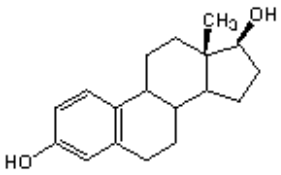
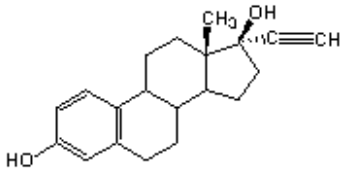
ORGANIC CHEMISTRY

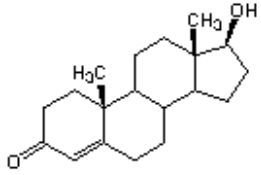
ORGANIC CHEMISTRY

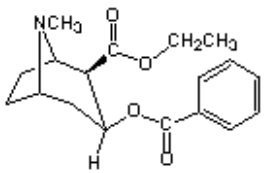
-Organic molecules contain only C, H, O, N and sometimes S and P

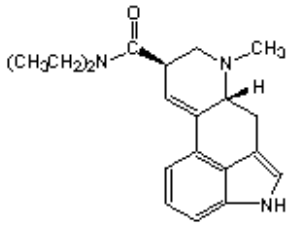
-56 204 570 organic substances have been recorded

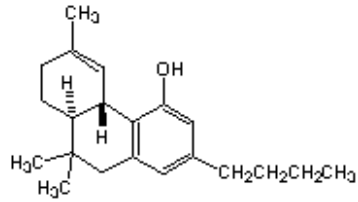

Estradiol

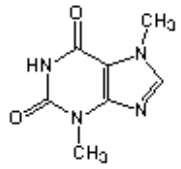

Mestranol (Norlutin)

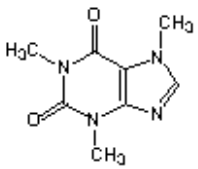

Testosterone

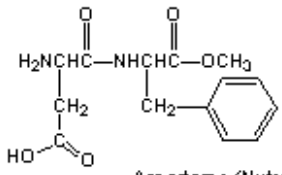

Cocaine

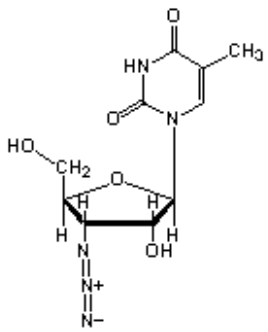

Lysergic acid diethylamide (LSD)

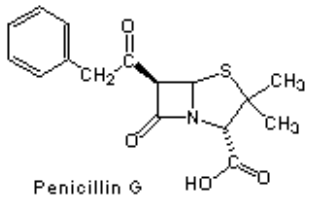

Tetrahydrocannabinol

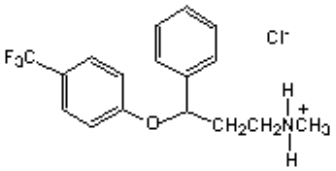

Theobromine

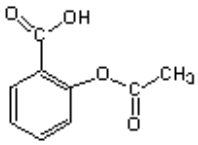

Caffeine

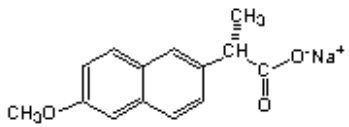

Aspartame (Nutrasweet)


Azidothymidine (AZT)


Penicillin G


Fluoxetine hydrochloride (Prozac)


Acetylsalicylic acid (aspirin)

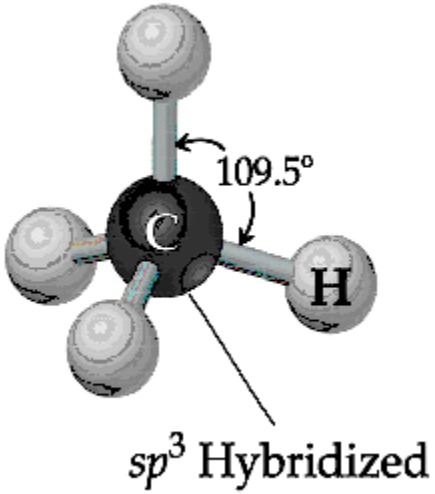

Naproxen sodium (Aleve)

ORGANIC CHEMISTRY

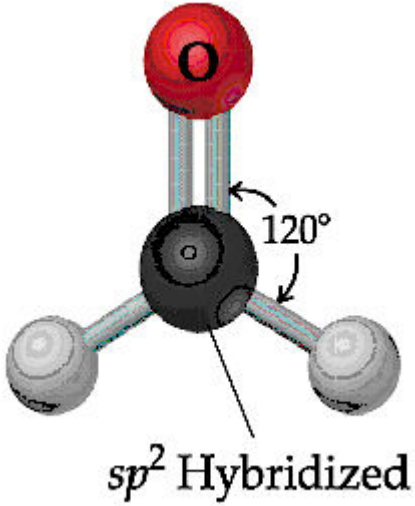
What allows for the diversity of organic compounds?

-Carbon can make 4 bonds

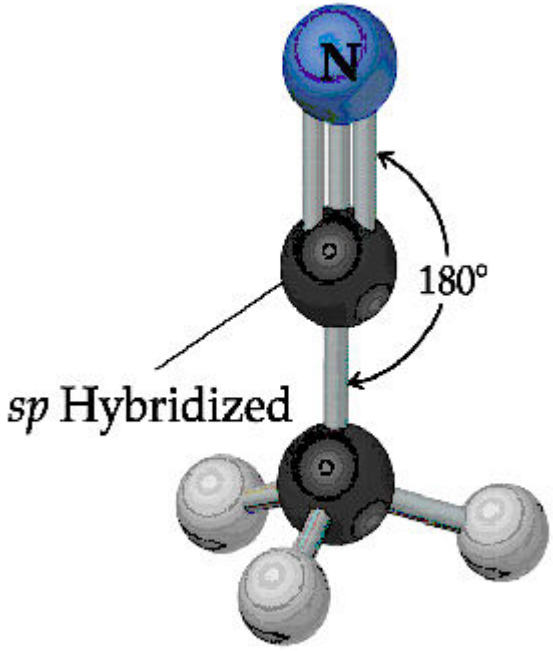
-The 4 bonds can be a combination of single, double, and triple bonds



methane, CH_4



methanal, CH_2O



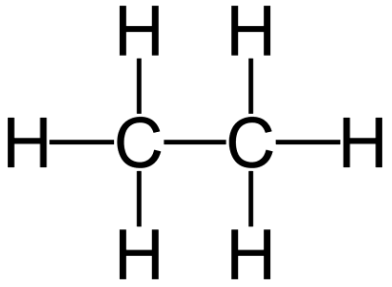
ethanenitrile, CH_3CN

ORGANIC CHEMISTRY

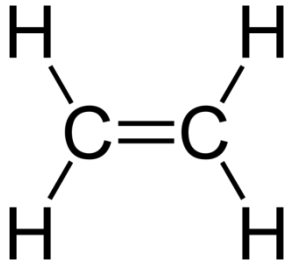
Hydrocarbons:

When an organic molecule is composed only of hydrogen and carbon, it is called a hydrocarbon:

Alkanes: Hydrocarbons with single bonds



Alkenes: Hydrocarbons with double bond(s)



Alkynes: Hydrocarbons with triple bond(s)

