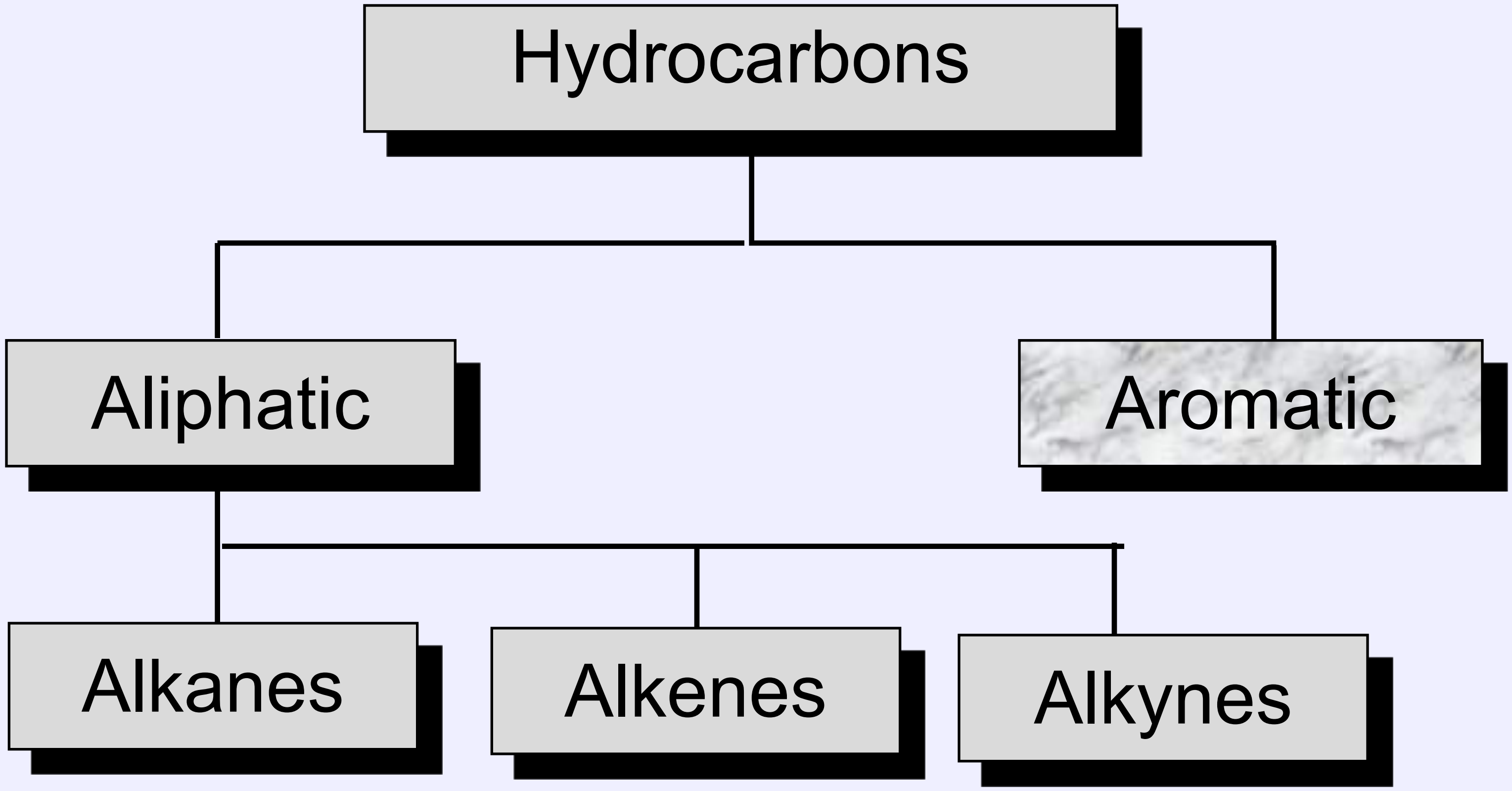
Chapter I

Hydrocarbons

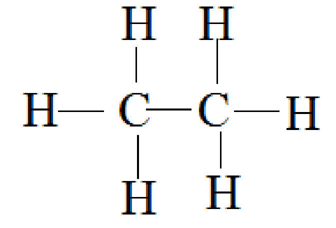

Hydrocarbons
Aliphatic
Aromatic
Alkanes
Alkenes
Alkynes


Alcohols
Aldehydes
Hydrocarbons Derivatives
Ketones
Carboxylic Acids

Molecular and structural formula

- Molecular formula: it is a formula that shows the type and number of atoms in a compound without showing their connectivity.
- Structural formula: it is a formula that shows the type and number of atoms in a compound and how they are connecting together.
- **Ex1: C_2H_6** (molecular formula)

it can be also written as: CH_3-CH_3

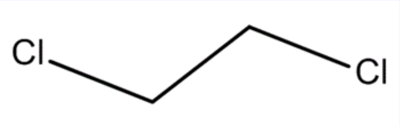


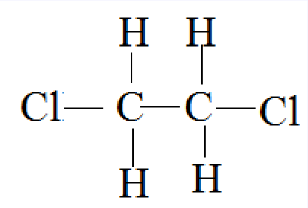
(Structural formula)

- **Ex 2: $C_2H_4Cl_2$** (molecular formula)

It can be also written as: CH_2Cl-CH_2Cl

and draw as follow:

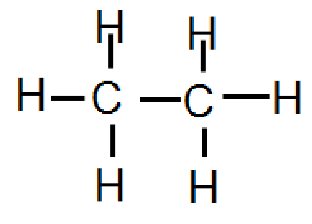




(Structural formula)

Alkanes

- Alkanes are hydrocarbons in which all of the bonds are single bonds.
