

1 Intro to Organic

Definition 1.1: Organic Chemistry

Organic Chemistry is the study of chemistry with respect to molecules involving Carbon and Hydrogen.

1.1 Carbon in Organic Chemistry

Carbon ${}^6\text{C}$ is able to form many compounds because of its properties when having 4 electrons in its valence shell.

- 4 covalent bonds can be formed
- All the electrons in a fully bonded Carbon are bond pairs
- Single, double and triple bonds can be formed

Organic compounds are stable and unreactive because:

- C-H and C-C / C=C / $\text{C}\equiv\text{C}$ are strong
- Carbon has no low-lying vacant orbitals / cannot expand octet and hence cannot form extra bonds
- Skeletal carbon have no lone pairs for reaction

Carbon causes varied geometries in organic molecules:

- sp^3 hybridized carbon occurs with 4 single bonds with a tetrahedral structure and a 109.5° angle.
- sp^2 hybridized carbon occurs with 3 bonds (2 single and 1 double) or in benzene rings (delocalised π e^- cloud) with a trigonal planar structure and a 120° angle
- sp hybridized carbon occurs with 2 bonds (two double / 1 single and 1 triple) with a linear structure and a 180° angle

1.2 Functional Groups

Definition 1.2: Functional Group

A Functional Group comprises an atom or a group of atoms to be bonded to the organic compound which determines its chemical properties.

Definition 1.3: Homologous Series

A Homologous series is a family of compounds with the same functional group.

Homologous series usually share chemical and physical properties, and therefore can be prepared by similar processes. Homologous series may differ with a member through the addition of a CH_2 group and its chemical formula follows a general pattern.

1.3 Structural Chemical Formula

In addition to empirical and molecular formula as discussed in Stoichiometry, organic chemistry now requires the understanding of structural formula due to the large size and convoluted bonding of organic molecules.

Definition 1.4: Condensed Structural

Condensed Structural formula describes each C in the skeletal chain and what groups are bonded to it. For example, $\text{CH}_2\text{CH}_1\text{CH}_3$ for but-1-ene.

Definition 1.5: Displayed / Full Structural

Full Structural formula describes each atom using labels, what bonds form between which atoms and also the arrangement of groups around carbon (4 groups drawn in orthogonal directions, 3 groups in trigonal).

Definition 1.6: Stereochemical

Stereochemical formula describes each atom using labels and the 3-dimensional distribution of bonded molecules. Solid lines are parallel to the plane of the paper, wedged bonds move out of the paper while hashed bonds move into the paper.

Definition 1.7: Skeletal

Skeletal formula describes primarily all atoms which are not carbon or hydrogen in a compound. Lines representing bonds are drawn in a imaginary hexagonal grid with each unlabeled vertice representing a carbon, functional groups are drawn and finally all vacant electron pairs are implicitly filled with hydrogen. Multiple bonds are drawn as multiple parallel lines.

Cyclic carbon are drawn by their skeletal formula with a line from the cycle to whatever other miscellaneous groups it is bonded to, and all C or H are implicit.

1.4 Functional Groups and Nomenclature

To name an organic compound:

1. Identify the functional group
2. Identify the longest C chain which includes the functional group.
3. Number Cs from one end to other
4. Identify side-chains, add di/tri prefixes
5. Order prefixes alphabetically, ignoring di/tri prefixes
6. Combine prefix, root, multiple bond infixes and suffix.

A chain must either not include cyclic C or must all be cyclic. Number of C determines the root. If the root is a cycle, cyclo- is added to the front. Root names are: meth, eth, prop, but, pent, hex, hept, oct, non, dec and so on.

1.4.1 Functional Groups

Functional groups are selected (in increasing priority):

- Carboxylic Acids (-oic acid) COOH
- Carboxylic Acid Derivatives: Esters ([Name of R]-yl [Root]-ate) COR, Acid Halides (-oyl [halide]-ide) COX, Amide (-amine) CONH_2
- Nitrile (-nitrile) $\text{C}\equiv\text{N}$
- "Oxygen groups" : Aldehyde (-al) OH Ketone (-one) O , Alcohol (-ol) —O—H
- Amine (-amine) NH_2

Other functional groups not in this list include:

1.4.2 Tiebreakers

Candidate carbon chains and C numbers are allocated by (in increasing priority):

- Minimizing the number of the functional group
- Minimizing the number of the multiple bonds
- Minimizing the number of the prefixes
- Minimizing the number of the alphabetically first prefix

Prefix names of functional groups are:

- Bromo-/Chloro-/Iodo- for halide groups
- Oxo- for aldehyde and ketone groups

- Alkoxy- for esters, Hydroxy- for alcohol groups
- Cyano- for nitrile groups
- Amino- for amine groups, Nitro- for NO_2
- Phenyl- for benzene ring
- Methyl-/Ethyl-/Propyl- for alkane groups

1.5 Organic Reactions

1.5.1 Organic Species

Definition 1.8: Lewis Acids and Bases

Lewis Acids are particles which readily accept e^- pairs. Lewis Bases are particles which readily donate e^- pairs.

Definition 1.9: Electrophile

An Electrophile is a species of particle which is electron-deficient or readily accepts electrons. This arises when the particle has vacant orbitals or has electrons strongly pulled from it such as a protonic H.

Definition 1.10: Nucleophile

A Nucleophile is a species of particle which is electron-rich or readily donates electrons. This arises when the particle has one or more lone pairs of electrons.

Electrophiles are attracted to electron rich sites of molecules while Nucleophiles are attracted to electron deficient sites.

1.5.2 Reaction Mechanisms

1.5.3 Types of Reactions

1.6 Isomerism

1.6.1 Constitutional Isomerism

1.6.2 Cis-trans Isomerism

1.6.3 Enantiomerism