Organic Chemistry

Alkanes

- Organic chemistry is the chemistry that studies carbon compounds.

- Currently there are over 8 million organic compounds known.

Ex. - CH_4 = methane $C_6H_{12}O_6$ = glucose $C_7H_5N_3O_6$ = T.N.T. $C_{10}H_{14}N_2$ = nicotine

$C_{17}H_{21}NO_4$ = cocaine $C_{19}H_{28}O_2$ = testosterone $C_{40}H_{56}$ = beta-carotene

- Organics are very important to us for . . .

1.) Plastics 2.) Solvents 3.) Pharmaceuticals

4.) Personal care products 5.) Oil products

- Organic chemistry uses special naming rules for all organic chemicals.

- Hydrocarbons – are organic compounds that contain only carbon and hydrogen atoms.

Ex. - CH_4 – methane gas or C_5H_{12} all the way to $C_{20}H_{42}$ – gasoline

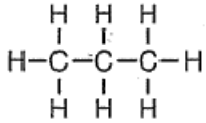
- Carbon has four valence electrons and so wants another four to complete its octet. This means anytime you have a carbon with less than 4 bonds, hydrogen will come and bond to the carbon to make those bonds.

- The first group of hydrocarbons are called the alkanes. This group is hydrocarbons with the carbon atoms all having **single bond connections**.

There is more than one way to represent a hydrocarbon formula, depending on how compact one wants to write the formula.

EXAMPLE: The structure of propane, C_3H_8, can be shown in three ways.

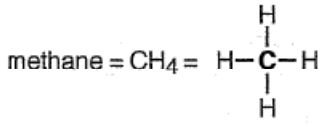
full structure:

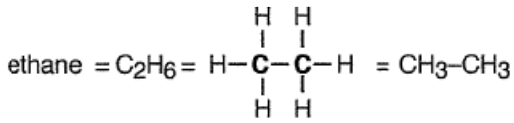


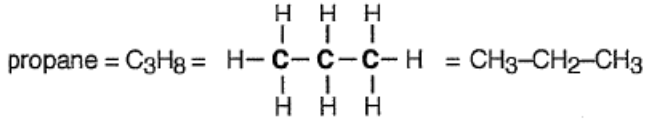
or condensed structure: $CH_3–CH_2–CH_3$ (or even $CH_3CH_2CH_3$)

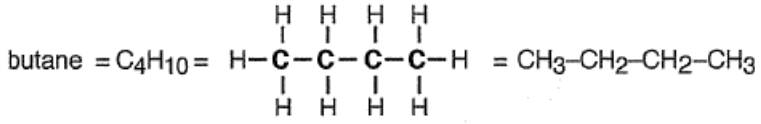
or molecular formula: C_3H_8

- Use the prefixes from last year combined with the ending "ane" because all of the above compounds are "alk**anes**" gives us the name and a pattern to follow.









and similarly pentane = C_5H_{12} = $CH_3–CH_2–CH_2–CH_2–CH_3$

hexane = C_6H_{14} = $CH_3–CH_2–CH_2–CH_2–CH_2–CH_3$

heptane = C_7H_{16} = $CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–CH_3$

octane = C_8H_{18} = $CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_3$

nonane = C_9H_{20} = $CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_3$

decane = $C_{10}H_{22}$ = $CH_3–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_2–CH_3$

- All of the above compounds are called <u>saturated</u> hydrocarbons. The word saturated means full. The hydrocarbons are "saturated" as they have no bonding sites to fit more hydrogen and as such are "full".

- The formula for figuring out how many hydrogen will fit with carbons is C_nH_{2n+2} . That is if I have 5 carbons then I will need 2(5) + 2 = 12 hydrogen to be saturated. **This formula only works for alkanes**!

<u>Alkyl Groups</u>

- When naming organic molecules the longest continual chain of carbons is counted and that is the "backbone" or "parent structure".

- Any carbon chains that branch off of this backbone are not part of the backbone and are called <u>alkyl groups</u>.

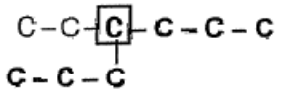
- <u>Alkyl groups</u> are alkanes that have lost one hydrogen atom.

- Alkyl groups are named by counting the carbons to find the "root name" (an alkane) and then changing the ending from "ane" to "yl". Ex. – meth**ane** would become meth**yl** or prop**ane** would become prop**yl**.