- General formula is C_nH_{2n+2}
- Functional group is a hydrogen atom.
- In their reaction, one of the hydrogens is substituted by some other atom or group (X) through a reaction called substitution reaction.

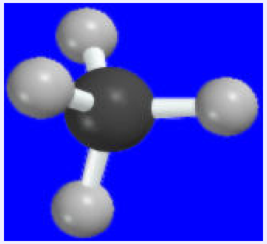


$$R\text{—}H + X_2 \longrightarrow R\text{—}X + HX$$

R: alkyl group, with molecular formula = C_nH_{2n+1}

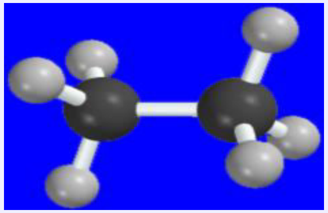
Examples:

Methane, CH_4



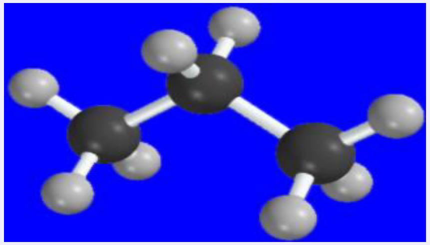
bp -160°C

Ethane, C_2H_6



bp -89°C

Propane, C_3H_8



bp - 42°C

IUPAC Nomenclature

1) Identify the longest carbon chain (parent chain).

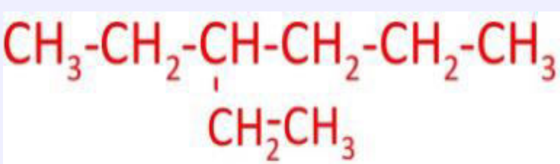
2) Identify all of the substituents (branches).

3) Number the carbons of the parent chain from the end that gives the substituents the lowest numbers.

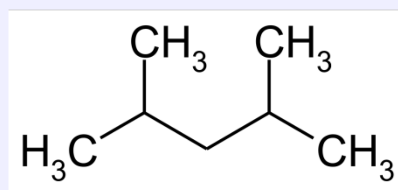
4) If the same substituent occurs more than once, add a prefix di, tri, tetra, etc..

