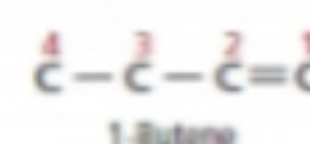
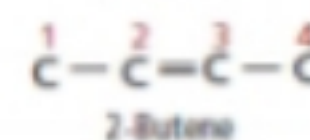
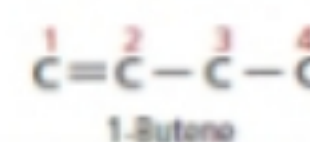
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- ✓ Alkenes must have a double bond between carbon atoms there is no 1-carbon alkene
- ✓ Ethene C_2H_4 is the simplest alkene
- ✓ Alkenes with only one double bond constitute a homologous series
- ✓ The general formula of alkenes C_nH_{2n}
- ✓ Each alkene has 2 fewer hydrogen atoms than a corresponding alkane (why?) because 2e now form the second covalent bond and are no longer available for bonding to hydrogen atoms .

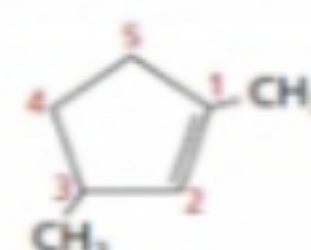
Name	Ethene	Propene	1-Butene	2-Butene
Molecular formula	C_2H_4	C_3H_6	C_4H_8	C_4H_8
Structural formula				
Condensed structural formula	$CH_2=CH_2$	$CH_3CH=CH_2$	$CH_3CH_2CH=CH_2$	$CH_3CH=CHCH_3$

➤ Naming alkenes :

- ✓ Alkenes are named in much the same way as alkanes
- ✓ Their names are formed by changing (-ane) ending to (-ene)
- ✓ To name alkenes with 4 or more carbons in the chain it is necessary to specify the location of the double bond
- ✓ Numbering the carbon in the parent chain, starting at the end of the chain that will give the first carbon in the double bond the lowest number
- ✓ Use only that number in the name



a. Straight-chain alkenes



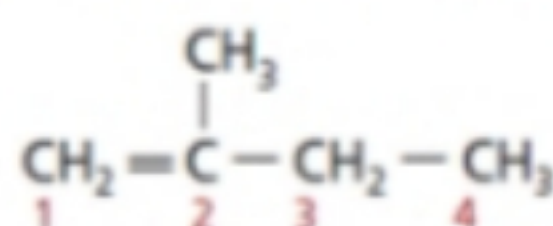
b. Cyclic alkenes

➤ Naming cyclic alkenes :

- ✓ Are named in much the same way as cyclic alkanes
- ✓ Carbon number 1 must be one of the carbons connected by the double bond

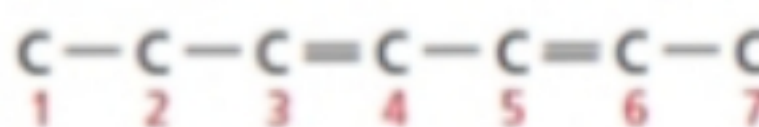
➤ Naming branched – chain alkenes :

- ✓ Same naming of alkanes but with 2 exceptions :
- ✓ 1-The parent chain in alkenes is always the longest chain that contains the double bond whether or not it is the longest chain of carbon atoms
- ✓ 2-The position of the double bond not the branches determines how the chain is numbered
- ✓ A number specifies the location of the double bond just as it does in straight-chain alkenes
- ✓ Some unsaturated hydrocarbons contain more than one double bond (or triple bond) the number of double bonds we will use a prefix (di, tri, tetra, and so on) before suffix-ene
- ✓ The positions of the bonds are numbered in a way that give the lowest set of numbers in branched and straight chain branched

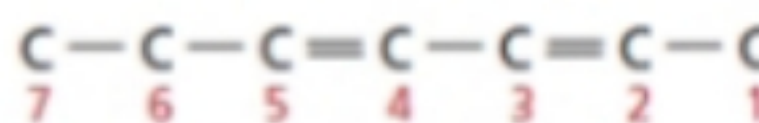


2-methylbutene

a. Single double bond



or



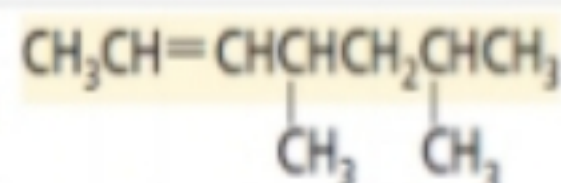
2,4-heptadiene

b. Two double bonds

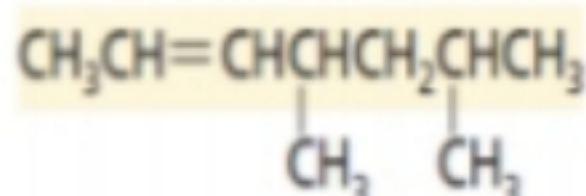
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Example:

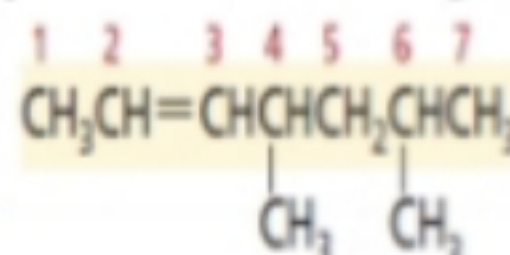
Naming branched- chain alkenes :