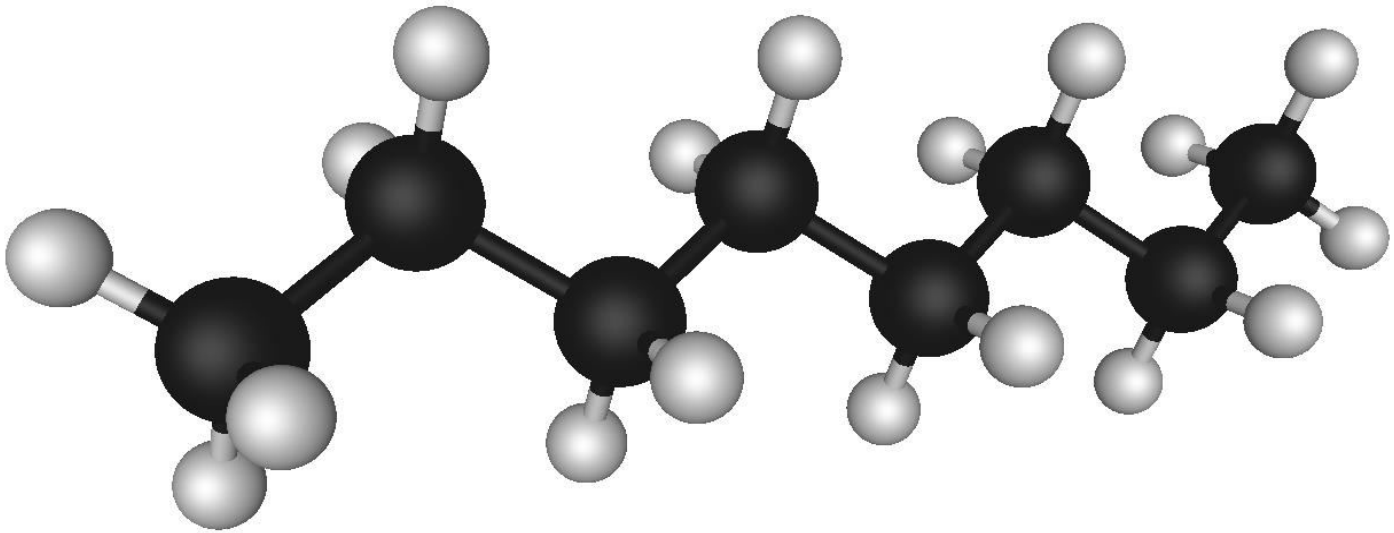
ALKANES

ALKANES

-Characterized by C-C single bonds

-Also known as *saturated hydrocarbons*

-empirical formula = C_nH_{2n+2}



→ C_nH_{2n+2}, n=8

= C_8H_{18}

ALKANES

Properties:

-Hydrophobic (does not mix with water and other polar substances)

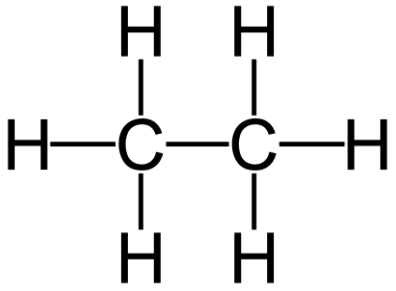
-Generally low boiling points (due to weak London Dispersion Forces)

- Longer alkane molecules have higher boiling points

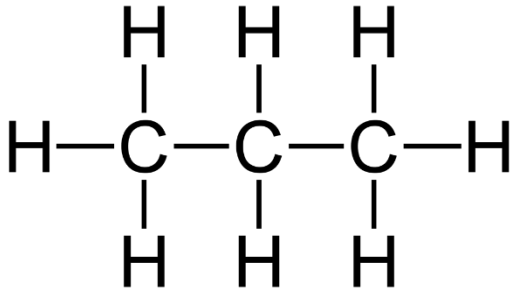
		B.Pt.(C)
methane	$CH_{4(g)}$	-164
ethane	$C_2H_{6(g)}$	-88
propane	$C_3H_{8(g)}$	-42
butane	$C_4H_{10(g)}$	0
pentane	$C_5H_{12(l)}$	+36
hexane	$C_6H_{14(l)}$	+68
heptane	$C_7H_{16(l)}$	+98
octane	$C_8H_{18(l)}$	+126

ALKANES

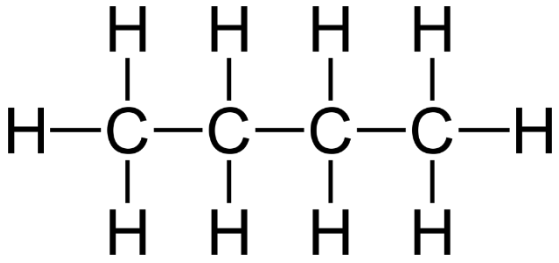
Some IUPAC* names of alkanes:



ethane



propane



butane

All alkanes have the suffix "ane"

*International Union of Pure and Applied Chemistry

ALKANES

IUPAC naming system:

Each alkane also has a prefix based on the number of carbon atoms:

meth = 1
eth = 2
prop = 3
but = 4
pent = 5
hex = 6
hept = 7
oct = 8
non = 9
dec = 10
undec = 11
dodec = 12

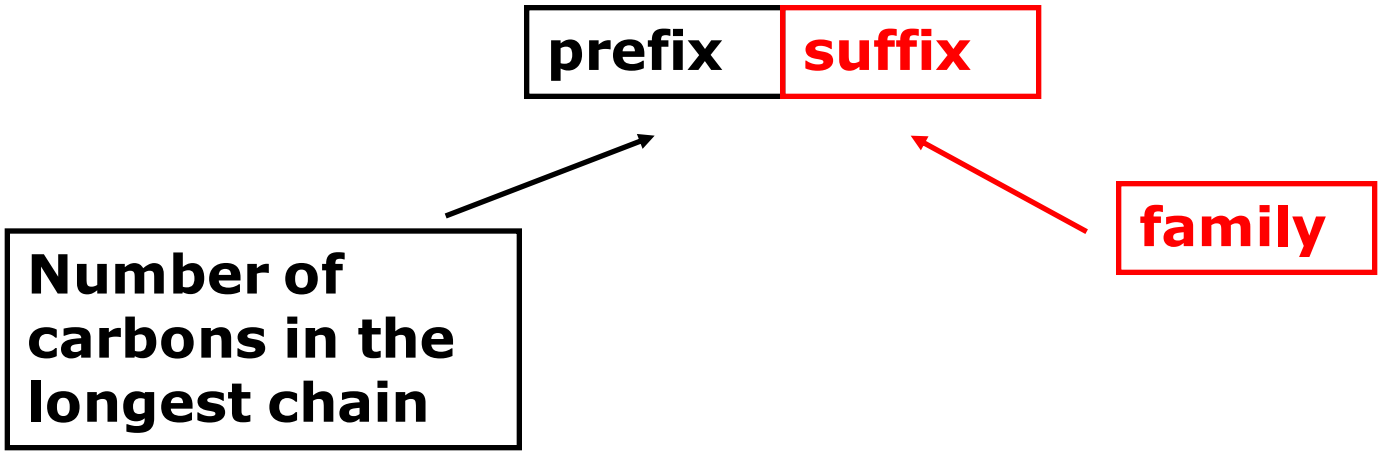
ALKANES

IUPAC naming system:

Molecular formula	Condensed Structural Formula	Name
CH_4	CH_4	**methane**
C_2H_6	CH_3CH_3	**ethane**
C_3H_8	$CH_3CH_2CH_3$	**propane**
C_4H_{10}	$CH_3CH_2CH_2CH_3$	**butane**
C_5H_{12}	$CH_3CH_2CH_2CH_2CH_3$	**pentane**
C_6H_{14}	$CH_3CH_2CH_2CH_2CH_2CH_3$	**hexane**
C_7H_{16}	$CH_3CH_2CH_2CH_2CH_2CH_2CH_3$	**heptane**
C_8H_{18}	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	**octane**
C_9H_{20}	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	**nonane**
$C_{10}H_{22}$	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$	**decane**