5) If there are two or more different substituents they are listed in alphabetical order.

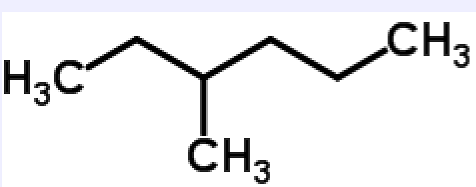
# of C	Name
1	methane
2	ethane
3	propane
4	butane
5	pentane
6	hexane
7	heptane
8	octane
9	nonane
10	decane



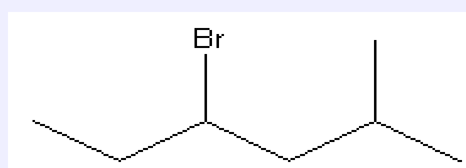
3-ethylhexane



2,4-dimethylpentane



3-methylhexane



4-bromo-2- methylhexane

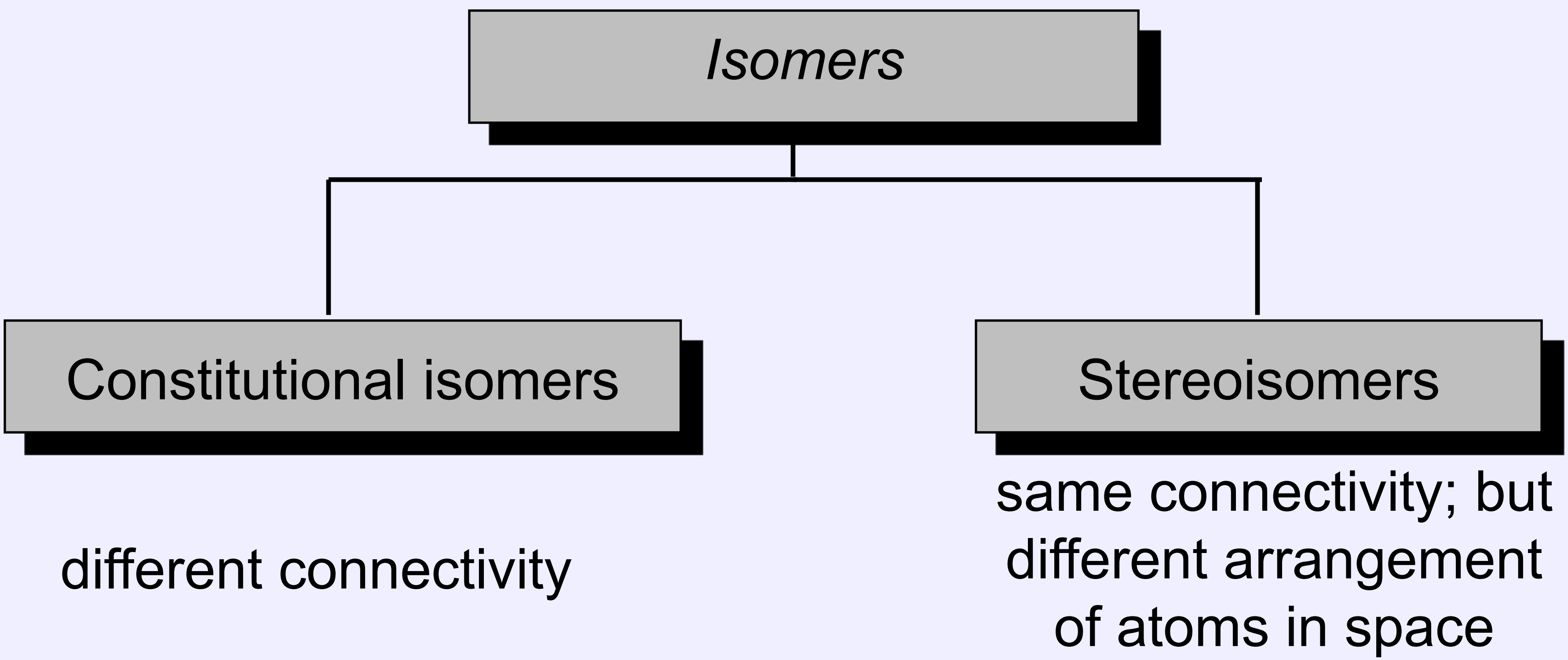
Remember

F	fluoro-
Cl	chloro-
Br	bromo-
I	iodo

Isomers

Isomers are different compounds that have the same molecular formula (composition) but different connectivity.

No isomers possible for C_1, C_2, C_3 hydrocarbons



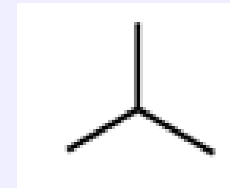
Isomeric Alkanes:

Isomers of Butane C_4H_{10}

n-Butane: $CH_3(CH_2)_2CH_3$

(bp -0.4°C)

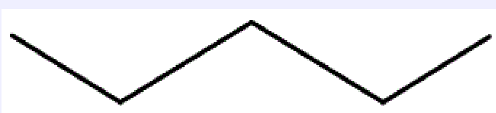
isobutane: $(CH_3)_3CH$



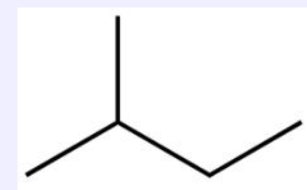
(bp -10.2°C)

Isomers of Pentane C_5H_{12}