**Answer :**

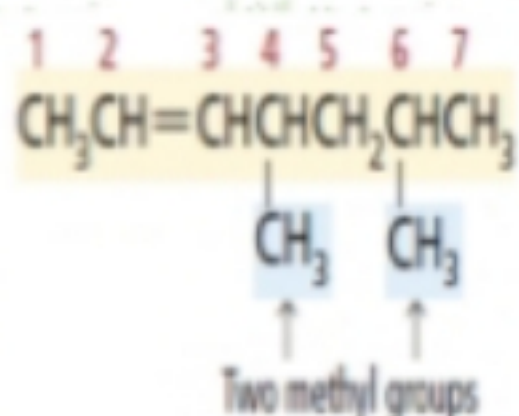
1

**Heptene parent chain**

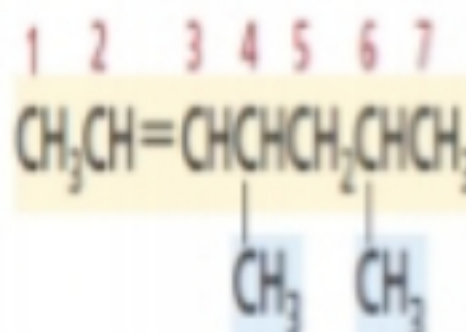
2

**2-heptene**

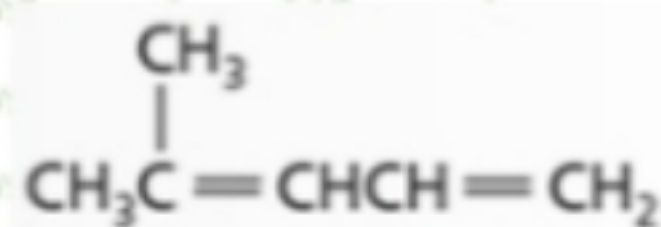
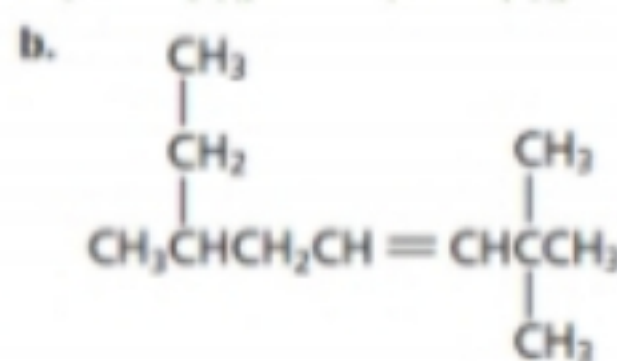
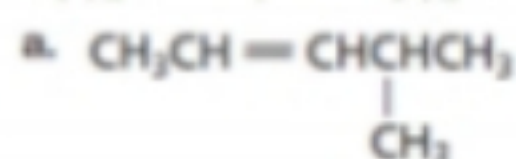
3



4

**4,6-di methyl 2-heptene****Applications**

1- Use the IUPAC rules to name the following structures :



2- Draw the structures of the following :

1,3-pentadiene

2,4-dimethyl-3-hexane

4-methyl – 1,3-pentadiene

2,3-dimethyl -2- butene

Properties of alkenes :

- ✓ Are nonpolar compounds like alkanes
- ✓ therefore have low solubility in water
- ✓ Have low melting and boiling points
- ✓ Are more reactive than alkanes because:

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- The second covalent bond increases the electron density between two carbon atoms
- Providing a good site for chemical reactivity
- Reactants that attract electrons can pull the electrons away from the double bond

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➤ Uses of alkenes :

- ✓ Several alkenes occur naturally in living organisms

Example : ethene C_2H_4

- ✓ Some of alkenes are responsible for the scents of lemons , limes and pine trees

✓ Uses of ethene :

- Is a hormone produced naturally by plants
- It causes fruit to ripen and plays a part in causing leaves to fall from deciduous trees in preparation for winter
- The fruits produce sold in grocery stores ripen artificially when they are exposed to ethene
- Is also the starting material for the synthesis of plastic polyethylene which is used to many products including plastic bags , rope , and milk jugs

Alkynes

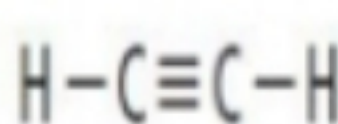
- ✓ Unsaturated hydrocarbons

- ✓ That contain one or more triple bonds between carbon atoms and form a homologous series

- ✓ General formula : C_nH_{2n-2}

- ✓ The simplest and commonly used alkyne is ethyne C_2H_2

✓ common name of ethyne is **acetylene**

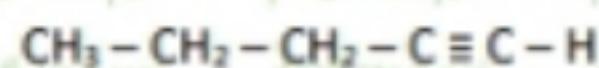


➤ naming of alkynes :

✓ straight – chain alkynes and branched –chain alkynes are named in the same way as alkenes

✓ the only difference is that the name of parent chain ends in –yne rather than –ene

Example: naming of the following :



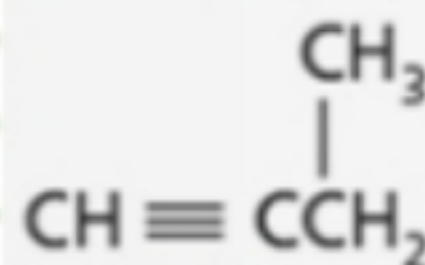
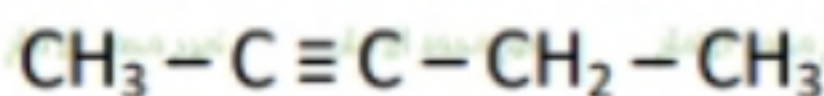
1-pentayne



3-methyl – 1- butyne

Applications

1- Use the IUPAC rules to name the following structures :



2- Draw the structures of the following :

1,4-di methyl-2- hexyne

3,4-dimethyl-1-heptyayne

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Name	Molecular Formula	Structural Formula	Condensed Structural Formula
Ethyne	C_2H_2	$\text{H} - \text{C} \equiv \text{C} - \text{H}$	$\text{CH} \equiv \text{CH}$
Propyne	C_3H_4	$\begin{array}{c} \text{H} \\ \\ \text{H} - \text{C} \equiv \text{C} - \text{C} - \text{H} \\ \\ \text{H} \end{array}$	$\text{CH} \equiv \text{CCH}_3$
1-Butyne	C_4H_6	$\begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H} - \text{C} \equiv \text{C} - \text{C} - \text{C} - \text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array}$	$\text{CH} \equiv \text{CCH}_2\text{CH}_3$
2-Butyne	C_4H_6	$\begin{array}{c} \text{H} \quad \quad \text{H} \\ \quad \quad \\ \text{H} - \text{C} - \text{C} \equiv \text{C} - \text{C} - \text{H} \\ \quad \quad \\ \text{H} \quad \quad \text{H} \end{array}$	$\text{CH}_3\text{C} \equiv \text{CCH}_3$

Properties of alkynes :

- ✓ Alkynes have physical and chemical properties similar to those of alkenes
- ✓ Alkynes undergo many of the reactions alkenes undergo
- ✓ Are nonpolar compounds
- ✓ Not soluble in water
- ✓ Are generally more reactive than alkenes (why?)
 - Because the triple bonds of alkynes have even greater electron density than the double bonds of alkenes
 - This cluster of electrons is effective at inducing dipoles in nearby molecules
 - Causing them to become unevenly charged and thus reactive .

