Organic Chemistry

1st stage students

2nd COURSE

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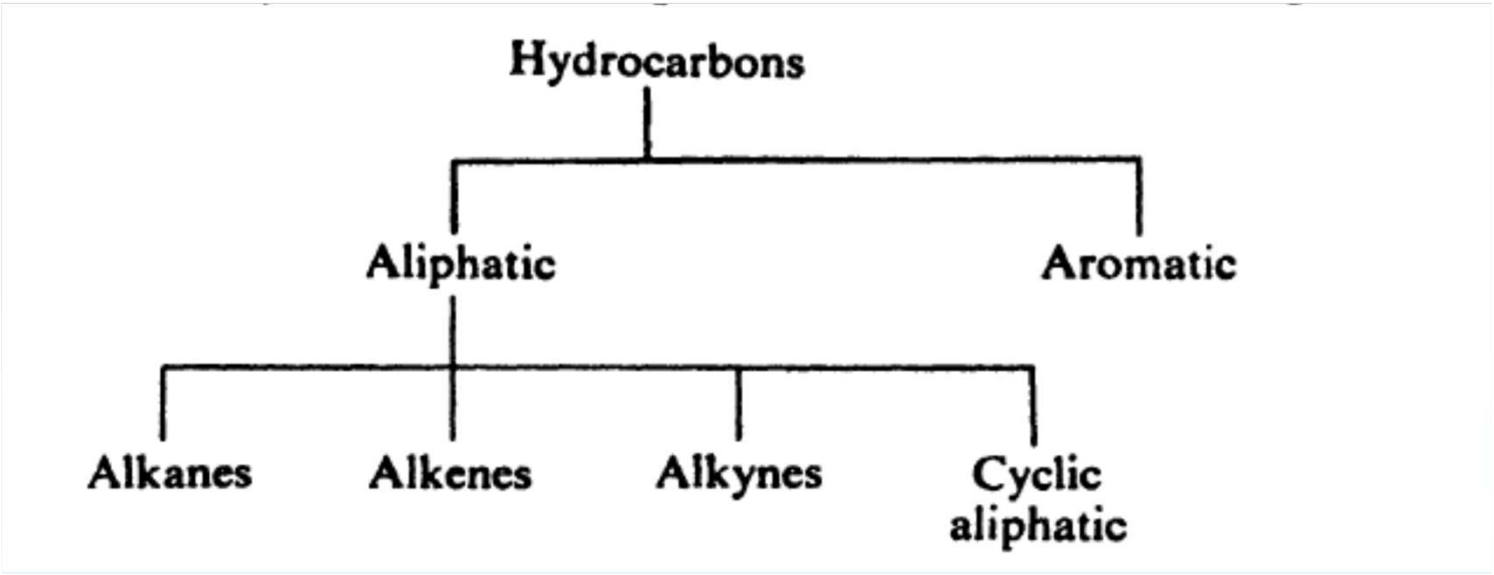
Hydrocarbons

- On the basis of structure, hydrocarbons are divided into two main classes, aliphatic and aromatic.

- Certain organic compounds contain only two elements, hydrogen and carbon, and hence are known as hydrocarbons.
- Aliphatic hydrocarbons are further divided into families: alkanes, alkenes, alkynes, and their cyclic analogs (cycloalkanes, etc.).

Aliphatic and aromatic compounds



Alkanes

Aliphatic and aromatic compound (contain other elements in addition to C, H like O, N) this compounds called hydrocarbon derivatives such as alcohol, ether, amines, ….).

An **organic compound**

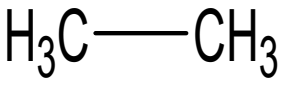
- is a compound made from carbon atoms
- has one or more C atoms
- has many H atoms
- may also contain O, S, N, and halogens
- usually has carbon written first

Typical organic compounds

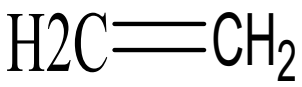
- have covalent bonds
- have low melting points
- have low boiling points
- are flammable
- are soluble in nonpolar solvents
- are not soluble in water

Vegetable oil is an organic compound and not soluble in water.

