# Organic Chemistry - Introduction

**Organic Chemistry**
- chemistry of carbon and its compounds, these compounds are called organic molecules.

## Synthesis

- making of organic compounds for particular uses, ex. For pharmaceutical industries, rubber, polymers, etc.
  Ex. when making compound D:

$$A + B \longrightarrow [C] \longrightarrow D$$

Reactants or Substances — Intermediate — Product

Intermediate: is not seen in the final product, but is formed on the pathway between reactants and products.

## Reaction Mechanism

The underlying details of the reaction constitute a reaction mechanism. Example in the above reaction, the mechanism is a 2-step reaction, i.e. reactant proceed to intermediates and the intermediates proceed to products.

## Hydrocarbons

- compounds of H and C only

- Aliphatic H'Cs
  - Alkanes
  - Alkenes
  - Alkynes
  - Alicyclic (Cyclic Aliphatic)
- Aromatic H'C's
  - Benzene
  - Benzene Derivatives

Alkylbenzenes

Cycloalkanes,
Cycloalkenes

Examples

The words 'aliphatic' and 'aromatic' are not confined to descriptions of hydrocarbons. They simply indicate whether or not compounds contain benzene rings. Aliphatic comes from the Greek word meaning 'fatty'. Aliphatic compounds do form the skeletons of most fats and oils. But the term can be used for many other compounds as well.

'Aromatic' comes from a Greek word meaning 'fragrant-smelling'. (However, note that many aromatic compounds have a foul smell and may also be toxic.)

Straight Chain and Branched Chain Alkanes:

## Primary, Secondary, and Tertiary Carbons

- A primary carbon is defined by being attached to only one other carbon, all hydrogens attached to a primary carbon become primary hydrogens.

- A secondary carbon is attached to two other carbons. All H's attached to a secondary carbon are secondary H's.

- A tertiary carbon, 3', is attached to three other carbons, all H's are 3' H's.

## Functional Groups (Centres of Reactivity)

The structure of a typical carbon compound can be considered as two parts: a saturated carbon – hydrogen 'skeleton', (backbone of carbons linked by single bonds with only H-atoms attached), which is comparatively unreactive, and a reactive part called the functional group:

Ethanol ethanonitrile ethanoic acid

Each functional group has its own characteristic properties, and they control the reactivity of the molecule as a whole. This means that the properties of any organic compound are, to a large extent, the sum of the properties of its functional group.

The name of an organic compound usually contains clues that indicate which functional groups are present (see later notes on Nomenclature of organic compounds). This means that organic chemistry is usually divided up into chemical families that have the same functional group.

Alkanes lack functional groups, as a result they are relatively non-polar and unreactive.

## Homologous Series

Compounds sharing the same functional group can be grouped together as a class i.e. they can be divided into families called homologous series.

Each member of a homologous series differs from the preceding one by the addition of a methylene group, $-CH_2$ group in its carbon chain. Molecules related in this way are ***homologs*** of each other and the series is *homologous series.*

The length of the carbon chain has little effect on the chemical reactivity of the functional group, however it does affect physical properties, such as m.p, b.p and solubility.

## Physical Properties

Physical properties include melting point, boiling point and solubility. These are determined by the intermolecular forces between the molecules.

Boiling point occurs when the molecules have sufficient energy to overcome the intermolecular forces operating between the molecules. Boiling point is affected by:

(1) the type of IMFA, and
(2) the size of the molecule

**1. Type of intermolecular force**

Hydrogen bonding is stronger than dipole-dipole forces, which are stronger than van-der-Waals forces. Thus hydrogen bonded liquids will have higher boiling points than dipole-dipole bonded liquids, and these in turn will have higher boiling points than liquids in which van-der-Waals forces operate.

Example: The following three liquids have ~ the same molecular mass, but their b.p decreases:

**The effect of different types of intermolecular forces on boiling point**

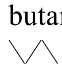
| Compound | Molar Mass | Structure | Type of IMFA | Boiling Point (K) |
|---|---|---|---|---|
| propan-1-ol | 60 | | hydrogen bonding | 371 |
| propanal | 58 | | dipole-dipole | 322 |
| butane | 58 | | van-der-Waals | 135 |

**2. Size of molecule**

In compounds where the same type of IMFA operates, then the van-der-Waals forces increase with the total number os electrons in the molecule and hence with increasing molecular mass.

Example: $CH_4$ b.p 109 K
$CH_3Cl$ b.p. 249 K

Melting point is affected by the same factors as boiling point: type of IMFA and relative molecular mass. However melting point is also affected by the shape of the molecule, as this affects the way the molecules can pack together in the solid state. The closer the molecules, the more effective are the intermolecular forces; usually the unbranched (linear) molecule has the higher melting point because its molecules can pack together more closely and are therefore harder to separate.

| Example: | butane | 2-methylpropane |
|---|---|---|
| |  |  |
| packing | efficient | poor |
| molar mass | 58 | 58 |
| m.p. | 135 K | 114 K |

Both of these isomers have the same molar mass, and they both have only van-der-Waals forces, however butane molecules pack more closely than those of 2-methylpropane.

## Solubility

The rule"like dissolves like" is a good rule to follow for solubility. In general, molecules with a functional group that can form hydrogen bonds will dissolve well in water, while non-polar molecules, like hydrocarbons will not.

Example:

Alcohols, R– O –H, amines, R – $NH_2$, and carboxylic acids, R– COOH, will all dissolve in water as long as the hydrocarbon chain of R is less than four carbon atom long. With longer carbon chains, the compounds gradually become less soluble, as the insoluble hydrocarbon begins to dominate the molecule's properties. However, a second hydrogen bonding group increases the solubility.

Polar molecules i.e. those possessing dipole-dipole forces can also confer water solubility:

Example: propanone, $CH_3 - \overset{\overset{\displaystyle O\,\delta-}{\|}}{\underset{\delta+}{C}} - CH_3$ , is very water soluble.

Non-polar compounds will dissolve well in non-polar solvents like hydrocarbons. A liquid of intermediate properties can often be used to get two immiscible (unmixable) substances to mix. Example: $H_2O$ and 1-iodobutane do not mix, but both water and 1-iodobutane will dissolve in ethanol; the ethanol is acting as a co-solvent.

## Reactivity of Organic Compounds

Bond energy give information about the amount of energy required to break a particular bond, see Table 10 of your Data Book. It is assumed that the weakest bond will break first in a molecule. This is true up to a point. It is possible to break the weaker $\pi$-bond of a multiple bond and leave the stronger $\sigma$-part intact. This usually occurs in the reactions of double bonds. The carbon chain rarely breaks at the position of the double bond.

## Equations in Organic Chemistry

In inorganic chemistry it is usual to write balanced symbol equations for reactions. This is sometimes possible in organic chemistry, but reactions are often written in other forms. Commonly, we simply write the organic starting material and organic product and the conditions above the arrow, rather than a fully balanced equation.

This is partly because organic chemist are simply interested in the product, and partly because organic reactions frequently give a mixture of products.
Oxidation (addition of oxygen) and reduction (addition of hydrogen) reactions are represented as [O] and [H] respectively.