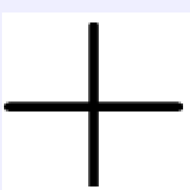
n-Pentane: $CH_3(CH_2)_3CH_3$



Isopentane: $(CH_3)_2(CH_2)_2CH_3$



Neopentane: $(CH_3)_4C$



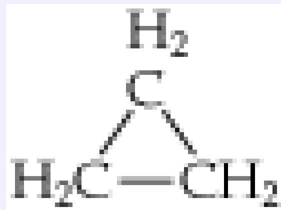
** The number of isomeric alkanes increases as the number of carbons increase.

CH_4	1	C_8H_{18}	18
C_2H_6	1	C_9H_{20}	35
C_3H_8	1	$C_{10}H_{22}$	75
C_4H_{10}	2	$C_{15}H_{32}$	4,347
C_5H_{12}	3	$C_{20}H_{42}$	366,319
C_6H_{14}	5	$C_{40}H_{82}$	62,491,178,805,831
C_7H_{16}	9		

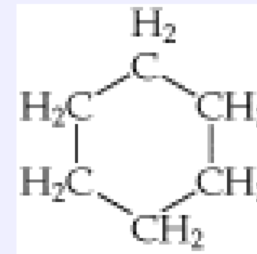
Cycloalkanes

- Carbon atoms that are joined in a ring or circle

EX.: cyclopropane



cyclohexane



- Naming: add cyclo- formula C_nH_{2n}

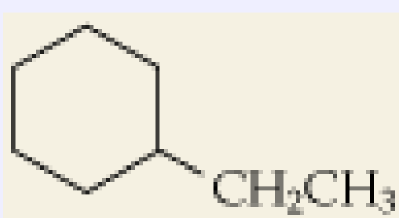
Ex. Draw structures for the following compounds:

a) Ethyl cyclohexane , b) 2-Ethyl, 1-methyl cyclopentane

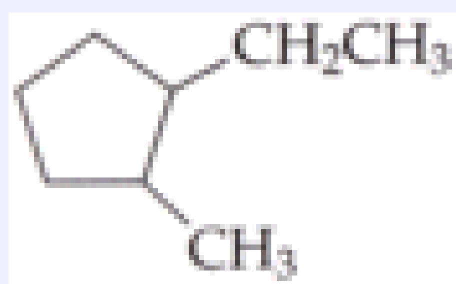
c) 1,1,2-trimethylcyclobutane

Answers

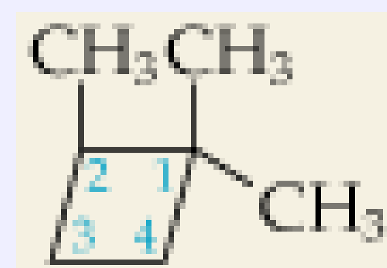
a)



