S5 ORGANIC CHEMISTRY NOTES [By Mr. Mumbi George]

(A continuation from where we stopped)

(e) Inductive Effect:

It is a tendency of a group of atoms to push electrons away from or pull electrons towards itself.

If a group has a tendency to push electrons away from itself, it is said to have a positive inductive effect. e.g alkyl groups have a positive inductive effect.

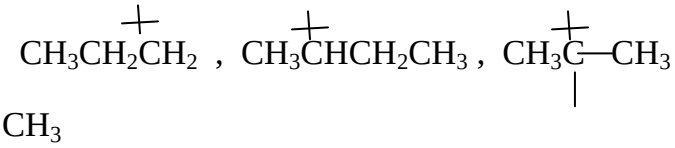
On the other hand, if a group has a tendency to pull electrons towards itself, it is said to have a negative inductive effect.e.g the nitro group ($-NO_2$) has a negative inductive effect.

(f) Carbonium Ion (Carbocartion):

A carbonium ion is a positively charged organic ion in which the positive charge is on a carbon atom.

In a carbonium ion, the positively charged carbon atom has only threebonds attaching it to other atoms, instead of the usual four.

Examples of carbocartions include the following:



There are three types of carbonium ions, namely:

(i) primary carbonium ions
(ii) secondary carbonium ions
(iii) tertiary carbonium ions

In a primary carbonium ion, the positively charged carbon atom is directly bonded to only oneother carbon atom, which is usually embedded in one alkyl group. Hence the general formula of a primary carbonium ion is $R\overset{+}{C}H_2$ e.g $CH_3CH_2\overset{+}{C}H_2$

In a secondary carbonium ion, the positively charged carbon atom is directly bonded to twoother carbon atoms, usually in the form of two alkyl groups. Therefore the general formula of a secondary carbonium ion is $R\overset{+}{C}HR^1$ e.g $CH_3\overset{+}{C}(CH_3)CH_3$

CH_3

The stability of a carbonium ion depends on the magnitude of positive chargeon the ion, the lower the magnitude (i.e closer to neutrality) the more stable and vise-versa.

Hence, the order of stability of the three types of carbonium ions is:

Primary carbonium ion < Secondary carbonium ion < Tertiary carbonium ion

i.e Primary carbonium ions are the least stable while tertiary carbonium ions are the most stable.

Reason:

In a primary carbonium ion, the positively charged carbon atom is directly bonded to one alkyl group. Since alkyl groups have a positive inductive effect, this single alkyl group pushes a small number of electrons towards the charged carbon atom- thereby reducing the positive charge to a small extent, thus the resultant magnitude of positive charge is highest.

In a tertiary carbonium ion, the positively charged carbon atom is directly bonded to three alkyl groups. These three alkyl groups push a big number of electronstowards the positively charged carbon atom- thereby greatly reducing the positive charge, thus the resultant magnitude of positive charge is lowest.

(f) Electrophile:

An electrophile is an electron-deficientspecies (particle).

Examples of electrophiles include: carbonium ions, proton (positively charged hydrogen ion, H^+), nitronium ion ($\overset{+}{N}O_2$).

In organic chemical reactions, electrophiles are electron-seeking ; hence they are attracted to electron-rich sites (i.e multiple bonds and atoms with lone pairs of electrons)

(g) Nucleophile:

A nucleophile is an electron-rich species. A nucleophile bears atleast a lone pair of electrons.

Examples of nucleophiles generally include all negatively charged ions and any molecule containing an atom with a lone pair of electrons.

e.g Chloride ions (Cl^-), Hydroxide ions (^-OH), Water molecules (H_2O) etc.

HOMOLOGOUS SERIES

1. Definition:

The term homologous series refers to a family (group) of organic compounds containing the same functional group, obeying the same general formula and in which one member differs from the previous one by possessing an extra methylene ($-CH_2-$) group.