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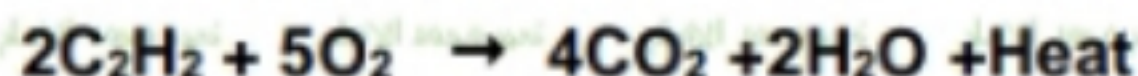
preparation of ethyne (acetylene):

- ✓ Is a by product of oil refining
- ✓ is also made in large quantities by the reaction of calcium carbide CaC_2 with water



Uses of ethyne (acetylene):

- ✓ is used as starting materials in the manufacture of **plastics** and other organic chemical used in industry.
- ✓ acetylene torches are commonly used in **welding**?(why?)
 - Because ethyne burns with an intensely hot flame that can reach temperatures as high as 3000°C
 - The triple bond makes alkynes reactive



اهدي هذا العمل المتواضع الي

أ.محمد ابو عبيد وأ. عادل الجبار موجهي الكيمياء سابقا

سائلا المولي عز وجل ان يبارك في اعمارهم ويرزقهم الخير الوفير

Section 4: Hydrocarbon Isomers

Main idea: some hydrocarbons have the same molecular formula but have different molecular structures

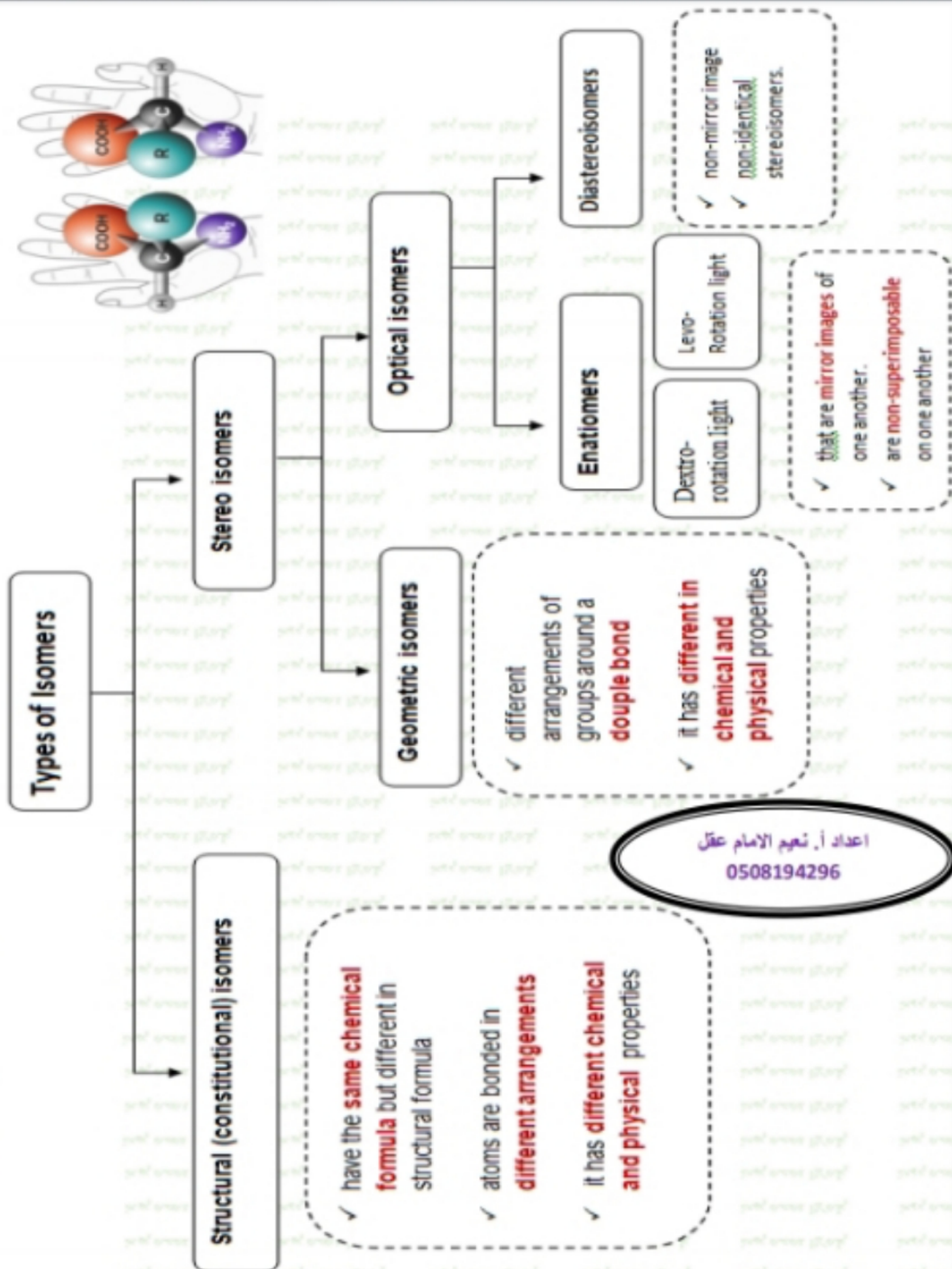
Real – world reading link : isomers like twins , identical twins have the same genetic makeup , yet they are two separate individuals with different personalities

Item	definition
Isomers	Are two or more compounds that have the same molecular formula but different molecular structures and its properties
Structural isomers	Are compounds have the same chemical formula , but their atoms are bonded in different arrangements so it has different chemical and physical properties
Stereoisomers	Are isomers in which all atoms are bonded in the same order but are arranged differently in space
Geometric isomers	Are compounds resulting from different arrangements of groups around a double bond so it has different in chemical and physical properties
Chirality	That property in which a molecule exist in a right-and left handed form
An asymmetric carbon	Is a carbon atom that has four different atoms or groups of atoms attached to it
Optical isomers	That result from different arrangements of four different groups around the same carbon atom , that have the same chemical and physical properties except in chemical reactions where chirality is important Example : mirror-image isomers
Optical rotation	An affect That produce when polarized light passes through a solution containing an optical isomer , the plane of polarization is rotated to the right (clock wise , when looking toward the light source) by a D-isomer or to the left (counter-clock wise) by an L-isomer