ALKANES

IUPAC naming system:

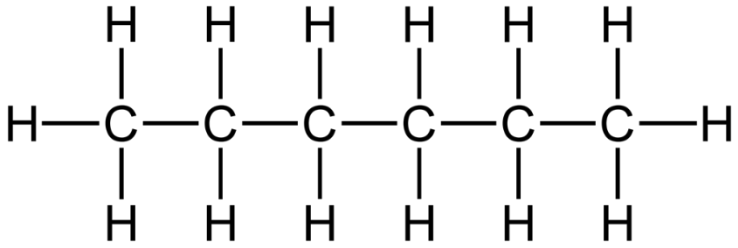


Ex: **meth**ane

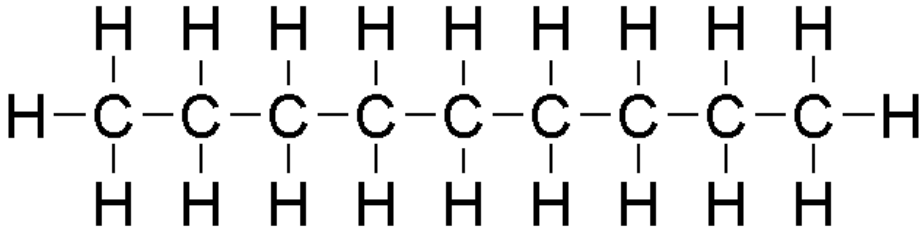
ALKANES

IUPAC naming system:

Name the following alkanes:



hexane



nonane

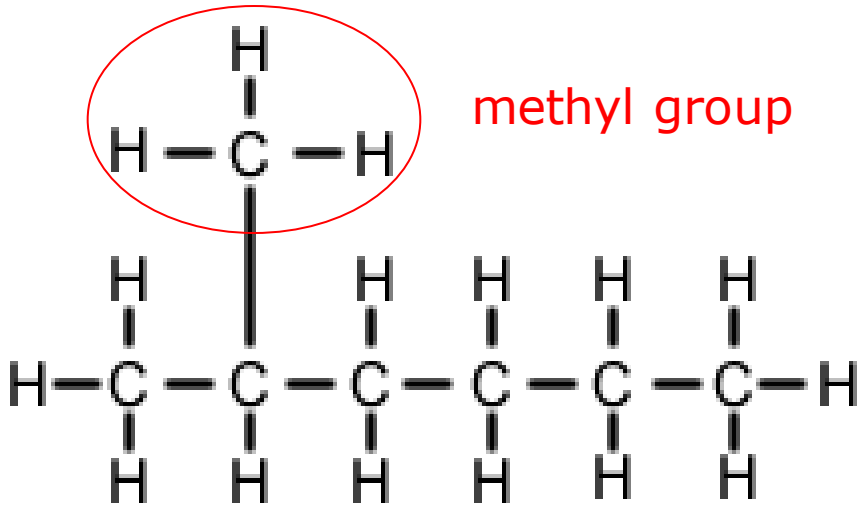
ALKANES

IUPAC naming system:

Not all alkanes are straight chains. Some alkanes have alkyl side groups (*alkyl substituents*) attached.

$-CH_3$	**methyl**
$-C_2H_5$	**ethyl**
$-C_3H_7$	**propyl**
$-C_4H_9$	**butyl**
$-C_5H_{11}$	**pentyl**
$-C_6H_{13}$	**hexyl**
$-C_7H_{15}$	**heptyl**
$-C_8H_{17}$	**octyl**

Ex:



name: 2-methylhexane

ALKANES

IUPAC naming system:

For alkanes with side groups…

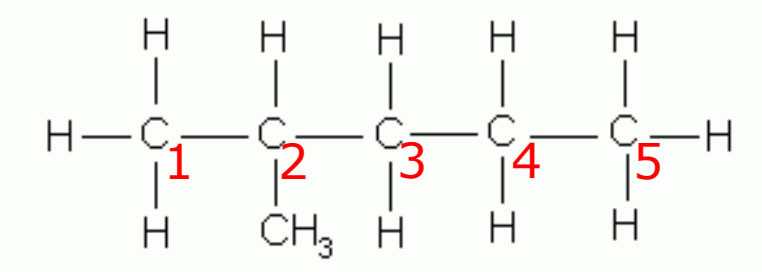
locant	Substituent(s)	prefix	suffix

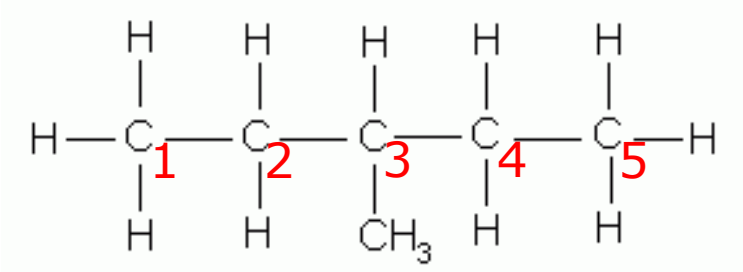
Ex: **2-methylhexane**

ALKANES

IUPAC naming system:

Name the following branched alkanes





2-methylpentane

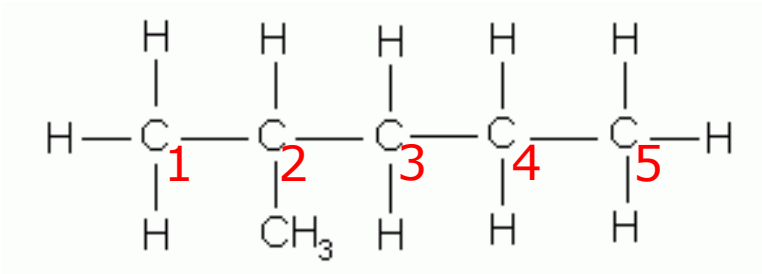
3-methylpentane

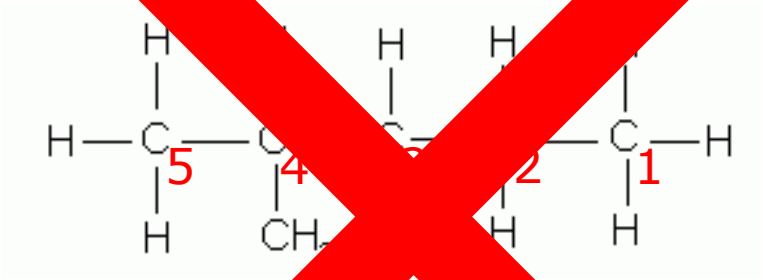
The substituent group is usually given the lowest locant possible

ALKANES

IUPAC naming system:

Which name is incorrect?