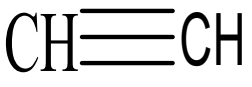
The chemical and physical properties of the hydrocarbons are result from the composition of that the way the atoms are joined together by covalent bonds (single, double or triple bonds) and the three dimensional shape of the molecules.



alkane



alkene



alkyne

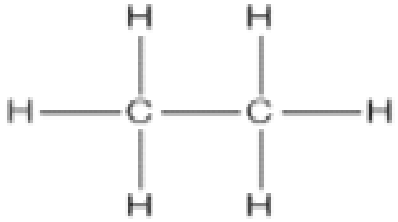
Structure of alkane

- The simplest member of the alkane family and, indeed, one of the simplest of all organic compounds is methane, CH_4, n=1. When n=2, C_2H_6 is ethane.

CnH2n +2 n= number of Carbon atom,
n=1,2,3

1-Molcular formula (MF) CH_4, C_2H_6, C_3H_8, …

2-Structure formula



$CH_3 - CH_3$

3-Bond-line formula

propane

3-methyl pentane

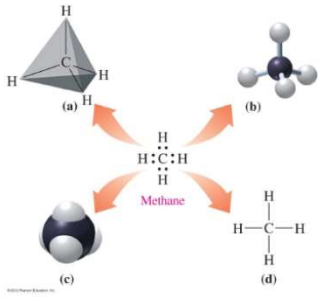
Alkanes

- Alkanes are organic compound with only C-C and C-H single (σ) bonds.
- General formula for alkanes $C_nH_{2n}+2$, saturated hydrocarbons.
- Isomer: compounds with the same chemical formula but different arrangement of atoms.

Tetrahedral Structure of Carbon CH_4

VSEPR theory predicts that a carbon atom with four single, covalent bonds has a tetrahedral shape.

Methane is represented using different models: (a) tetrahedron, (b) ball-and-stick model, (c) space-filling model, (d) expanded structural formula.



Physical properties (mp., bp.,solubility)

Physical properties (mp., bp.,solubility)

1-Alkanes C_1-C_2 low molecular weight (M.Wt.) gas.

2- Alkanes C_5-C_{18} (Medium M.Wt.) liquids.

3- Alkanes (higher M.wt.) like solid.

- When M.wt increase melting point (MP.) increase.
- Alkanes non polar compounds dissolve in non-polar solvent (liquid).
- Branched isomer have a lower mp. than straight isomer.

Ex**. n-butane bp. (boiling point) 0^{o}C.**

Isobutene bp. -12^{o}C .

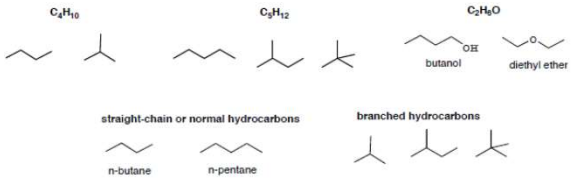
Alkanes show: regular increase in bp and mp as the molecular weight increase. Branching lowers the bp or alkanes

n-pentane bp= 36.1 °C

iso-pentane bp= 27.9 °C

neo-pentane bp= 9.5°C

- That branching should lower the boiling point is reasonable: with branching the shape of the molecule tends to approach that of a sphere; and as this happens the surface area decreases, with the result that the intermolecular forces become weaker and are overcome at a lower temperature.