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➤ 1-Structural isomers :

- ✓ That have the same molecular formula
- ✓ but different structure formula
- ✓ That are bonded in different arrangement
- ✓ Have different chemical and physical properties

Notes

- The structure of a substance determines its properties
- As the number of carbons in a hydrocarbon increases , the number of possible structural isomers increases
- **Why pentane and cyclopentane are not isomers?**
Because they are not the same molecular formula cyclopentane's molecular formula C_5H_{10} and pentan C_5H_{12}

Example:

❖ CH_4 , C_2H_6 , C_3H_8 :

not have isomers because it has the only one structure

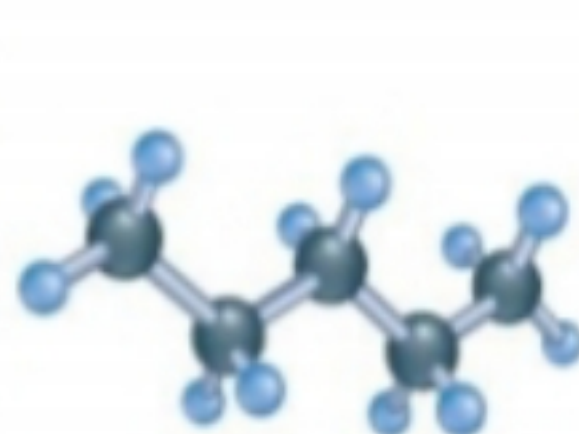
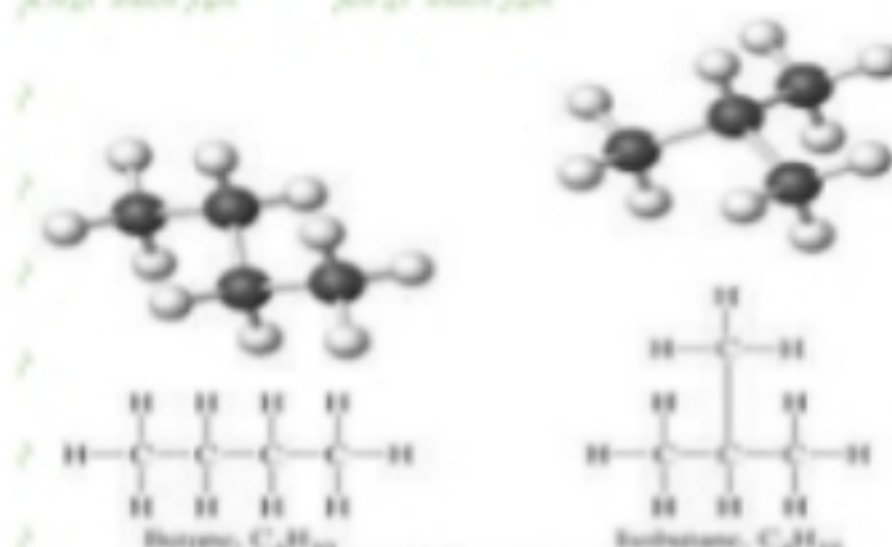
❖ C_4H_{10} :there are 2 isomers

❖ C_5H_{12} : 3 isomers

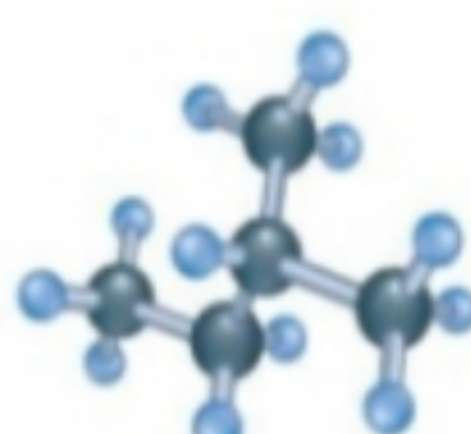
❖ C_6H_{14} :5 isomers

❖ C_7H_{16} :9 isomers

❖ $C_{20}H_{42}$:there are more than 300,000 structural isomers.



Pentane
bp = $36^{\circ}C$



2-Methylbutane
bp = $28^{\circ}C$



2,2-Dimethylpropane
bp = $9^{\circ}C$

➤ 2-The stereoisomers:

- ✓ Involves a more subtle difference in bonding
- ✓ All atoms are bonded in the same order but arranged differently in space

Types of stereoisomers

Geometric isomers

- ✓ Occurs in alkene and cyclo alkane
- ✓ Why geometric isomers not found in alkane ?
Because the single bond between carbons can rotate freely in relationship to each other , however , when a second covalent bond is present the carbons can no longer rotate they are locked in place
- ✓ Geometric isomers divide into :
 - ✚ Cis: two groups on the same side
 - ✚ Trans: two groups on opposite side
- ✓ Different in physical properties (such as melting point and boiling point)
- ✓ Differ in some chemical properties (if the compound is biologically active, such as a drug , the cis- and trans- isomers usually have very different effects)

✓ Example :

2-butene

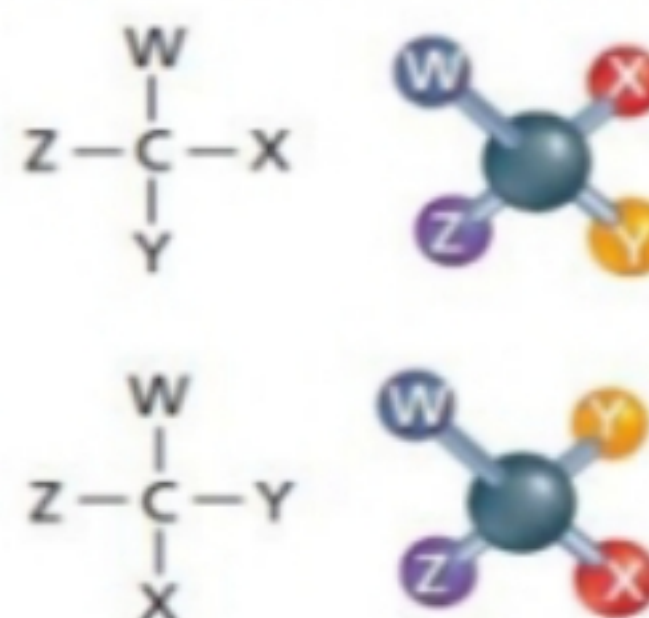
Isomers of 2-butene differ in the arrangement in space of the two Methyl groups at the ends .