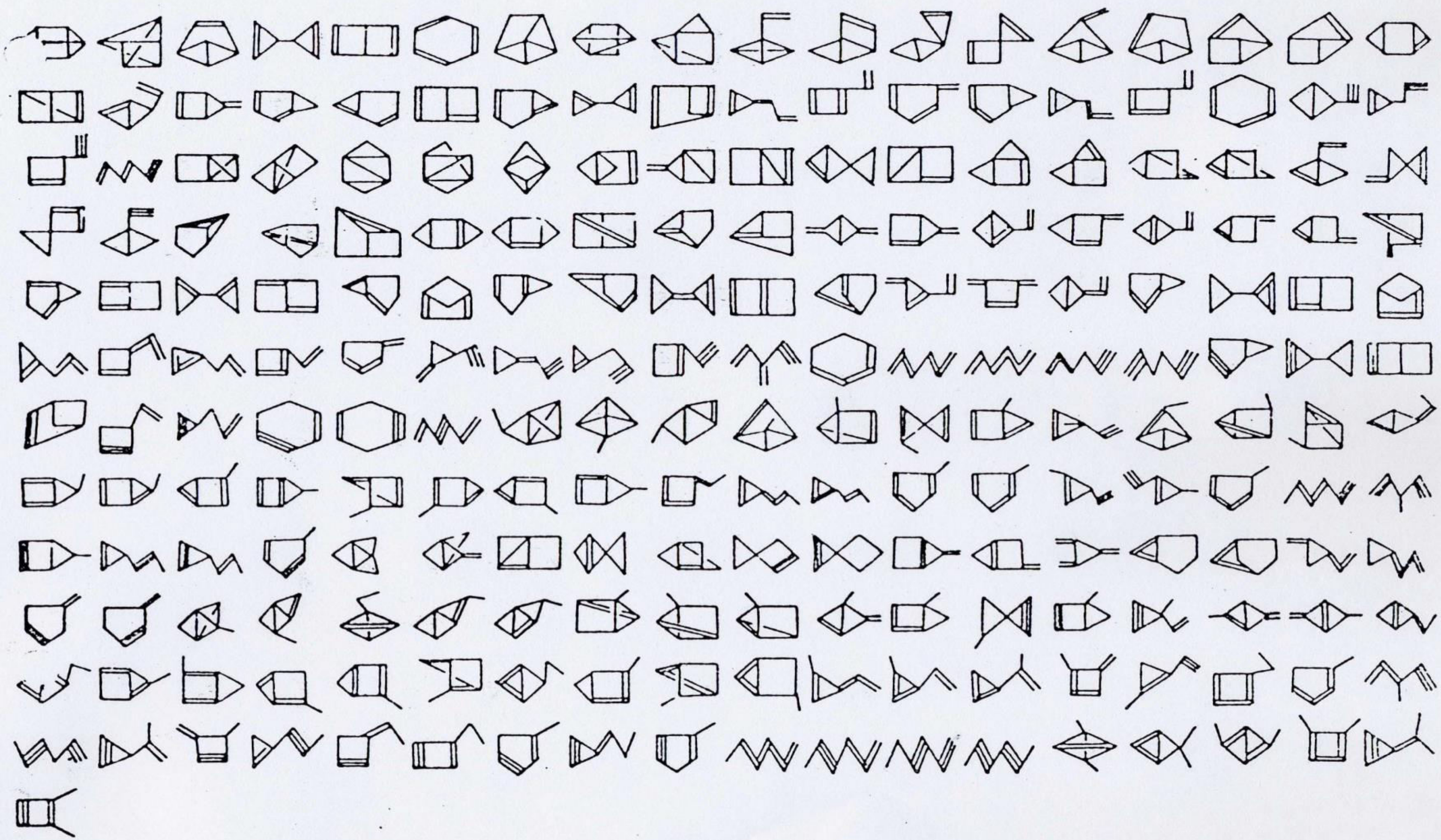
b)



c)