C_4H_{10}
C_5H_{12}
C_2H_6O
OH
butanol
O
diethyl ether
straight-chain or normal hydrocarbons
n-butane
n-pentane
branched hydrocarbons

Systematic Nomenclature (IUPAC system)

- **IUPAC** International union of pure and applied chemistry

Naming Alkanes

General Formula: $C_nH_{(2n+2)}$

suffix: -ane

Parent Names:

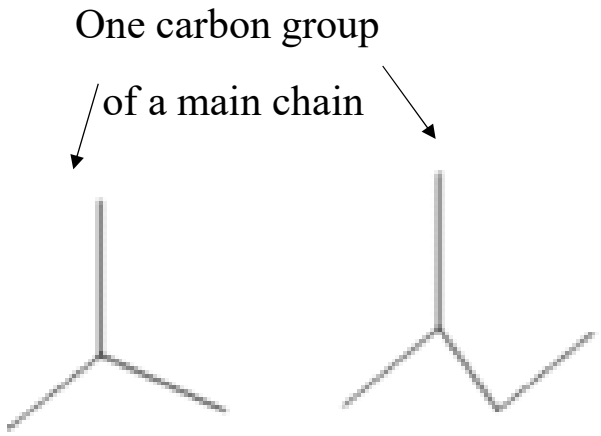
1	CH_4	**Meth**ane	CH_4
2	CH_3CH_3	**Eth**ane	C_2H_6
3	$CH_3CH_2CH_3$	**Prop**ane	C_3H_8
4	$CH_3(CH_2)_2CH_3$	**But**ane	C_4H_{10}
5	$CH_3(CH_2)_3CH_3$	**Pent**ane	C_5H_{12}
6	$CH_3(CH_2)_4CH_3$	**Hex**ane	C_6H_{14}
7	$CH_3(CH_2)_5CH_3$	**Hept**ane	C_7H_{16}
8	$CH_3(CH_2)_6CH_3$	**Oct**ane	C_8H_{18}
9	$CH_3(CH_2)_7CH_3$	**Non**ane	C_9H_{20}
10	$CH_3(CH_2)_8CH_3$	**Dec**ane	$C_{10}H_{22}$

Common Name

- **Prefix –substitution**
- **Parent-number of carbons**
- **Suffix-functional groups**
- Prefix n (normal) straight alkane
- Iso (one branched on the alkane)
- Neo (two branched on the alkane)

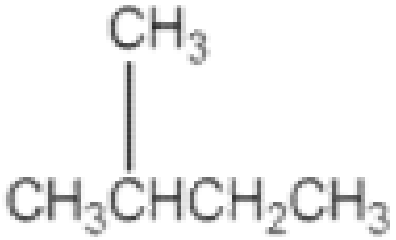
Alkyl substituents (group):

- **carbon chains which are a substructure of a molecule**
-

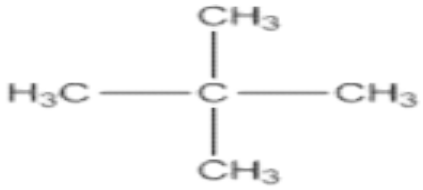


Isomer of alkane

- $CH_3CH_2CH_2CH_2CH_3$ n-pentane

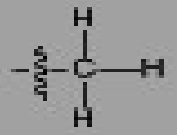
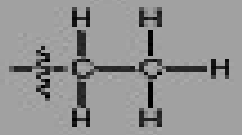
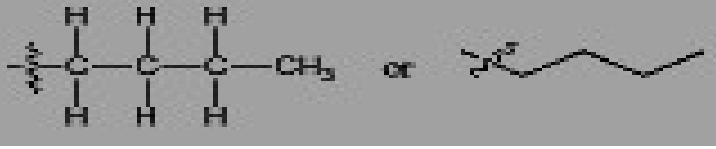


Isopentane



neopentane

Naming Branches as Groups

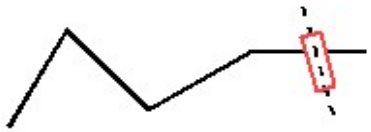
Group Formula	Prefix	Suffix	Name	Abbreviation	Structure
$-CH_3$	meth-	-yl	methyl	–Me	
$-C_2H_5$	eth-	-yl	ethyl	–Et	
$-C_3H_7$	prop-	-yl	propyl	–Pr	
$-C_3H_7$	iso-prop-	-yl	iso-propyl	–Pr	
$-C_4H_9$	but-	-yl	butyl	–Bu	