2.Examples:

The table below gives examples of homologous series:

Functional Group	Name of Homologous series	Example of member
(a) -OH	Alcohols (Alkanols)	CH_3CH_2OH
(b) $-NH_2$	Amines	CH_3NH_2
(c) -COOH	Carboxylic acids (Alkanoic acids)	CH_3CH_2COOH
(d) $-\overset{|}{C}=\overset{|}{C}-$	Alkenes	$H_2C=CH_2$
(e) $-C\equiv C-$	Alkynes	$CH_3C\equiv CH$

(f) $-\overset{\overset{O}{\|}}{C}-$	Ketones(Alkanones)	$CH_3\overset{\overset{O}{\|}}{C}-CH_3$ (or CH_3COCH_3)
(g) $-\overset{\overset{O}{\|}}{C}-H$	Aldehydes (Alkanals)	$CH_3CH_2CH_2\overset{\overset{O}{\|}}{C}-H$ (or $CH_3CH_2CH_2CHO$)
(h) –O-	Ethers	CH_3OCH_3
(i) –X (X= F, Cl, Br or I)	Alkylhalides (Haloalkanes)	$CH_3CH_2CH_2Br$

3.General Nomenclature of Members of the Various Homologous Series

(According to the IUPAC System)

The International Union of Pure and Applied Chemistry (IUPAC) has got a systematic way of naming an organic compound. This depends on the particular homologous series to which the compound belongs.

(a) Alcohols (Alkanols):

Members of this homologous series are named by replacing the final ‘e’ in the name of the corresponding alkane with ‘ol’, thus making the name to generally be of the form alkanol. (i.e replacing the ‘e’ in alkane wit ‘ol’)

For some members, the name must include a number, to specify the position of the functional group. [To obtain this position, the carbon atoms in the chain are numbered. The numbering can either be from left to right or right to left; the direction which gives a smaller position for the carbon atom with the functional group is taken]

In this case, the number comes just before ‘ol’ and the number must be separated from a letter by a hyphen(i.e ‘- ‘). Hence, the name is generally of the form, ‘alkan-No-ol’

e.g CH_3OH , Methanol

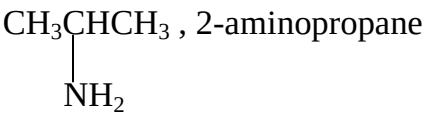
$CH_3CH_2CH_2OH$, Propan-1-ol

(b) Amines:

Members of this homologous series are named by putting the prefix ‘amino’ infront of the name of the corresponding alkane. Hence, the general name of the amine is of the form, aminoalkane.

Forsome members, the name must include a number to specify the position of the functional group. In this case, the number comes infront of the prefix ‘amino’. Therefore, the name will generally be of the form, No-aminoalkane.

e.g $CH_3CH_2NH_2$, Aminoethane



, 2-aminopropane

e.t.c

(c) Carboxylic acid (Alkanoic acid):

Members are named by replacing the final ‘e’ in the name of the corresponding alkane with ‘oic acid’- thus making the general name to be of the form, alkanoic acid.

In a carboxylic acid, the functional group is always in one position(position 1)-hence the reason why there is no need for including a number to show the position of the functional group.

e.g CH_3COOH , Ethanoic acid

CH_3CH_2COOH, Propanoic acid

e.t.c

(d) Alkenes:

Members of the series are named by replacing the final ‘ane’ in the name of the corresponding alkane with ‘ene’.

For some members, the name must include a number to indicate the position of the functional group (i.e the carbon- carbon double bond). In this case, the position is the smaller number of the two numbers between which the double bond lies and the direction of numbering the chain is that which gives a smaller sum of numbers between which the double bond lies.

In this case the number to indicate the position of the double bond comes just before 'ene'

e.g $H_2C{=}CH_2$, Ethene

$CH_3CH_2CH{=}CH_2$, But-1-ene

$CH_3CH{=}CHCH_3$, But-2-ene

e.t.c

(f) Alkynes:

Members of the series are named by replacing the final 'ane' in the name of the corresponding alkane with 'yne'.