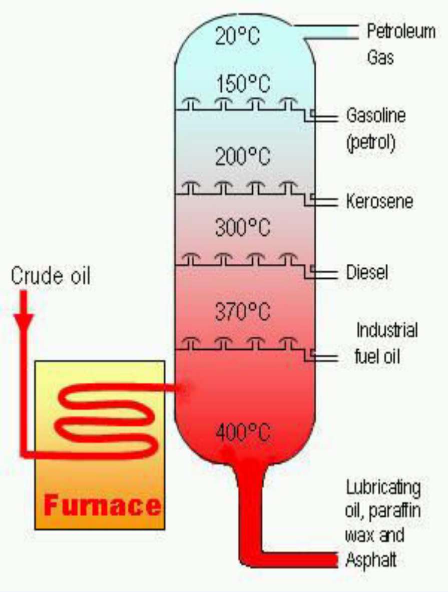
C_6H_6 **Isomers: Can you imagine** How many isomers with the composition C_6H_6 ?? can you draw?



THE C_6H_6 ISOMERS

Sources and Physical Properties of Alkanes

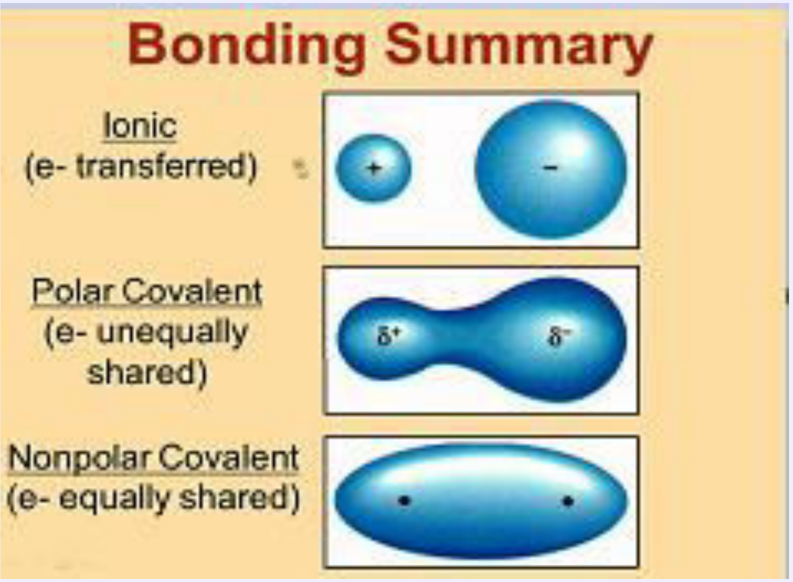
➢The most important source of alkanes is natural gas and crude oil. Alkanes are separated in an oil refinery by fractional distillation and processed into many products.



Physical properties:

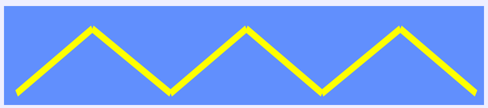
1. Low melting and boiling point
2. Low density
3. Soluble in organic solvent
4. Not soluble in water.
5. Cannot conduct electricity

➢ These properties are governed by strength of intermolecular attractive forces, since alkanes are nonpolar, so dipole-dipole and dipole-induced dipole forces are absent.