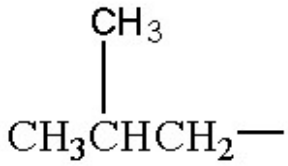
$CH_3CH_2CH_2CH_3$

butane

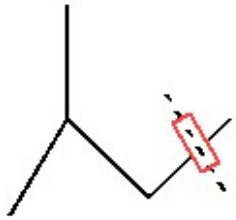
$CH_3CH_2CH_2CH_2$—

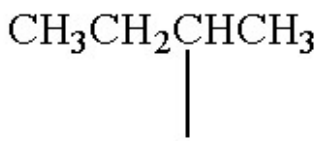
n-butyl



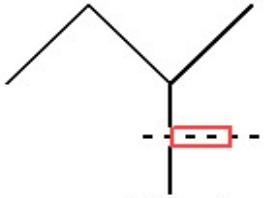


Isobutyl



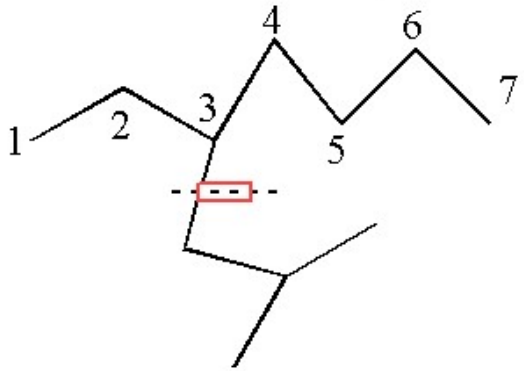


Secondary butyl

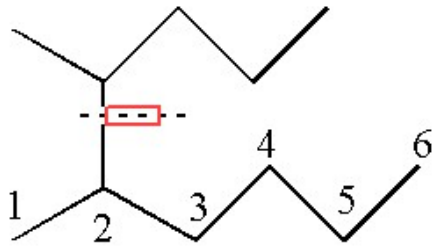


Sec-butyl

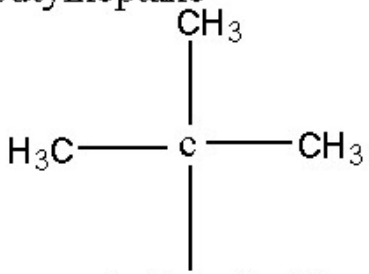
Examples:



3-isobutylheptane

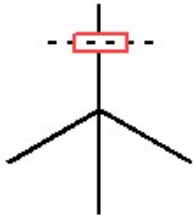


2-Sec-pentyl hexane



tertiary butyl

tert-butyl



$CH_3CH_2CH_2CH_2CH_3$

n-Pentane

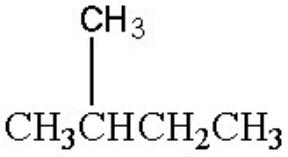
$CH_3CH_2CH_2CH_2CH_2-$

n-pentyl

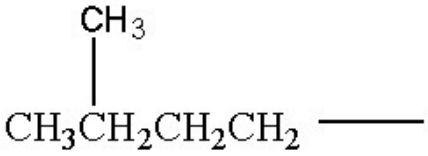
$CH_3CHCH_2CH_2CH_3$

sec-pentyl

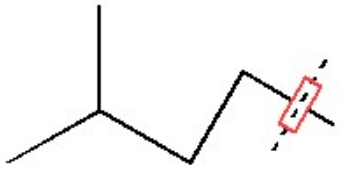
sec-is used when the bonding carbon atom of substituent group is a secondary carbon



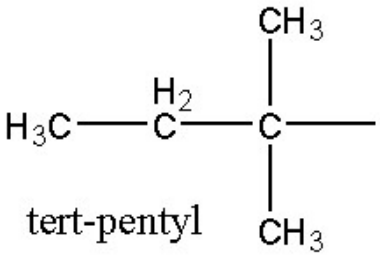
Isopentane



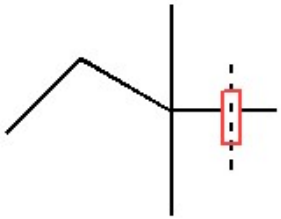
isopentyl



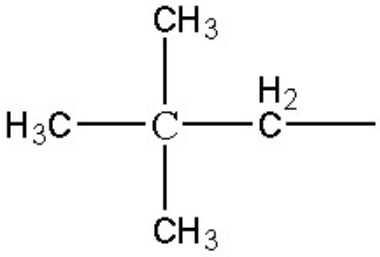
iso- is used when a methyl group is attached to second last carbon.