The double-bonded carbon atoms cannot rotate with respect to each other , so the methyl groups are fixed in one of these two arrangements

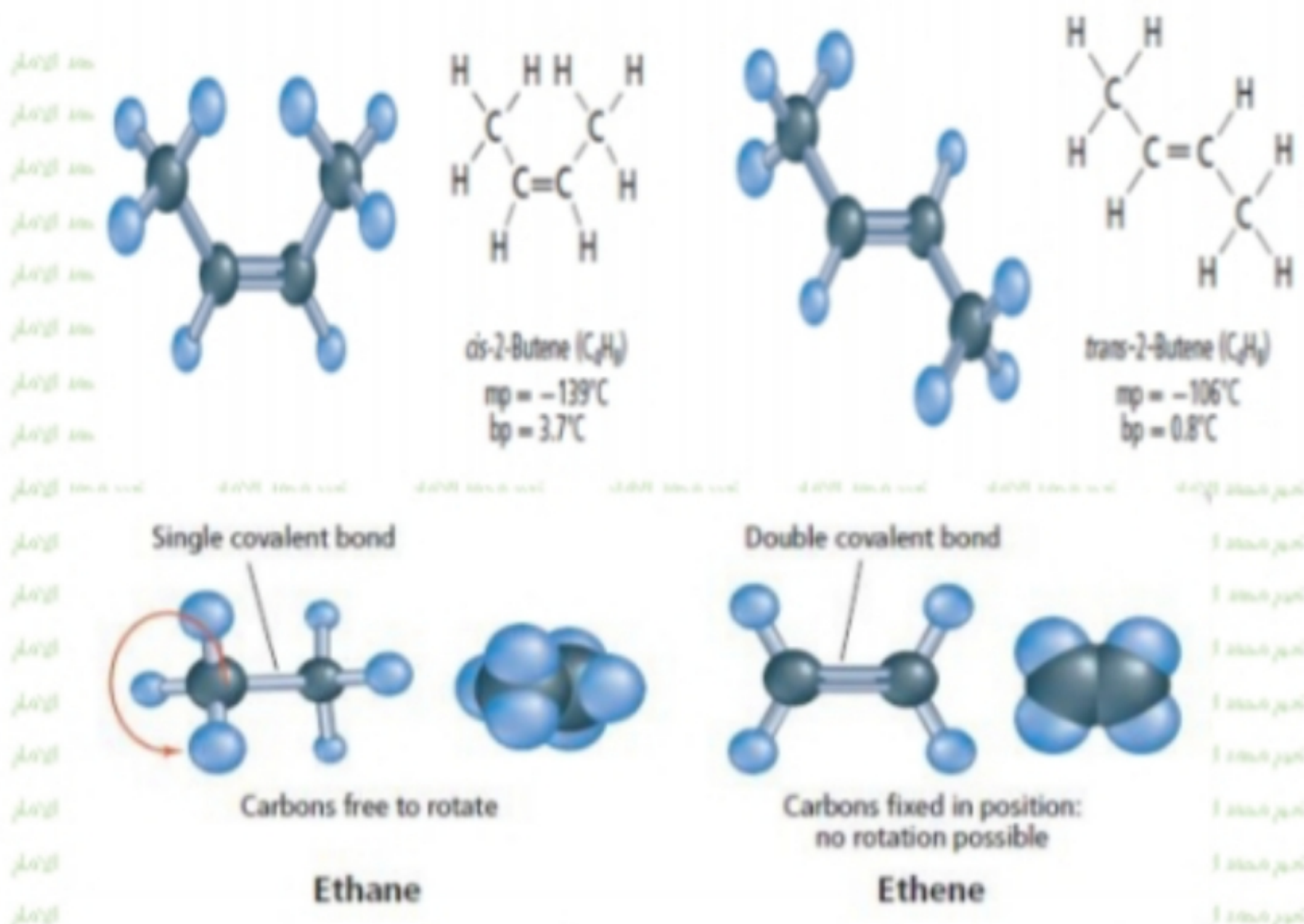
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Optical isomers

- ✓ Isomers that result from:
 - 1- different arrangements of 4 different groups X,Y,Z,W around the same carbon atom
 - 2- mirror image to each other and non-superimposable
 - ✓ Have the same physical and chemical properties except in chemical reactions where chirality is important
- #### Examples
- ✓ : enzyme-catalyzed reaction in biological systems .
 - ✓ Human cells , incorporate only L-amino acids into proteins
 - ✓ Only the L-form of ascorbic acid is active as vitamin C
 - ✓ The chirality of a drug molecule can also be important Only one isomer of some drugs molecule is effective and the other isomer can be harmful



These models represent two different molecules , groups X and Y have switched places



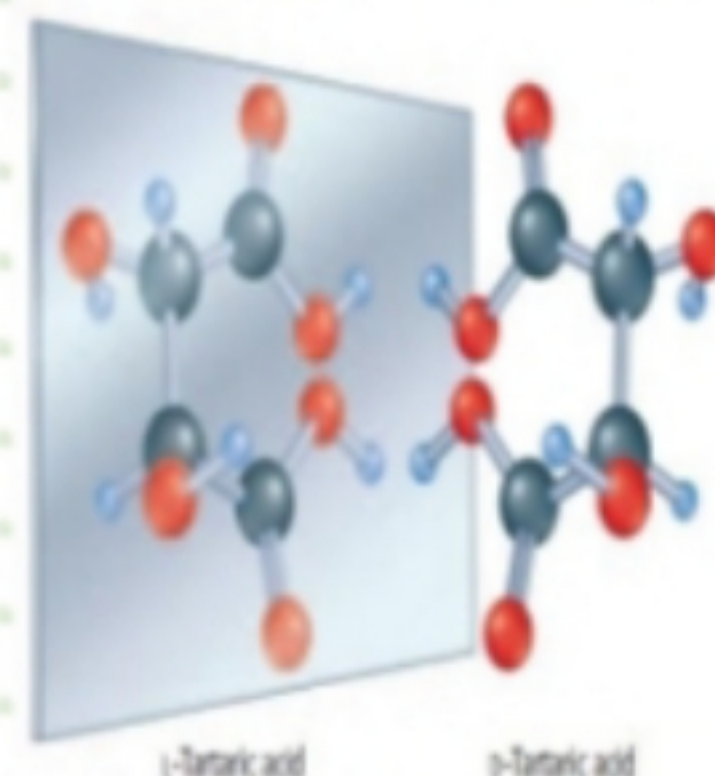
Chirality :

✓ Louis Pasteur (1822-1895) discovered that crystals of the organic compound tartaric acid, which is a by-product of fermentation of grape juice to make wine, existed in 2 shapes that were not the same but were mirror images of each other.