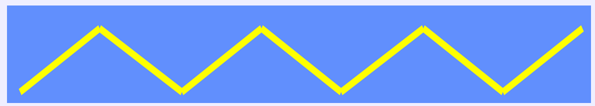


Boiling Points of alkanes

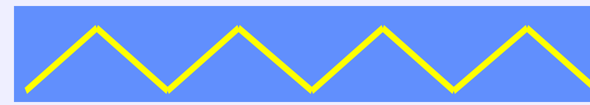
It increases with increasing number of carbons because more atoms means more electrons and more chance for induced dipole forces.



Heptane, bp 98°C

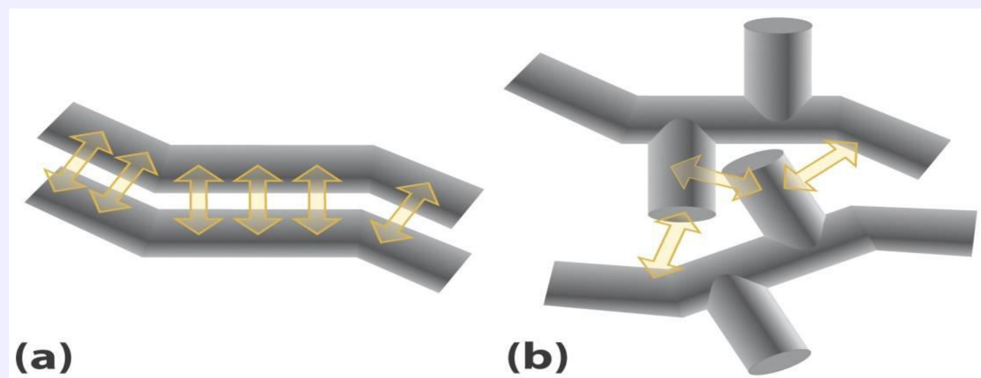


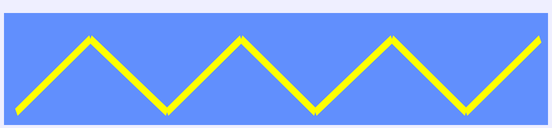
Octane, bp 125°C



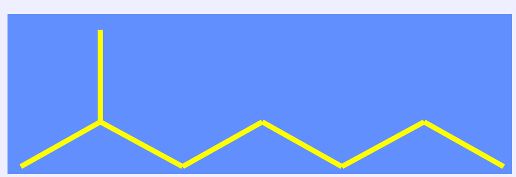
Nonane, bp 150°C

However, it decreases with chain branching because branched molecules are more compact with smaller surface area, so fewer points of contact with other molecules