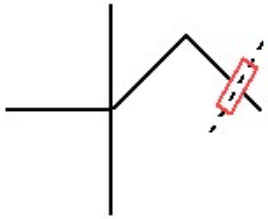
tert-pentyl



tert- is used when the bonding carbon atom of substituent group is a tertiary carbon.

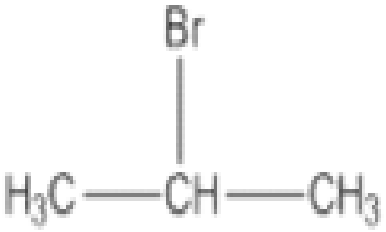


Neo-pentyl



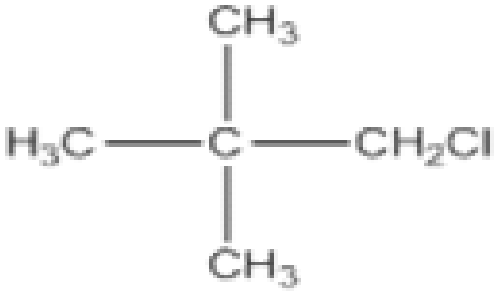
Neo-is used when in the end of the substituents we have a tert-butyl group.

Alkyl halide



iso propyl bromide
(2-bromo propane)

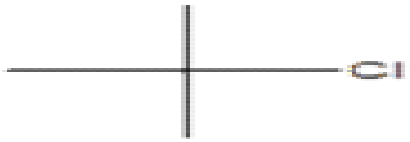
CH3 $(CH_2)_5I$
n-hexyl Iodide
(1-iodo hexane)



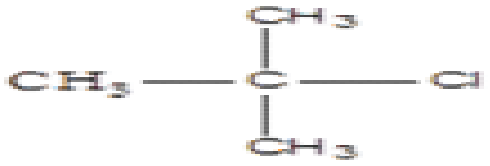
Neo pentyl chloride
(1-chloro-2,2-dimethylpropane)

isobutylchloride
1-Chloro-2-methyl-propane

sec-butylchloride
2-Chloro-butane



tert--butyl chloride
2-Chloro-2-methyl-propane



Rule for systematic Nomenclature of Alkanes

1- Fined the parent chain

a-identify the longest continous carbon chain as the parent chain.

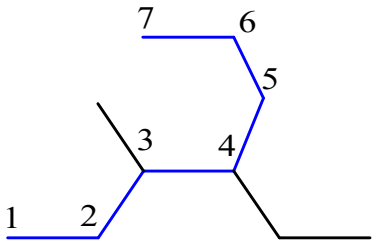
CH_3-CH-CH_3 (2-methyl propane)

| (Isobutane)

CH_3

CH_3-CH_2-CH-CH_3 2-methyl butane

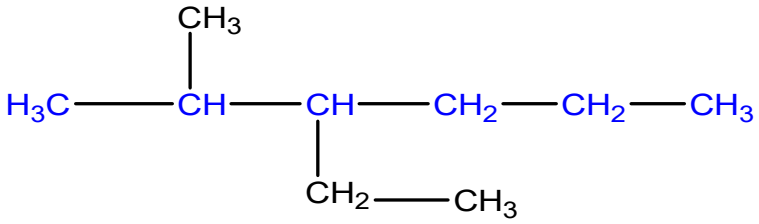
CH_3



4-ethyl-3-methyl heptane

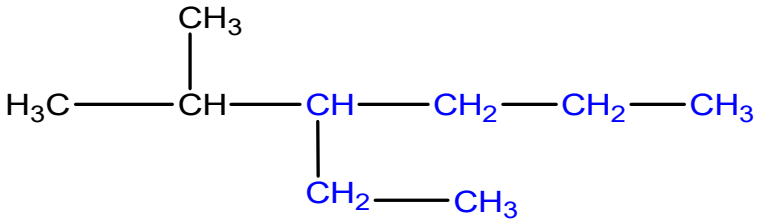
Rule for systematic Nomenclature of Alkanes