2-methylpentane

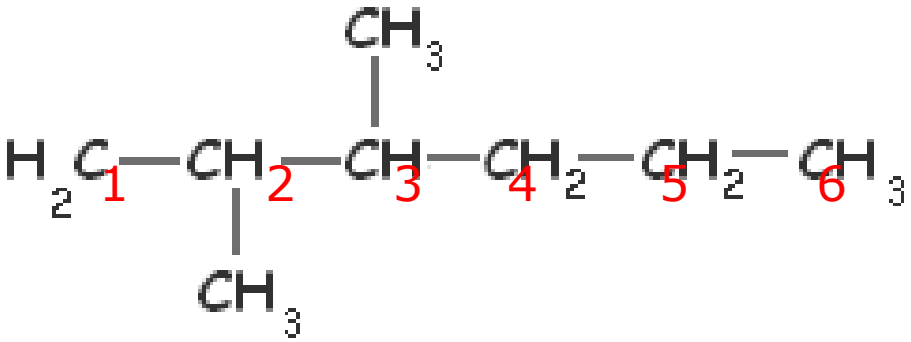
methylpenta

The substituent group is usually given the lowest locant possible

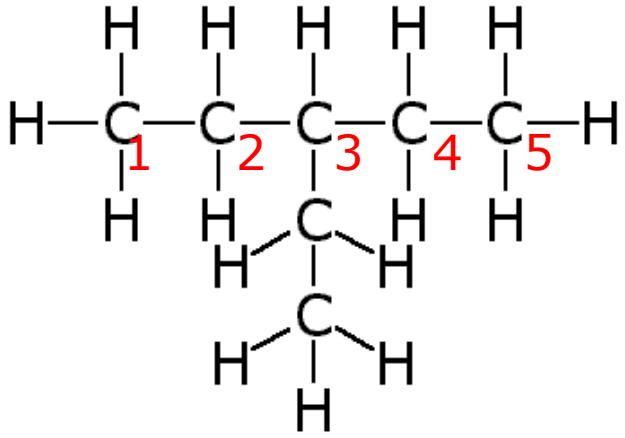
ALKANES

IUPAC naming system:

Name the following branched alkanes



2,3-dimethylhexane



3-ethylpentane

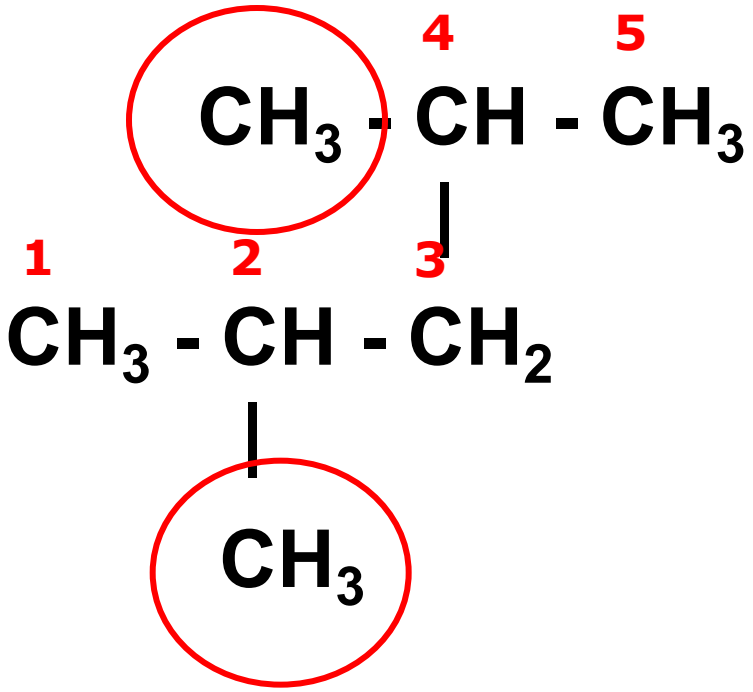
ALKANES

IUPAC naming system:

Name the following branched alkane

1. Find the longest continuous chain of C atoms (parent chain)

2. Identify any substitutents

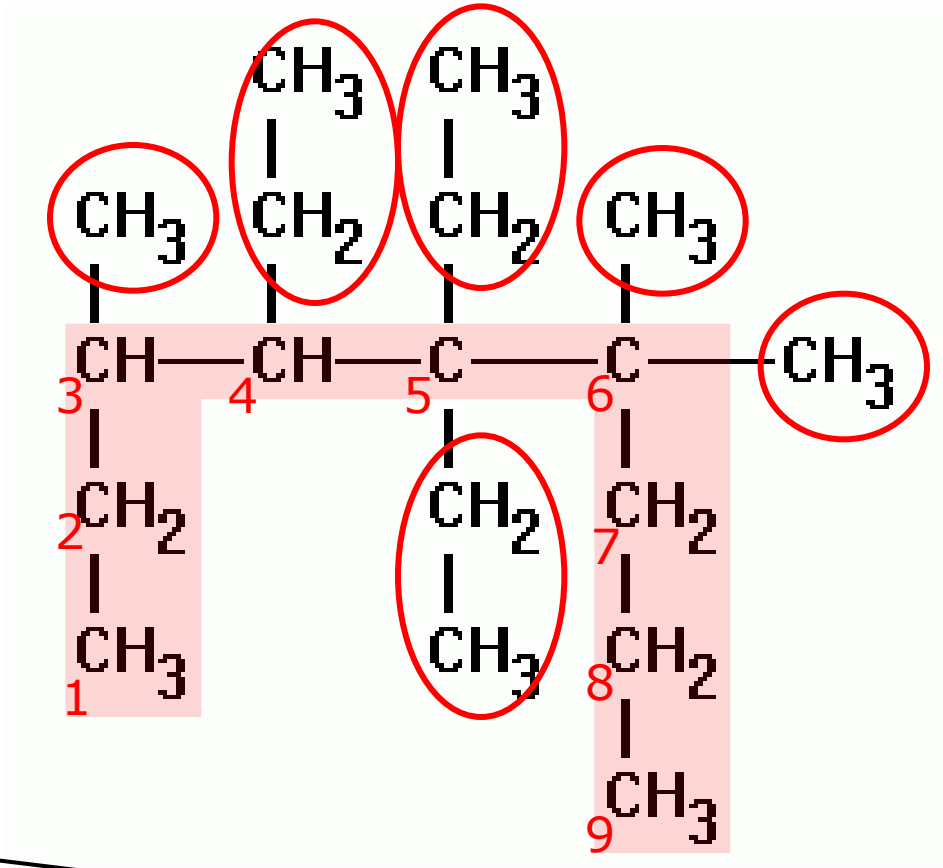


2,4 -dimethylpentane

ALKANES

IUPAC naming system:

Name the following branched alkane



The order of substituents in the name is based on alphabetical order

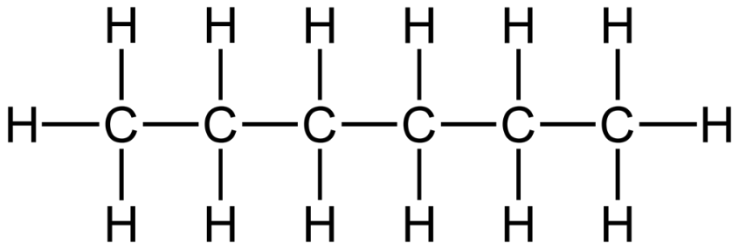
4,5,5-triethyl-3,6,6-trimethylnonane

ALKANES

Drawing alkanes:

3 types of diagrams

Structural diagram



Condensed diagram

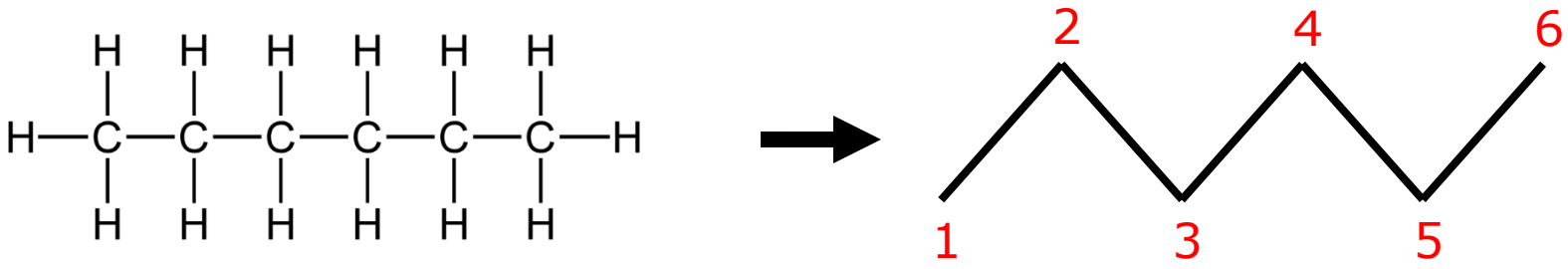
$CH_3CH_2CH_2CH_2CH_2CH_3$

Line diagram

ALKANES

Drawing alkanes:

Line diagrams:



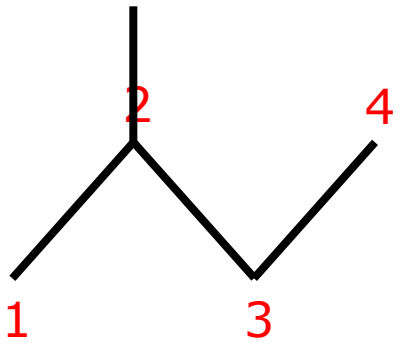
Every end or point on a line diagram represents a carbon atom. Hydrogen atoms are not shown.

ALKANES

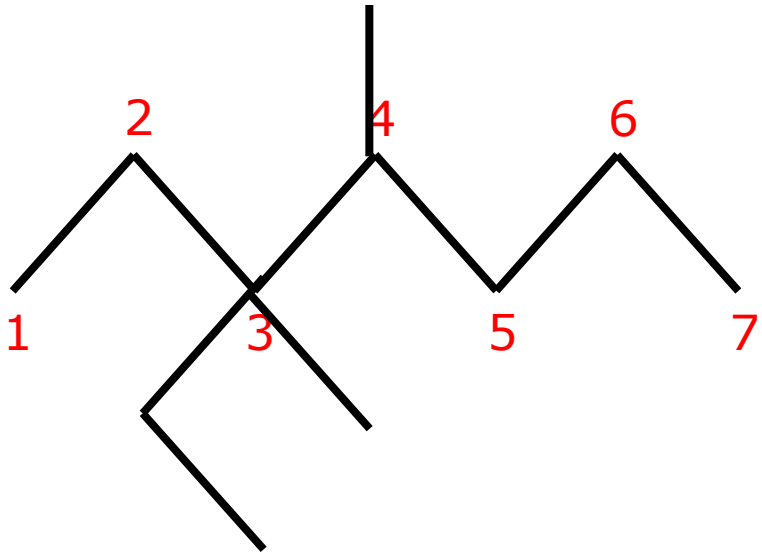
Drawing alkanes:

Draw the following alkanes using line diagrams

methylbutane

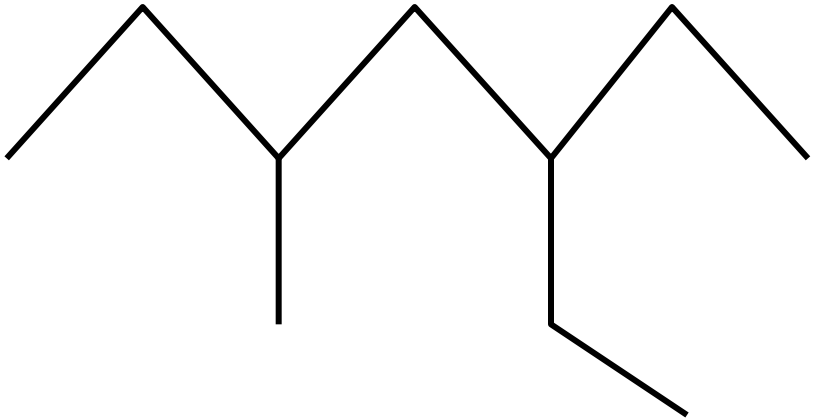


3-ethyl-3,4-dimethylheptane



ALKANES

When two possible names exist:



3-ethyl-5-methylheptane or ~~5-ethyl-3-methylheptane~~?

The ethyl has priority (and gets the lower number) because it comes before methyl in the alphabet.

ALKANES

Homework:

Page 14 #1, 2

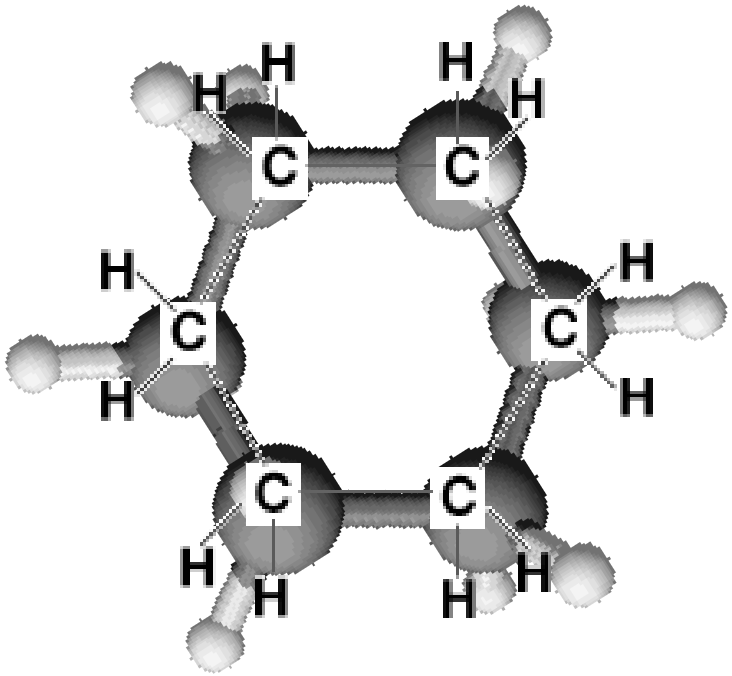
Page 17 #1, 2, 4-7

CYCLOALKANES

CYCLOALKANES

-Ring-like structures of alkanes

-empirical formula = C_nH_{2n}



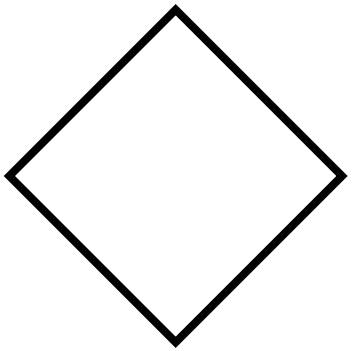
→ C_nH_{2n}, n=6

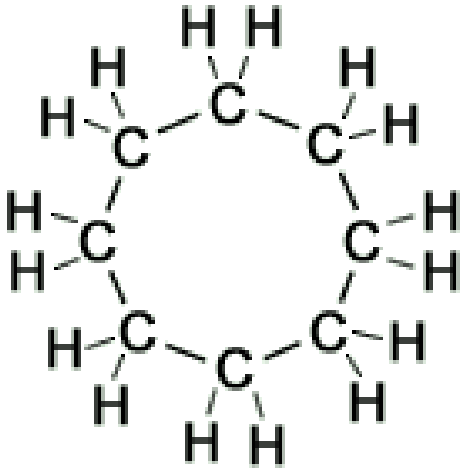
= C_6H_{12}

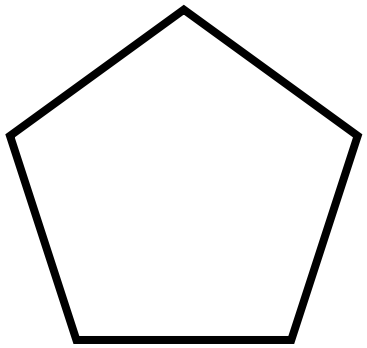
CYCLOALKANES

IUPAC naming system:

Name the following alkanes:







cyclobutane

cyclooctane

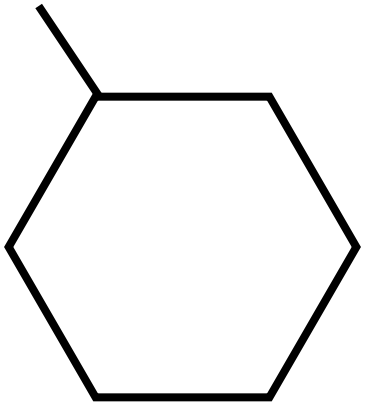
cyclopentane

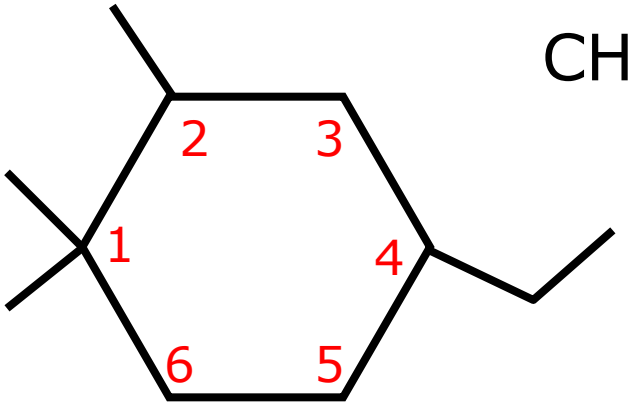
The prefix "cyclo" is added to the alkane name

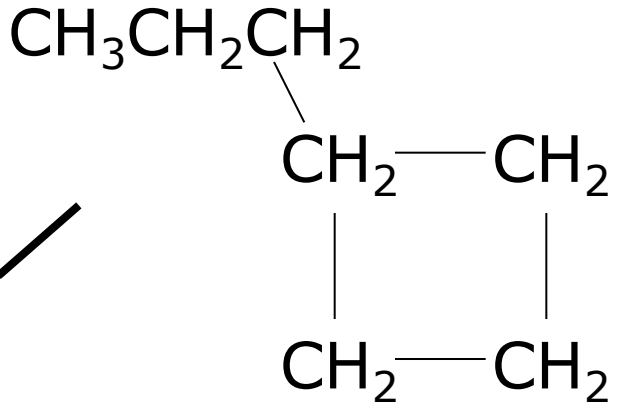
CYCLOALKANES

IUPAC naming system:

Name the following alkanes:







4-ethyl-1,1,2-trimethylcyclohexane

methylcyclohexane

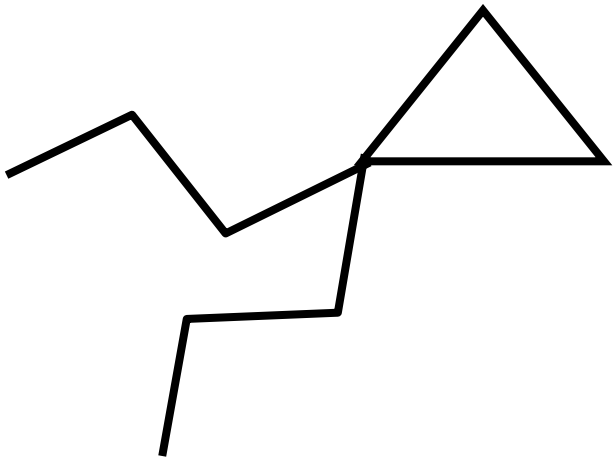
propylcyclobutane

CYCLOALKANES

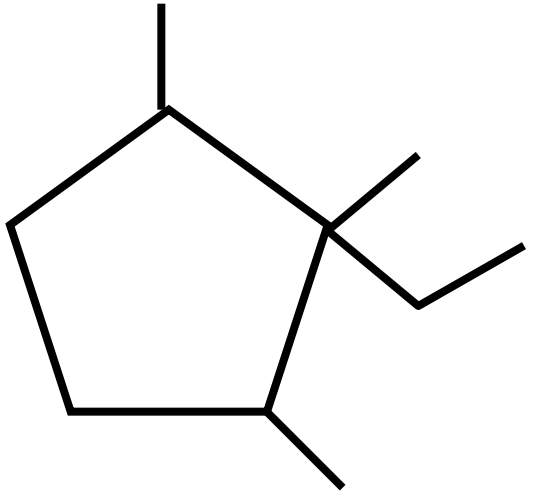
IUPAC naming system:

Draw the following alkanes using line structures:

1,1-dipropylcyclopropane



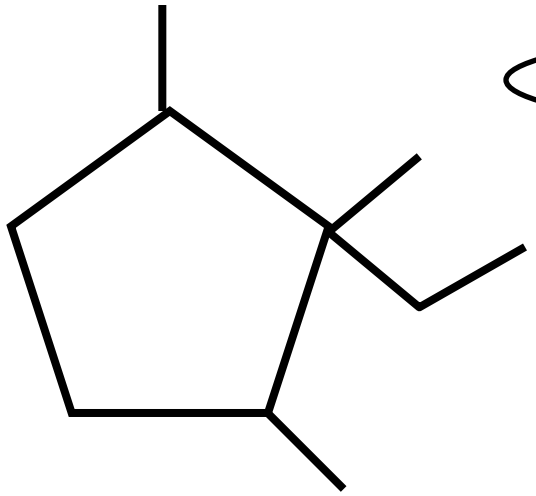
1-ethyl-1,2,5-trimethylcyclopentane



CYCLOALKANES

IUPAC naming system:

Which name is correct?



1-ethyl-1,2,5-trimethylcyclopentane

vs.

2-ethyl-1,2,3-trimethylcyclopentane

When two different substituents (ex. ethyl and methyl) can be assigned the same number, then the group that comes first in the alphabet gets the lowest number.

CYCLOALKANES

Properties:

Cycloalkanes have higher boiling points than their straight-chain (alkane) counterparts

Physical Properties of Alkanes and Cycloalkanes

Compounds	Bp, °C	Mp, °C	Density, d_4^{20}, g ml^{-1}
propane	−42	−187	0.580[a]
cyclopropane	−33	−127	0.689[a]
butane	−0.5	−135	0.579[b]
cyclobutane	13	−90	0.689[b]
pentane	36	−130	0.626
cyclopentane	49	−94	0.746
hexane	69	−95	0.659
cyclohexane	81	7	0.778
heptane	98	−91	0.684
cycloheptane	119	−8	0.810
octane	126	−57	0.703
cyclooctane	151	15	0.830
nonane	151	−54	0.718
cyclononane	178	11	0.845

Notice cycloalkanes have higher densities, meaning their molecules have less space between one another

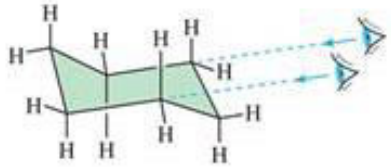
Cycloalkane molecules stack closer together due to their ring conformations forming "stackable" shapes. The closer distance allows stronger London dispersion forces.