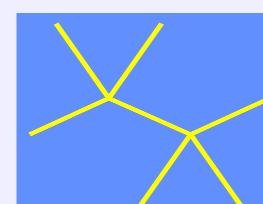




Octane: bp 125°C



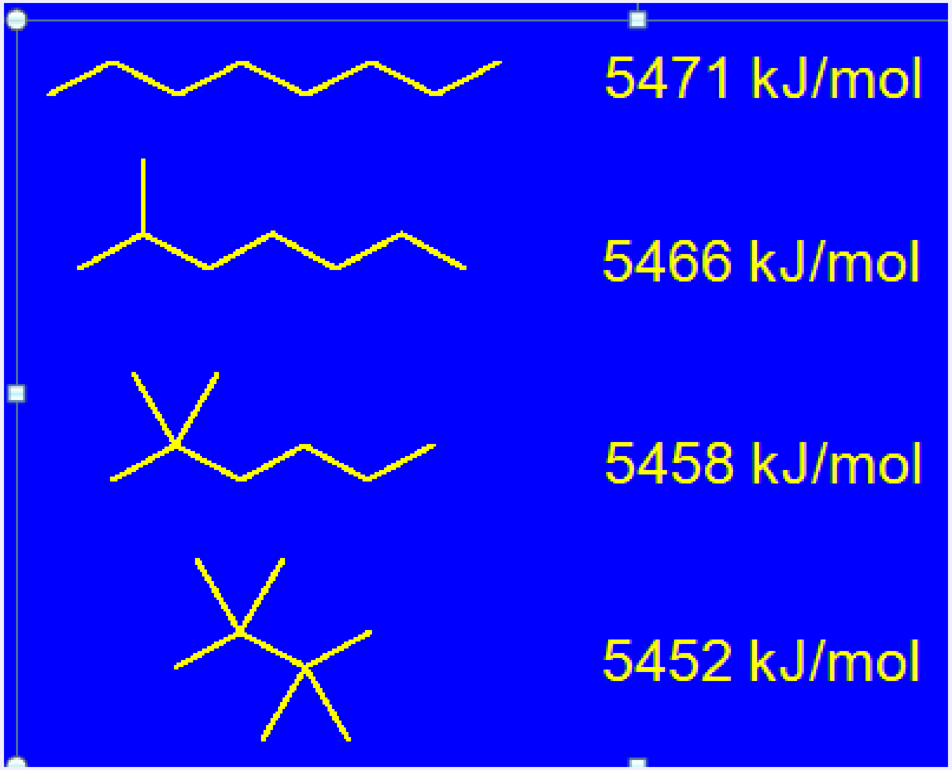
2-Methylheptane: bp 118°C



2,2,3,3-Tetramethylbutane: bp 107°C

Heat of Combustion of alkanes

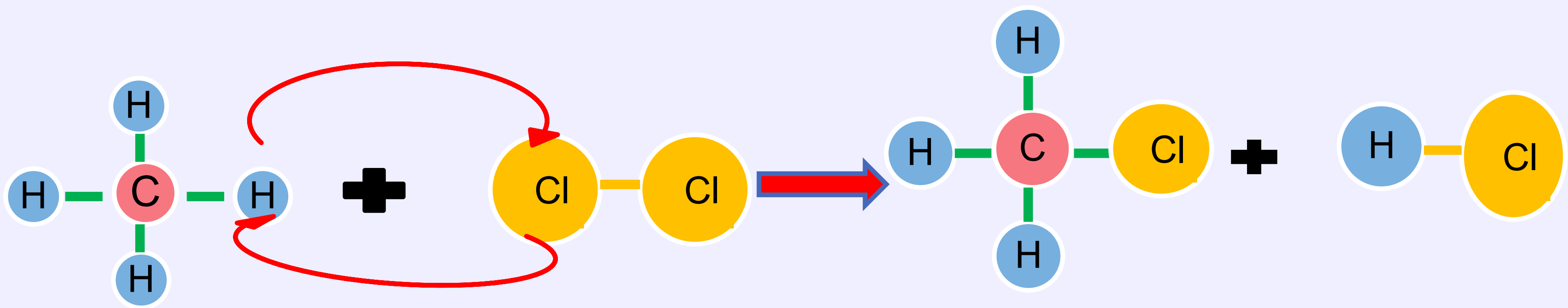
It is the heat released when one mole of substance is combusted in enough amount of oxygen. It increases with increasing number of carbons, however it decreases with chain branching because branched molecules are more stable than their unbranched isomers



Chemical Properties of Alkanes

1. Do not react with many laboratory agents
2. Usually very flammable
3. Undergo combustion reactions: $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O + \text{Heat}$
4. React with substitution reactions

Substitution reactions: reaction in which one atom, ion or group is replaced (substituted) by another. Usually occurs in saturated compounds.



1) $CH_4 + Cl_2 \longrightarrow CH_3\text{-}Cl + HCl$

2) $CH_3Cl + Cl_2 \longrightarrow CH_2\text{-}Cl_2 + HCl$

3) $CH_2\text{-}Cl_2 + Cl_2 \longrightarrow CH\text{-}Cl_3 + HCl$

4) $CHCl_3 + Cl_2 \longrightarrow C\text{-}Cl_4 + HCl$