- b-If more than one different chains are of equal length (number of carbons).choose the one with the greater number of branch points (substituents) as the parent.



3-Ethyl-2-methyl-hexane

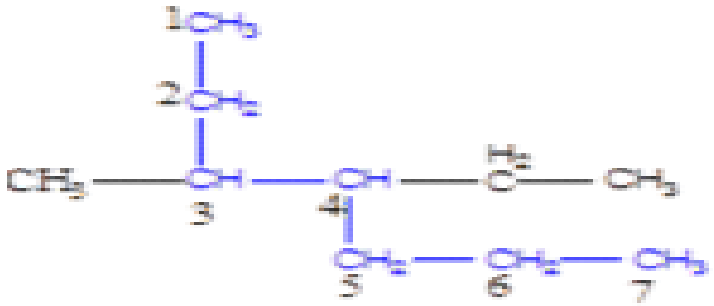
2-branch



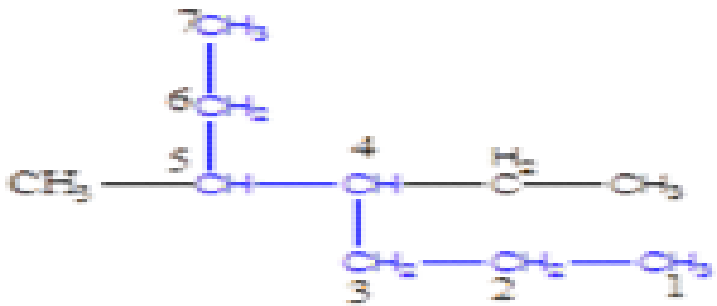
1-branch

2. Numbering the carbons of the parent chain

a. Number the carbon atoms of the parent chain so that any branch points have the lowest possible number.

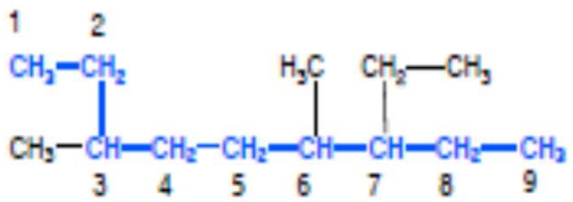


branch points at C3 &C4

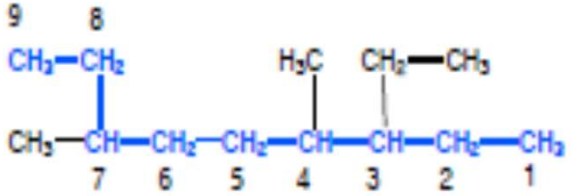


branch points at C4 &C5

- b. If there is branching equidistant from both ends of the parent chain, number so the second branch point has the lowest number. Use commas to separate two numbers (Ex:2,2) and use hyphens to separate numbers from words.(Ex:2-methyl)