For some members, the name must include a number to indicate the position of the functional group (i.e the carbon- carbon triple bond). In this case, the position is the smaller number of the two numbers between which the triple bond lies and the direction of numbering the chain is that which gives a smaller sum of numbers between which the triple bond lies.

In this case the number to indicate the position of the triple bond comes just before 'yne'

e.g $CH_3C{\equiv}CH$, Propyne

$HC{\equiv}CCH_2CH_3$, But-1-yne

(g) Aldehydes (Alkanals):

Members of this homologous series are named by replacing the final 'e' in the name of the corresponding alkane with 'al'- hence making the name to generally be of the form, alkanal.

Just like the carboxylic acids, the functional group in an aldehyde is always in the same position, position1.Therefore, the name of an aldehyde also does not include a number to show the position of the functional group.

e.g 

HC-H , Methanal

$CH_3CH_2CH_2CHO$, Butanal

e.t.c

(h) Ketones (Alkanones):

Members are named by replacing the final 'e' in the name of the corresponding alkane with 'one', thus making the name to be generally of the form, alkanone.

For some members, the name must include a number to show the position of the functional group. In this case, the number comes just before, 'one' This therefore makes the name to be of the form, alkan-No-one.

e.g 

$CH_3C\text{-}CH_3$, Propanone

$CH_3CH_2COCH_2CH_3$, Pentan-3-one

e.t.c

(i)Alkylhalides (Haloalkanes):

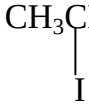
Members are named by attaching the appropriate 'halo' prefix (i.e fluoro- for F, chloro- for Cl, bromo-for Br and Iodo-for I) infront of the name of the corresponding alkane.

For some members, the name must include numberto indicate the position of the halogen atom (i.e the functional group). In this case, the number comes just before the halo prefix, thus making the name to be of the general form, No-haloalkane.

In case the alkylhalide contains more than one identical halogen atoms, then we use prefixes –di (for two), tri (for three), tetra (for four) etc, to indicate their number. However, this is preceeded by numbers(that are separated by commas, each number corresponding to a halogen atom)

e.g CH_3Cl , Chloromethane

CH_3CH_2Br , Bromoethane



CH_3CHCH_3 , 2-Iodopropane

I

$BrCH_2CH_2Br$, 1,2-Dibromoethane

e.t.c

Note:

In case the compound contains different halogen atoms , then we use alphabetical order to tell which halo prefix comes first in the name. However, the position of each halogen has to be indicated, by numbering.

e.g $BrCH_2CH_2CH_2Cl$, 1-Bromo-3-chloropropane

Cl_2CHCH_2I , 1,1-Dichloro-2-iodoethane

e.t.c

(j) Ethers:

The general structure of an ether is ROR^1 , where R and R^1 are alkyl groups.

The name of an ether generally is of the form, Alkoxy alkane; the alkoxy group corresponding to RO- or $-OR^1$ and the alkane name being derived from the other alkyl group (which has not been associated with the oxygen atom in identifying the alkoxy group in the compound).

The alkyl group chosen to be associated with the oxygen atom so as to form the alkoxy group is the one with a smaller number of carbon atoms.

e.g $CH_3OCH_2CH_3$, Methoxy ethane

$CH_3CH_2CH_2OCH_2CH_3$, Ethoxy propane

e.t.c

EXERCISE:

1) Give the IUPAC name of each of the following compounds:

(a) $CH_3\underset{\underset{|}{OH}}{CH}CH_2CH_3$

(b) $CH_3CH_2CH_2CH_2COOH$

(c) $CH_3CH_2\underset{\displaystyle NH_2}{\underset{|}{C}}HCH_2CH_3$

(d) $CH_3CH_2COCH_3$

(e) $CH_3C{\equiv}CCH_2CH_3$

2) Write the structural formula of each of the following compounds:

(a) Pent-2-ene

(b) Methoxy butane

(c) 1,2-dichloropropane

(d) Ethanal

(e) Cyclohexanol