✓ Handed property :

- Person's hands are like mirror images
- The crystals were called the right-handed and left-handed forms (**chirality**)
- D-tartaric acid and L-tartaric acid resemble each other in the same way that your right hand and left hand resemble each other
- The reflection of your right hand looks the same as your left hand
- The two forms of tartaric acid had the same chemical properties, melting point, density and solubility in water
- Only the left-handed form was produced by fermentation



- Bacteria were able to multiply when they were fed the left-handed form as a nutrient, but they could not use the right –handed form
- Many of the substances found in living organisms such as the amino acids that make up proteins have this property.
- Many pre-packaged foods are made with trans fats because they have a longer shelf life .evidence suggests that trans fat increases the unhealthy form of cholesterol and decreases the healthy form, which increases the chance of heart disease

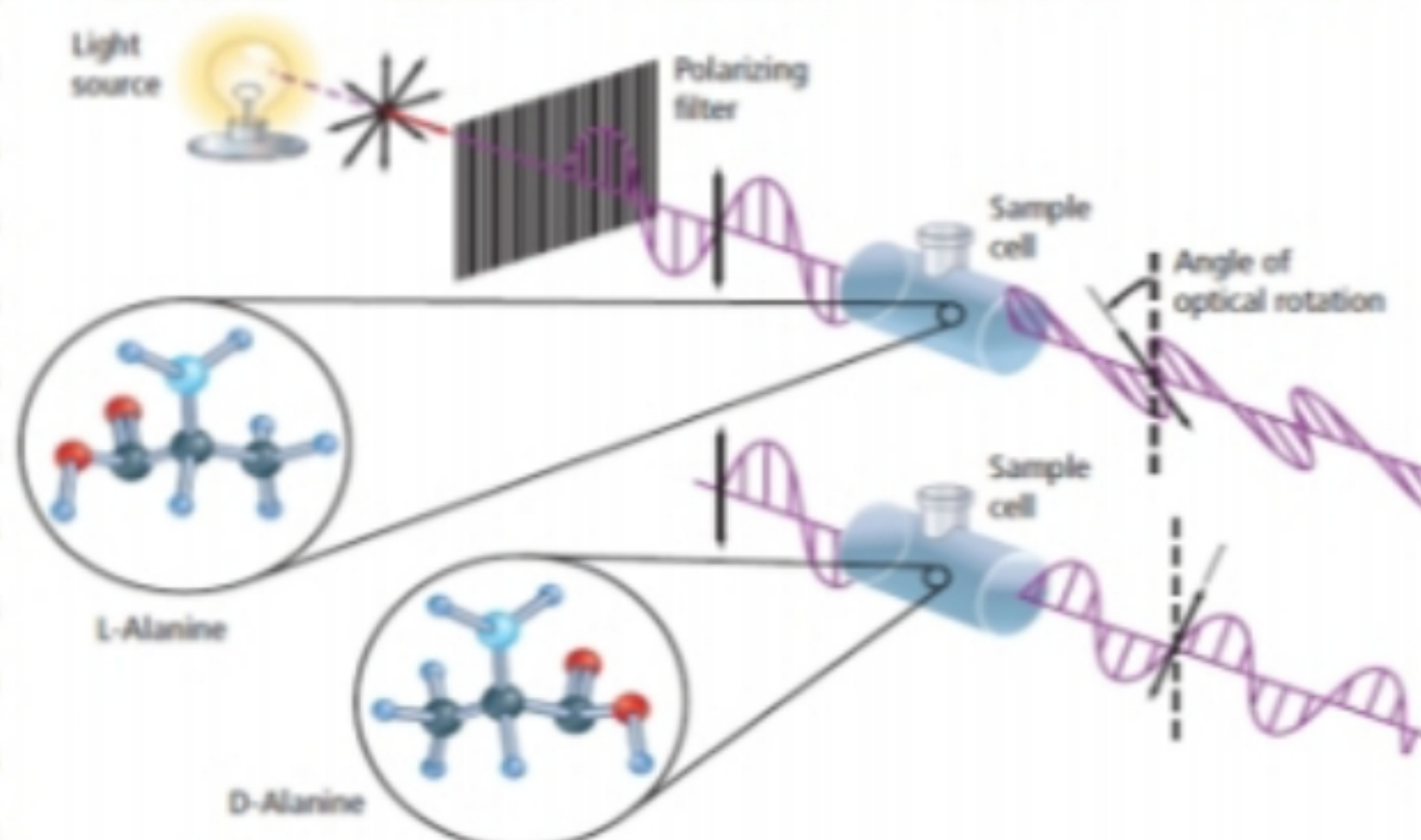
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➤ Optical rotation :

- ✓ Mirror –image isomers are called optical isomers (why?)
Because they affect light passing through them
- ✓ Normally the light waves in a beam from the sun or a light bulb move in all possible planes
- ✓ Light can be filtered or reflected in such a way that the resulting waves all lie in the same plane (this type of light called polarized light)
- ✓ When polarized light pass through a solution containing an optical isomer
- ✓ Optical rotation effect produce when The plane of polarization is rotated to the right (clockwise, when looking toward the light source) by a D-isomer or to the left(counter clockwise) by an L-isomer , producing .