CYCLOALKANES

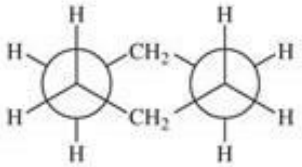
"Boat" vs "chair" conformations of cyclohexane

Chair *conformation of cyclohexane*

chair conformation

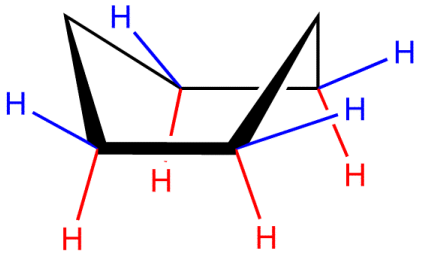


viewed along the "seat" bonds



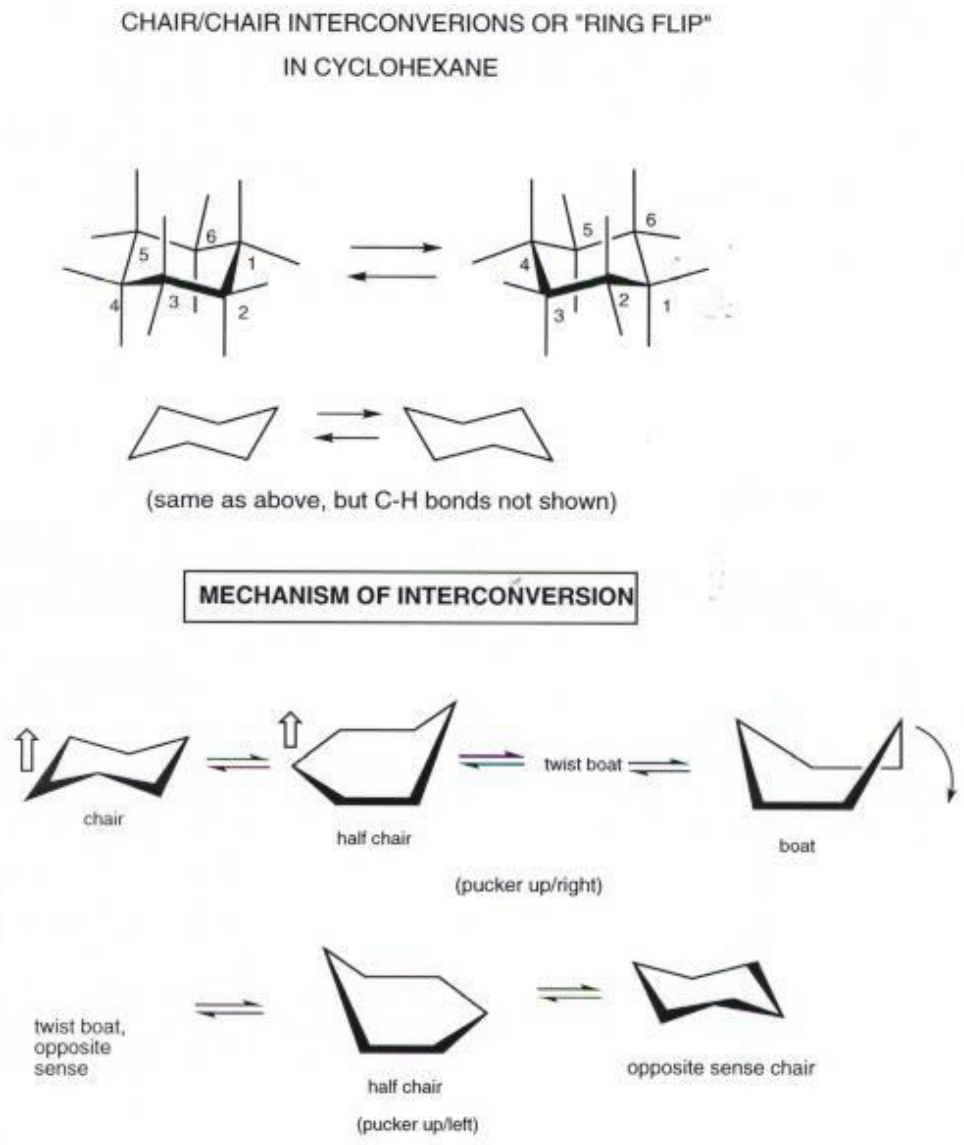
Newman projection *(side view)*

Boat *conformation of cyclohexane*



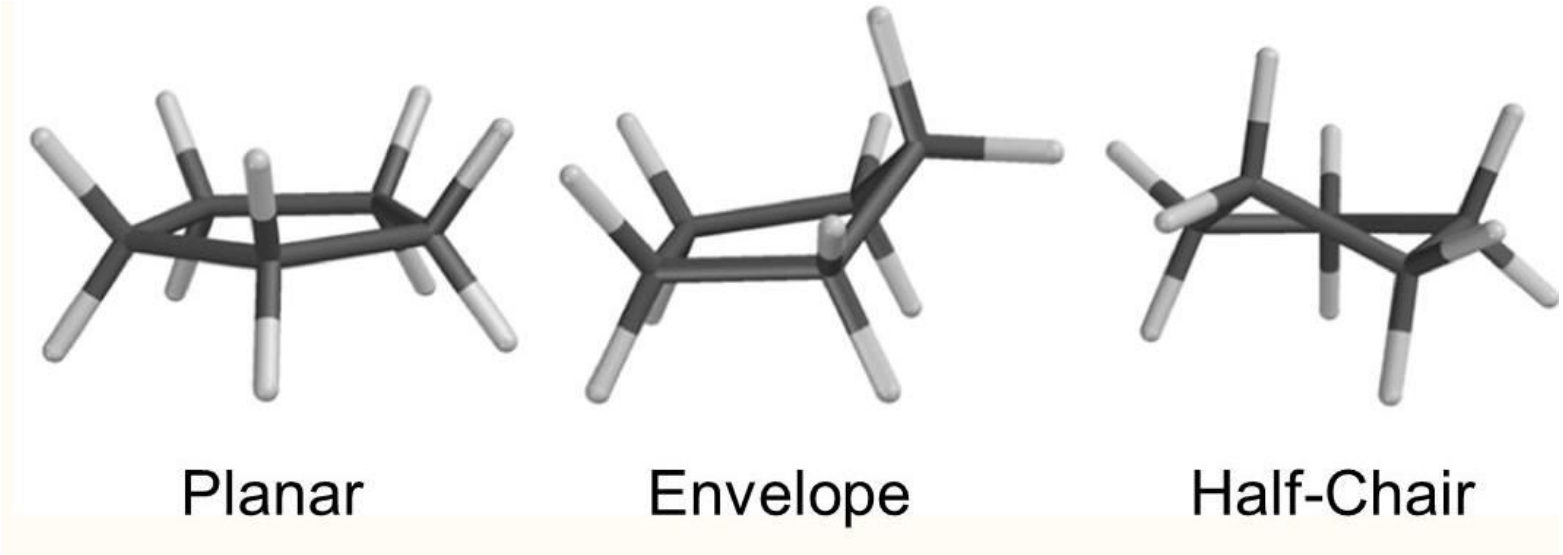
CYCLOALKANES

"Boat" vs "chair" conformations

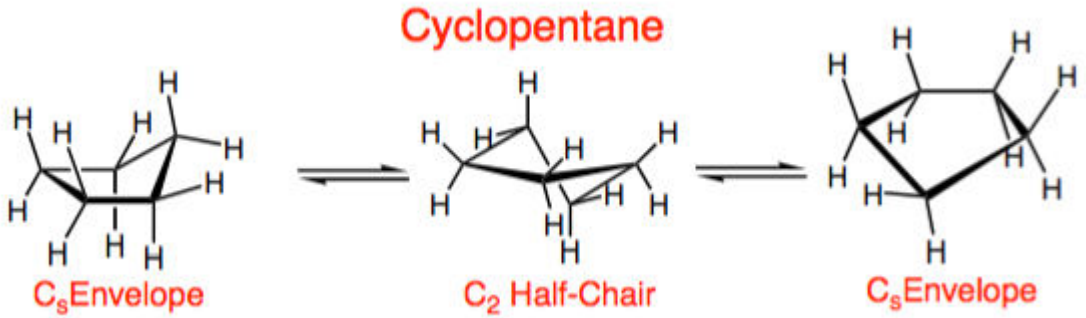


CYCLOALKANES

"Envelope" vs "half-chair" conformations of cyclopentane



The planar conformation has too much torsional strain. The envelope and half-chair conformations relieve the strain.

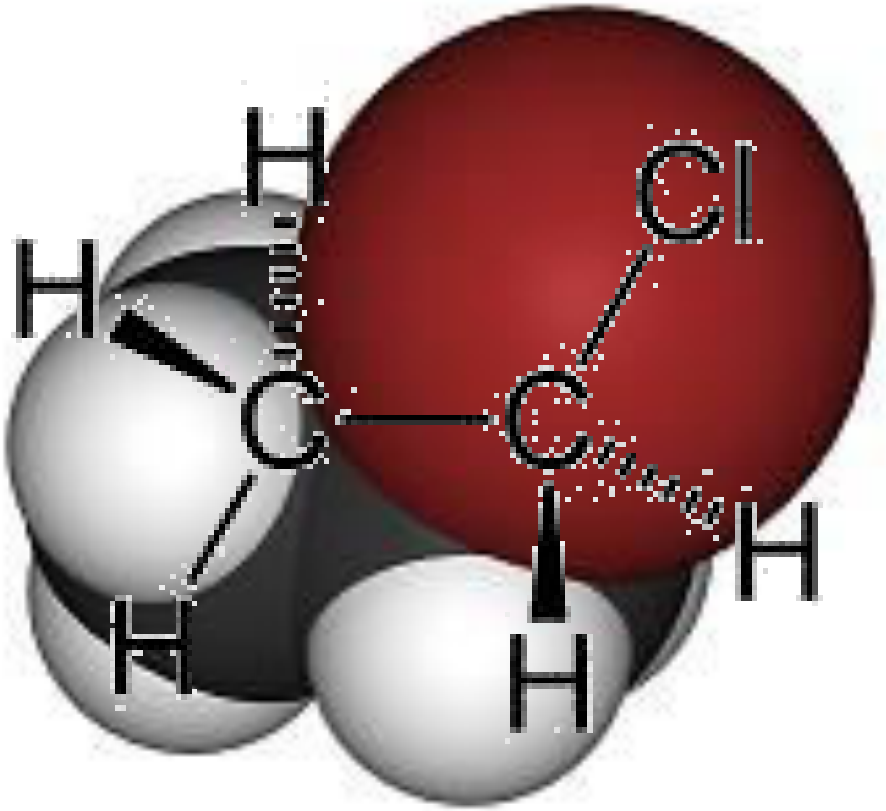


HALOALKANES

HALOALKANES

-Alkanes with halogen atoms

