1 Organic Chemistry

Organic chemistry: the chemistry of carbon compounds

- Contain carbon
- Have covalent bonds - low melting points, low boiling points, are soluble in nonpolar solvents, burn in air
- Can form large molecules (polymers)

Hydrocarbons

- Compounds that contain only carbon and hydrogen

Complete structural formulas show all the atoms with the bonds between each of the atoms represented by lines.

Condensed structural formulas are a shorthand way and list all atoms in order and tells how they are bound together.

Molecular formula - atoms w/ subscripts making up molecule.

Skeleton structure/formula - leaves out H atoms, only C skeleton and connecting bonds shown and bonds are represented as lines

Bond-line Drawing - Only C-C bonds are shown. Each vertex represents a carbon atom. It is understood that hydrogen atoms are attached as needed to complete the bonding.

Alkanes

- Alkanes are hydrocarbon chains that have only single bonds between the carbons

Branched chain alkanes

- Sometimes carbons are not bonded in a straight chain. Sometimes there are branches.
- The longest branch is called the parent chain. The side branches are called the substituent groups.

Name of Alkyl groups

- The group names have the same prefix as their corresponding parent chains, but the -ane suffix is replaced with -yl

Rules for Naming Organic Structures

- Count the carbons in the longest chain. This parent chain provides the base name of the structure.
- Number each carbon in the parent chain, starting with the end closest to a substituent group.
- Name each alykl group substituent before the name of the parent chain. Include the alykl name the number of the carbon it is attached to in the parent chain.
- If the alykl group occurs more than once, use a prefix before its name to indicate how many times it appears.
- Whenever different alykl groups are attached to the same parent chain, name them in alphabetical order
- Write the entire name using hyphens to separate numbers from words and commas to separate numbers. No spaces.

Cyclic Alkanes

- Cyclic hydrocarbons are organic compounds that exist as carbon rings.
- The prefix cyclo- is used

- Alkyl groups added to front of name of ring

Naming branched cycloalkanes

- The ring is considered the parent chain
- Number the carbons beginning with the one attached to a substituent group that gives the lowest possible sum of numbers in the name

Multiple Carbon-Carbon Bonds

- Alkanes all have single bonds between carbons. These are called saturated hydrocarbons.
- Some hydrocarbons contain double or triple bonds. These are referred to as unsaturated hydrocarbons.

Alkenes

- Alkenes contain at least one double bond between carbon atoms.

Naming alkenes

- Alkenes are named like alkanes, but their names have -ene at the end.
- The double bond will always be part of the parent chain.
- You also must specify the location of the double bond with a number. This is the number of the carbon atom where the double bond starts.

Naming cycloalkenes

- Named like cycloalkanes, but carbons #1 & 2 must be attached to the double bond.

Naming branched alkenes

- The longest carbon chain must contain the double bond. Always start numbering closest to the double bond.
- If there is more than one double bond, use a prefix before the -ene to indicate how many.

Alkene Geometric Isomers

- All atoms are bonded in the same order but are arranged differently in space
- We'll discuss isomers further later
- cis- the functional groups are on the same side of the molecule
- trans- the functional groups are on opposite sides of the molecule

Alkynes

- Alkynes are hydrocarbons that contain at least one triple bond. They are named in the same way as alkenes, but with suffix -yne.
- Can have 1 triple bond
- Parent c hain must contain both C atoms of triple bond

Remember: each C forms a covalent bond with 4 other atoms.

Classes of hydrocarbons:

- Aliphatic - does not contain benzene ring
- Aromatic - contains benzene ring
- Aliphatic -
  - Alkanes - simplest class of organic compounds contain only C and H and have only single bonds
  - Alkenes have a C-C double bond
  - Alkynes have a C-C triple bond

Saturation:

- Saturated: hydrocarbon has maximum #H'2
- Unsaturated: hydrocarbon has less than maximum #H's (can be cyclic or have double or triple bonds)

Substituents: atoms that take the place of H

Functional Groups

- Small structural units within molecules where most chemical reactions occur
- R (radical) represents any hydrocarbon attached to functional groups
- Since double & triple bonds are chemically reactive, they are considered functional groups

Benzene

- Compounds containing benzene rings are called aromatic compounds.
- There are not 3 single bonds and 3 double bonds in a benzene ring. Instead, the electron pairs are delocalized, which means they are shared among all 6 C's in the ring.
- If there are other groups present on the benzene ring the compound is said to be a substituted benzene.
- When benzene is a substituent on a carbon chain, it is called phenyl.

Alcohols

- Carbon compounds containing a hydroxyl group, -OH
- -ol added on to name of compound
- Classified by how many substituents are attached to the C of -OH group

Halocarbons

- Carbon compounds containing halogens (Cl, F, Br, I)
- Alkyl halide - halogen attached to carbon of aliphatic chain
- Aryl halide - halogen attached to aromatic hydrocarbon
- Occur by substitution reaction (hydrogen replaced by halogen)

Ethers

- 2 C's single bonded to oxygen atom
- General formula R_1-O-R_2
- Simple ethers can be named by namimg alykl groups alphabetically followed by word "ether".
- Another way is name smaller hydrocarbon prefix, add -oxy, and join it to alkane name of the larger hydrocarbon group.

Ketones

- In middle of compound
- Change final -e of alkane to -one.
- Indicate number before name to indicate position of ketone group
- Less reactive than aldehydes, so popular as solvents

Aldehydes

- at end of compound
- Change final -e of alkane to -al
- Many have characteristic odors/flavors

Amines

- Contain N-C in aliphatic chains or aromatic rings
- Primary amine general formula R-NH_2

- Called amino group (found in amino acids)
- Suffix -amine
- Amines are stinky!

Amides

- -OH of carboxylic acid is replaced by N bonded to other atoms
- Write name with same number of carbon atoms, replacing final -e with -amide

Carboxylic Acids

- Organic acid with carboxyl group (-CO_2H or -COOH)
- Change -ane of alkane to -anoic acid
- Weak acids (ionize slightly to give carboxylate ion and proton)

Esters

- Carboxyl group where H of hydroxyl group replaced by alkyl group (-OR)
- General formula $R_1CO_2R_2$
- Formed by reaction of an alcohol and a carboxylic acid
- Substituent suffix -oate

Aromatic Hydrocarbons

- Substituents attached to benzene ring are usually named as derivatives of benzene
- Benzene is the parent compound if there is no continuous HC longer than 6 C's joined with it

Disubstituted Aromatic Hydrocarbons

- o-/m-/p- not used with 2 different substituents
- Name substituents in alphabetical order

Isomers

- Compounds with same molecular formula but different structures
- Structural isomers - same molecular formula but different connections between atoms
- Funtional isomerism - substances have same molecular formula but different functional groups
- Positional isomerism - occurs when same functional groups are in different positions on same C chain
- Stereoisomers - same molecular formula, same connections between atoms, but different arrangements of atoms in 3-D space
- Geometric isomers - result from different arrangements of groups around double bond

Properties and uses of Alkanes

- Nonpolar
- Low boiling point/melting point
- Immiscible in water but soluble in nonpolar solvents
- Low reactivity due to nonpolarity
- Relatively strong C-C and C-H bonds limit their use

Properties and Uses of Alkenes

- Nonpolar/low solubility in water
- Low melting/boiling points
- More reactive than alkanes

- Several occur naturally in living organisms
- Ethene used in plastics
- Scents of lemons, limes and pine trees

Properties and Uses of Alkynes

- Useful starting material in many synthesis reactions due to reactivity
- Physical and chemical properties similar to alkenes.