✓ Example :

- L-menthol is natural isomer has a strong, minty flavor, and cooling odor and taste
- The mirror –image isomer,D-menthol ,does not have the same cooling effect as L-menthol



Section 5: aromatic hydrocarbons

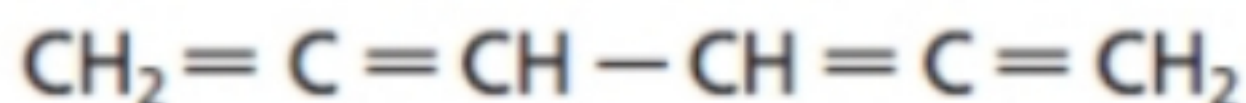
Main idea : aromatic hydrocarbons are unusually stable compounds with ring structures in which electrons are shared by many atoms

Real-world reading link : colorful and essential oils for perfums they both contain aromatic hydrocarbons.

item	Defination
Aromatic compounds	That organic compounds contain benzene rings as part of their structures Aromatic : found in pleasant – smelling oil that come from species , fruits and other plant parts
Aliphatic compounds	Hydrocarbons such as the alkanes , alkenes and alkynes Aliphatic comes from the greek word for fat which is aleiphatos (obtained it by heating animal fats)
Delocalized electrons	The electron pairs are shared among all six carbons in the benzene ring
carcinogens	Are substances that can cause cancer

➤ The structure of benzene :

- ✓ Certain hydrocarbons ring structures remained a mystery
- ✓ The simplest example of aromatic compounds is benzene
- ✓ Michael faraday first isolated benzene from the gases given off when heated
- ✓ Although chemists had determined that benzen's molecular formula was C_6H_6 , it was hard for them to determine what sort of hydrocarbhone structure would give such a formula
- ✓ Chemists reasoned that it must be unsaturated that is , it must have several double or triple bond or combination of both



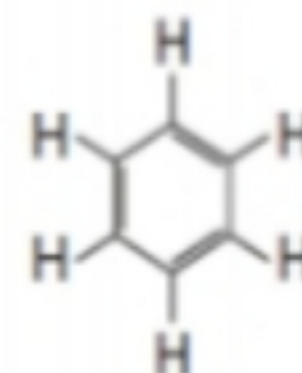
- ✓ chemists suggested structural for benzene but incorrect because of its many double bonds make the compound unstable and extremely reactive

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however benzene was fairly unreactive and it did not react in the ways that alkenes and alkyne usually react .

➤ **kekule`s dream :**

- ✓ Kekule` claimed that benzene`s structure came to him in a dream while he dozed in front of a fireplace in ghent , belguim
- ✓ He said that had dreamed of the ourooros (snake)devouring its own tail and that had made him think of ring –shapped structure.
- ✓ The flate , hexagonal structure kekule` proposed explained some of the properties of benzene but it did not explain benzene`s lack of reactivity



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➤ **A modern model of benzene :**

- ✓ Benzene`s unreactivity could not be explained until the 1930s
- ✓ Linus pauling proposed the theory of hybrid orbitals
- ✓ When applied to benzene , this theory predicts that the pair of electrons that form the second of each of benzene`s double bonds are not localized(delocalized) between only two specific carbon atoms as they are in alkenes
- ✓ Delocalization makes the benzene molecule chemically stable because electrons shared by six carbon nuclei are harder to pull away than electrons held by only two nuclei
- ✓ Three pairs of electrons form cloud represented by circle in the middle of hexagon .
- ✓ Are numbered in a way that gives the lowest-possible numbers for the substituents



➤ **Properties of benzene :**

- ✓ chemically stable
- ✓ Benzene is immiscible in water but soluble in organic solvent
- ✓ It is a colourless liquid and has an aromatic odour.
- ✓ Benzene shows resonance.
- ✓ It is highly inflammable and burns with a sooty flame.

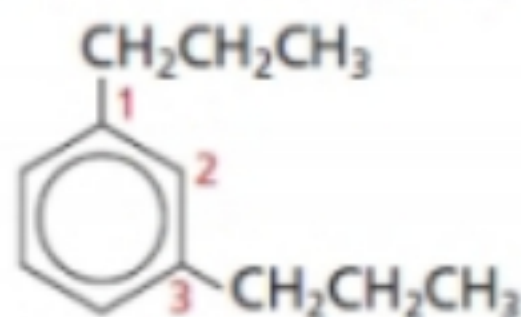
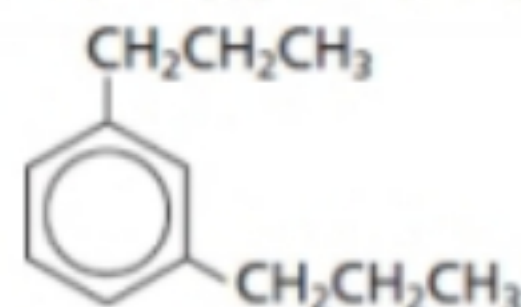
➤ Naming substituted aromatic compounds

✓ Are named in the same way as cyclic alkanes

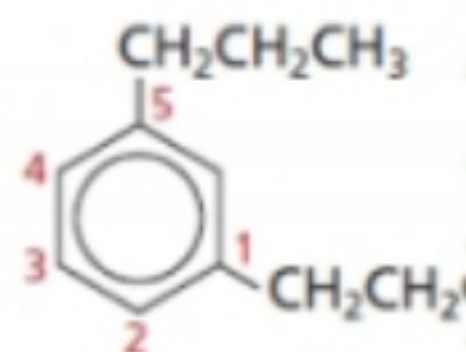
Examples :

Name the aromatic compound shown :

Answer :



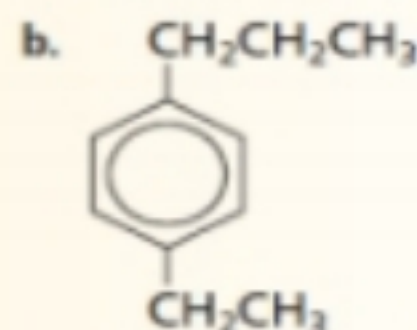
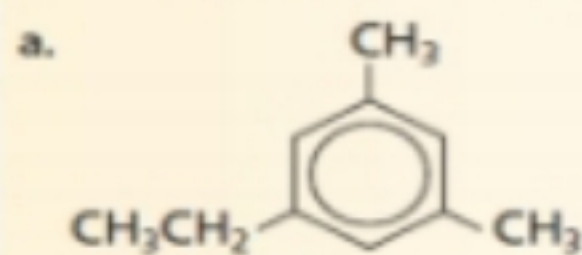
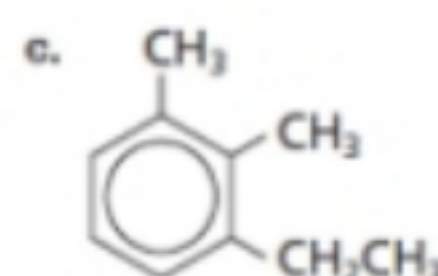
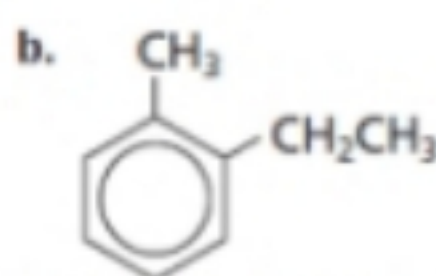
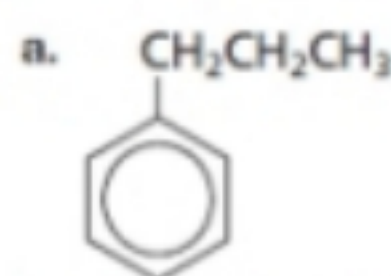
1,3-di methyl benzene