Ex. -

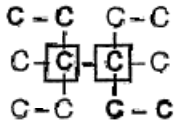
Original Hydrocarbon	Alkyl Group
Methane = CH_4	Methyl = CH_3
Ethane = CH_3-CH_3	Ethyl = CH_3-CH_2-
Propane = CH_3-CH_2-CH_3	Propyl = CH_3-CH_2-CH_2-
Butane = CH_3-CH_2-CH_2-CH_3	Butyl = CH_3-CH_2-CH_2-CH_2-

- To find the longest carbon chain, look at every "branch point" carbon (in a box in the examples below) and decide which TWO branches create the longest overall path (shown in bold). Only carbons are shown so as to make the various branches easier to see.

a) 

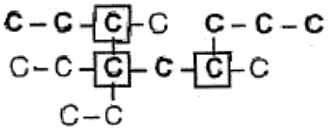
The carbon in the box has 3 branches: the longest route involves the right branch (3 carbons) and the lower branch (3 carbons).

Longest path length = 7 carbons = **heptane**

b) 

Here, no unique "longest path" exists. The longest chain involves either the upper or lower pair of carbons on the left side and either the upper or lower group of two carbons on the right. The bold path shown was selected randomly from the 4 possible choices.

Longest path length = 6 carbons = **hexane**

c) 

Do you agree with the bold path shown?

Longest path length = 9 carbons = **nonane**

- So, to name an organic compound that has alkyl branches hanging off the parent chain you

1.) Write the carbon number at which the alkyl branches from the parent. Follow this by a dash.

2.) Find all carbon branches off of the parent and count the carbons to name them making sure the name ends in "yl".

3.) Find the longest chain and name it as the root of the whole name making sure it ends in "ane".

Ex. -

4.) If more than one DIFFERENT alkyl group is attached to a hydrocarbon, then list the alkyl groups **alphabetically** with the number where it is attached preceding the name and separated by a dash.

Ex. -

5.) If an alkyl group is repeated, then list each carbon number where the repeated group is attached, separated by commas and a prefix if front of the alkyl name saying how many there are (bi, tri, tetra etc.).

Ex. -

Structural Isomers

- Structural Isomers are compounds with the same formula but different configurations of atoms.

Ex. –

- Alkanes are quite unreactive as C-C and C-H bonds are strong and not easily broken

- Methane, ethane, propane and butane all are gases, pentane and longer are liquids (gasoline) and above $C_{16}H_{34}$ you get paraffins or waxes (candles).

Cycloalkanes

- Cycloalkanes are alkanes that connect the first carbon and the last to form a ring.

Ex. –

- Cycloalkane rules are as follows:

1.) Name the substituent branch using numbers to indicate which carbon is the attachment point ONLY IF THERE IS MORE THAN 1 SUBSTITUENT. The first substituent is always one (name alphabetically to know which one is the #1 carbon).

Ex. –

Multiple Bonds

- Often in organic chemistry two carbons will have a double or triple bond between them instead of just a single. An alkene is an organic compound containing a carbon-carbon DOUBLE bond. An alkyne is an organic compound containing a carbon-carbon triple bond.

Ex. –

- Naming for alkenes and alkynes is straight forward.

1.) If a double bond is present change the ending to 'ene" and if a triple bond is present change to "yne".

2.) Use a number, immediately in front of the name with a dash, to indicate the lowered number carbon atom in the double/triple bond. If a branch is in the compound pick the carbon in the double triple bond so that the branch has the lowest number possible.

Cis-Trans Isomerism

- In organic chemistry you can have two of the same compounds that have different arrangements of atoms. These are called isomers.

Ex. – C_4H_{10} = butane ➔ $CH_3\text{-}CH_2\text{-}CH_2CH_3$ or $CH_3\text{-}\underset{\displaystyle CH_3}{\underset{|}{C}}H\text{-}CH_3$

- Both isomers have different physical and chemical properties.

Ex. – Write the condensed structure and name for the 3 structural isomers of C_5H_{12}.

- In alkanes the groups attached to the parent can rotate around the single bonds. However, in alkenes the double bond locks the molecule into one shape. Thus you can have one molecule having two very different isomers.

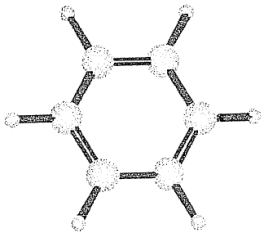
- Cis isomers have the branching groups on the same side of the double bond. Trans means the branching groups are on the opposite sides of the double bond.

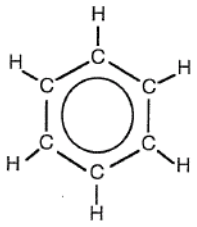
Ex. -

Aromatic Compounds

- An aromatic compound is a molecule containing one or more benzene rings. So, what is a benzene ring?

- Benzene is C_6H_6 and is very important. The structure is as follows.





- Benzene is so special because it has what are called <u>resonance structures</u>. Resonance structures are the same structure **differing only** in that they have alternating double bonds placed in between alternating double bonds.

  <u>Ex.</u> –

- Benzene's resonance structures give it unusual stability (unusually high resistance to chemical reactivity).

- Benzenes often have groups attached to the ring making very important chemicals for life.

  <u>Ex.</u> –