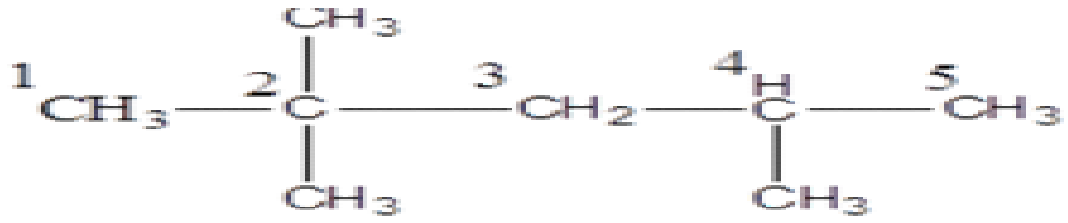
branch pts. at carbons 3, 6, 7



branch pts. at carbons 3,4,7

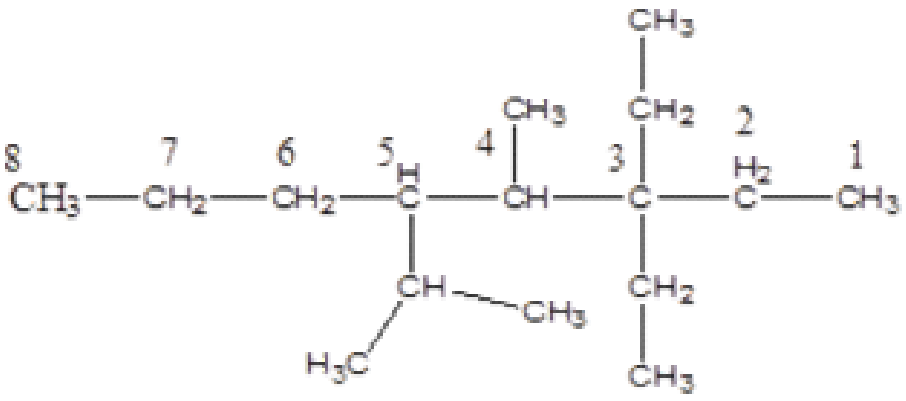
3-ethyl-4,7-dimethyl nonane

- **c**. If the same alkyl group occurs more than once as side chain indicate this by the prefix (di, tri, tetra, etc.…)



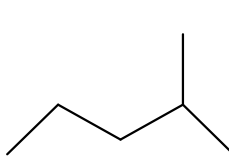
2,2,4-trimethyl pentane

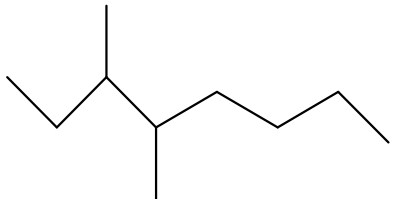
- d- If there are several different alkyl group attached to the parent chain. Name them in order of increase size.

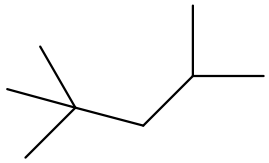


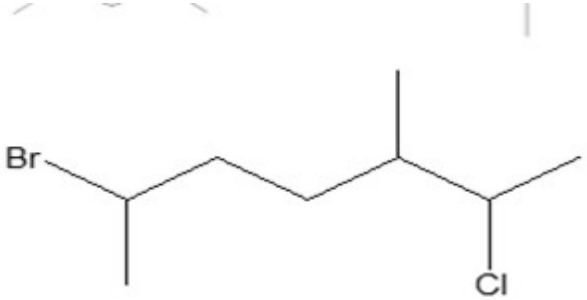
4-methyl-3,3-dimethyl-5-isopropyl octane

- H.W : what is the name of the following alkanes







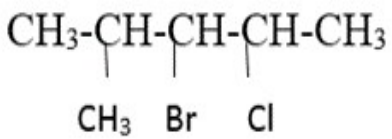


- e-If there another group on the parent chain (not alkyl group) it will arranged by alphabetical order.

NH_2 ⟶ amino CN ⟶ cyno NO_3 ⟶ nitro

F ⟶ flouro Cl ⟶ chloro

I ⟶ iodo Br ⟶ bromo OH ⟶ hydroxyl



3-bromo-4-chloro-2-methyl pentane

- (CH3) Methyl group: 1° hydrogens — primary hydrogens
- (CH2) methylene group: 2° hydrogens — secondary hydrogens
- (CH) methine group: 3° hydrogens — tertiary hydrogens

A primary (1°) hydrogen is a hydrogen atom residing on a primary carbon in an organic species.