-Also known as *alkyl halides*

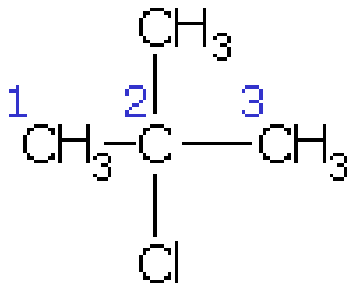


HALOALKANES

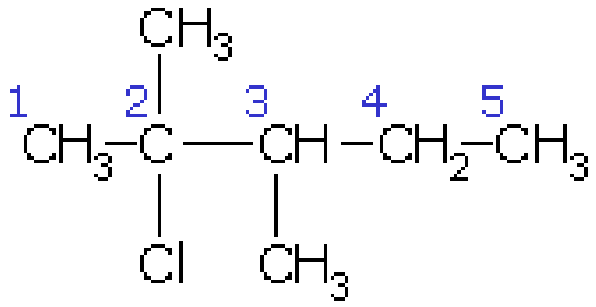
IUPAC naming system:

Halogen groups:	**-F**	fluoro
	-Cl	chloro
	-Br	bromo
	-I	iodo

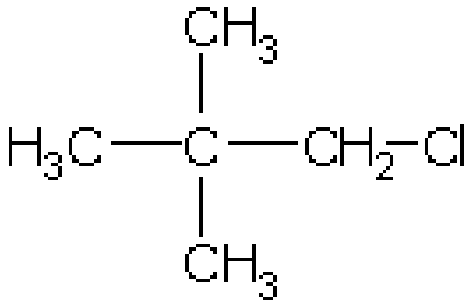
Just like alkyl substituents, the halogens are placed at the beginning of the name, and are ordered alphabetically.



2-Chloro-2-methylpropane



2-Chloro-2,3-dimethylpentane

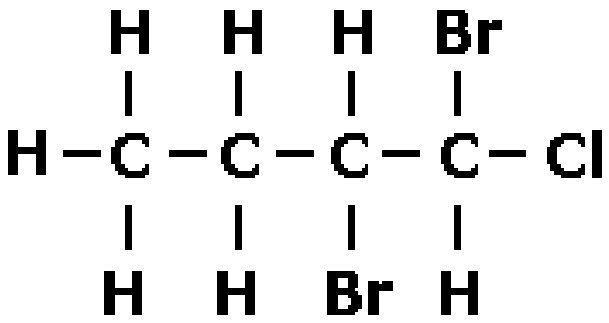


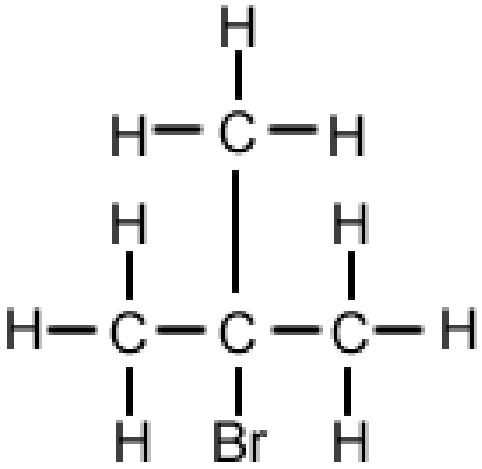
1-Chloro-2,2-dimethylpropane

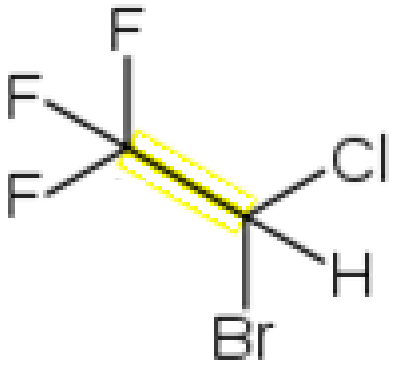
HALOALKANES

IUPAC naming system:

Name the following haloalkanes:







1,2-dibromo-1-chlorobutane

2-bromo-2-methylpropane

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