(X) wrong

Applications

1- naming the following structures :



2- Draw the structures of the following :

1,4-di methyl benzene

2-ethyl -1,4- di methyl benzene

Iso propyl benzyl benzene

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➤ Carcinogens :

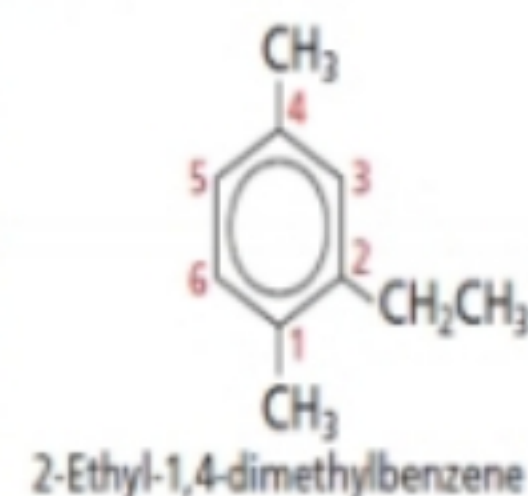
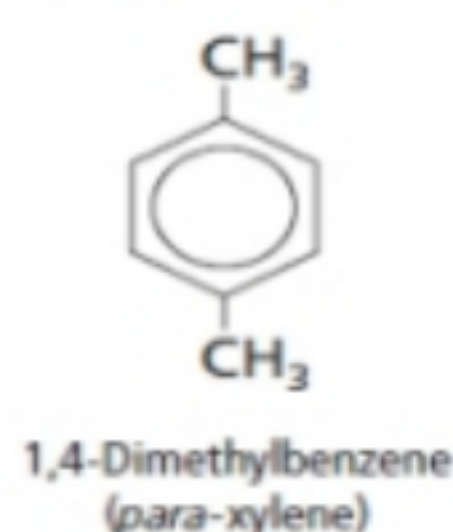
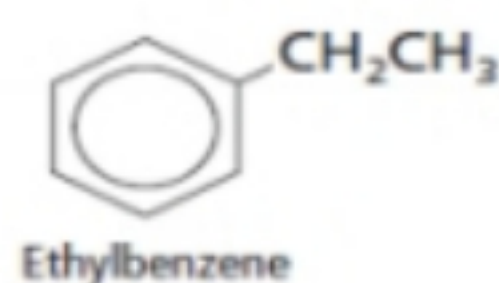
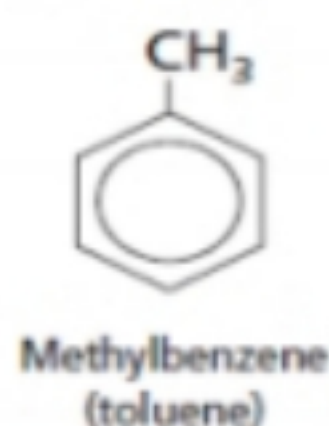
- ✓ The use Aromatic compounds should be limited because they can affect
- ✓ The first known **carcinogen** was an aromatic substance discovered a round the turn of the twentieth century in **chimney soot** because chimney sweeps in great Britain were known to have abnormally high rates of cancer
- ✓ Scientists discovered that the cause of the cancer was the aromatic compound **benzopyrene**
- ✓ Benzopyrene product by burning of complex mixtures of organic substances such as wood and coal
- ✓ Some aromatic compounds found in gasoline are also known to be carcinogenic


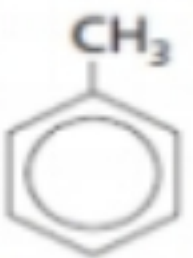
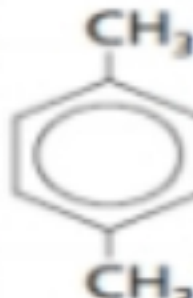
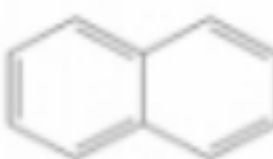


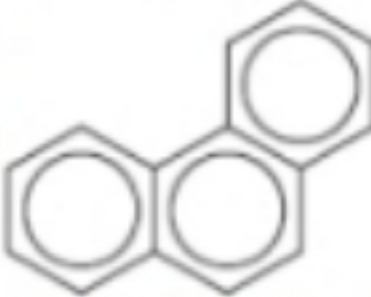


Risks of aromatic compounds :

- Respiratory ailments
- Liver problems
- Damage to the nervous system
- Cause cancer

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➤ examples of substituted aromatic compounds



Structures of some aromatic compounds		
Compound	Structural formula	Uses
Benzene		<ul style="list-style-type: none"> Industrial and laboratory solvent
Toluene (methyl benzene)		<ul style="list-style-type: none"> Industrial and laboratory solvent
Para-xylene (1,4-Dimethylbenzene)		<ul style="list-style-type: none"> Make polyester fibers Make fabrics Industrial and laboratory solvent
naphthalene		<ul style="list-style-type: none"> Make dyes As a moth repellent 
Anthracene		<ul style="list-style-type: none"> Produce dyes Produce pigments
phenanthrene		<ul style="list-style-type: none"> Is present in the atmosphere due to the incomplete combustion of hydrocarbons 
benzopyrene		<ul style="list-style-type: none"> Is a cancer causing chemical that is found in soot, cigarette smoke and car exhaust