CHM 102
Organic Chemistry

HOMOLOGOUS SERIES AND FUNCTIONAL GROUPS

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HOMOLOGOUS SERIES

- **A homologous series represent a group of compounds with the same functional group**.

- Members of the same homologous series are known as homologs and the general characteristics of homologs include:

- They are represented by the same general formula
- Each member differs from the next member by a $–CH_2$ unit.
- The physical properties change gradually with increasing molar mass.
- They have similar chemical properties.
- And can be prepared by the same method.

Homologous (family) Series

- **Each series has a general formula.**

- All members possess the same **functional group**. It is the functional group that gives the series its **characteristic reactions**.

- There is a gradual change in physical properties from one member to the next. The most common example of this is the increasing melting and boiling points as we go up a series. The reason for this is that the molecules get larger and therefore harder to break.

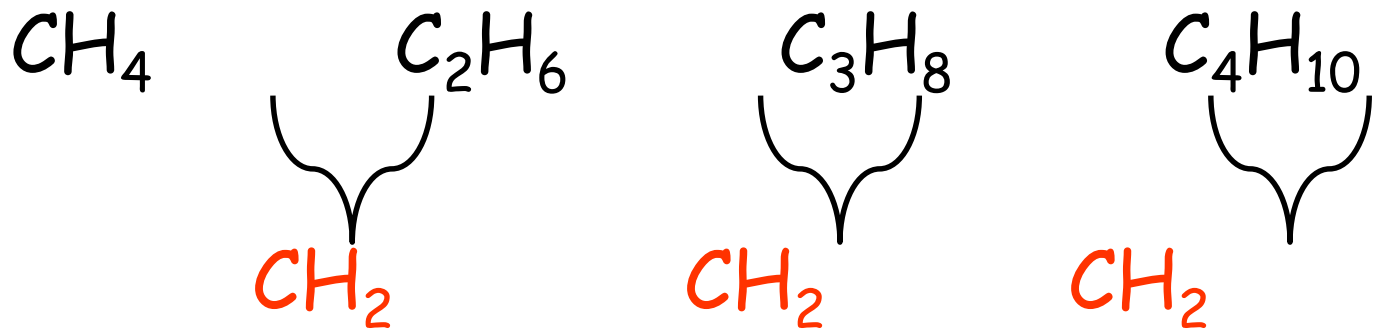
- Members of the same homologous series have similar chemical properties.

Characteristics of a homologous series

- All members of the series can be represented by the same general formula
- Each member of the series differs from the members before or after it by a – CH_2- functional group
- All members of the series possess similar chemical properties
- All members of the series show a gradual change in their physical properties as their molecular mass increases. In general, as molar mass increases, melting point, boiling point and density increase

Homologous Series

A homologous series is a series of compounds that have the same functional group, and each member differs from the next member by a – CH_2 – unit in their formulae.



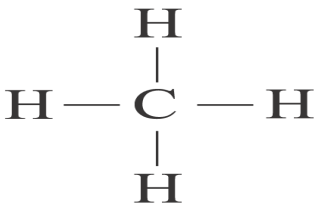
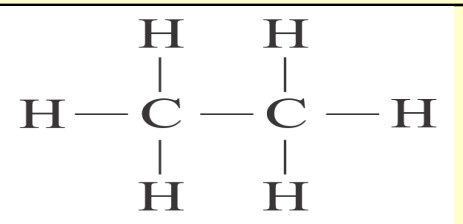
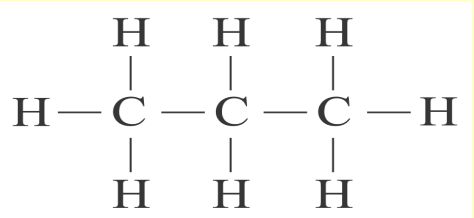
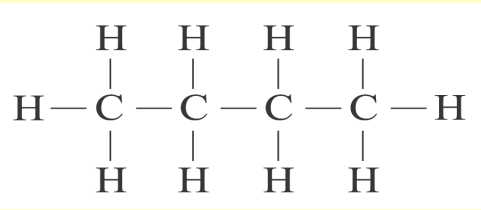
Homologous Series of Hydrocarbons

Hydrocarbons are compounds that only have Carbon and Hydrogen...

- There are several types of homologous series of hydrocarbons that are based on the number of bonds and the arrangement the atoms in that compound. They include:

Alkanes, Alkenes, Alkynes, & Benzene

The first four members of straight-chain alkanes

Number of carbon atom(s)	IUPAC name	Molecular formula	Condensed structural formula	Structural formula
1	Methane	CH_4	CH_4	
2	Ethane	C_2H_6	CH_3CH_3	
3	Propane	C_3H_8	$CH_3CH_2CH_3$	
4	Butane	C_4H_{10}	$CH_3CH_2CH_2CH_3$	

Homologous Series

- The physical properties change gradually along the homologous series
- e.g. the longer the carbon chain in the molecule (or the greater the molecular mass)

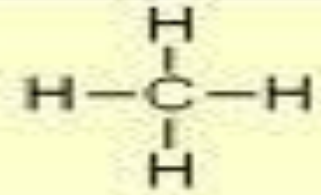
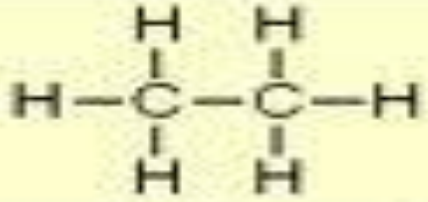
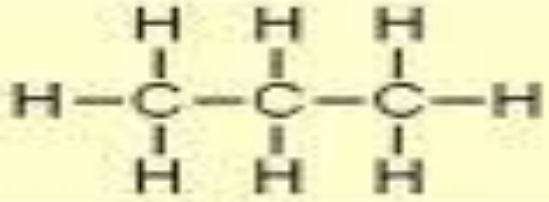
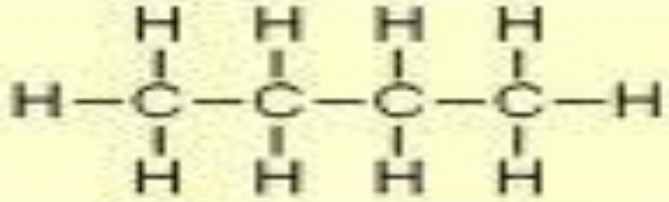
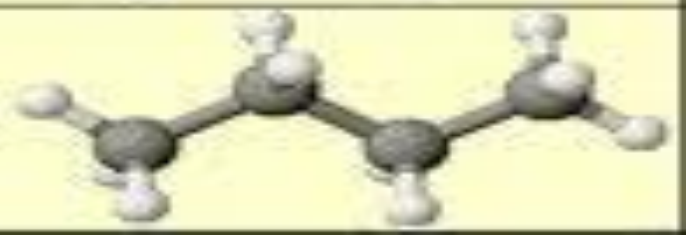
  ➔ the greater the attractive force between molecules

  ➔ the higher the melting point, boiling point and density

Homologous Series

A homologous series is a group of compounds which all possess the same functional group. Members of homologous series all have the same general formula.

- Example Alkanes : **C_nH_{2n+2}**

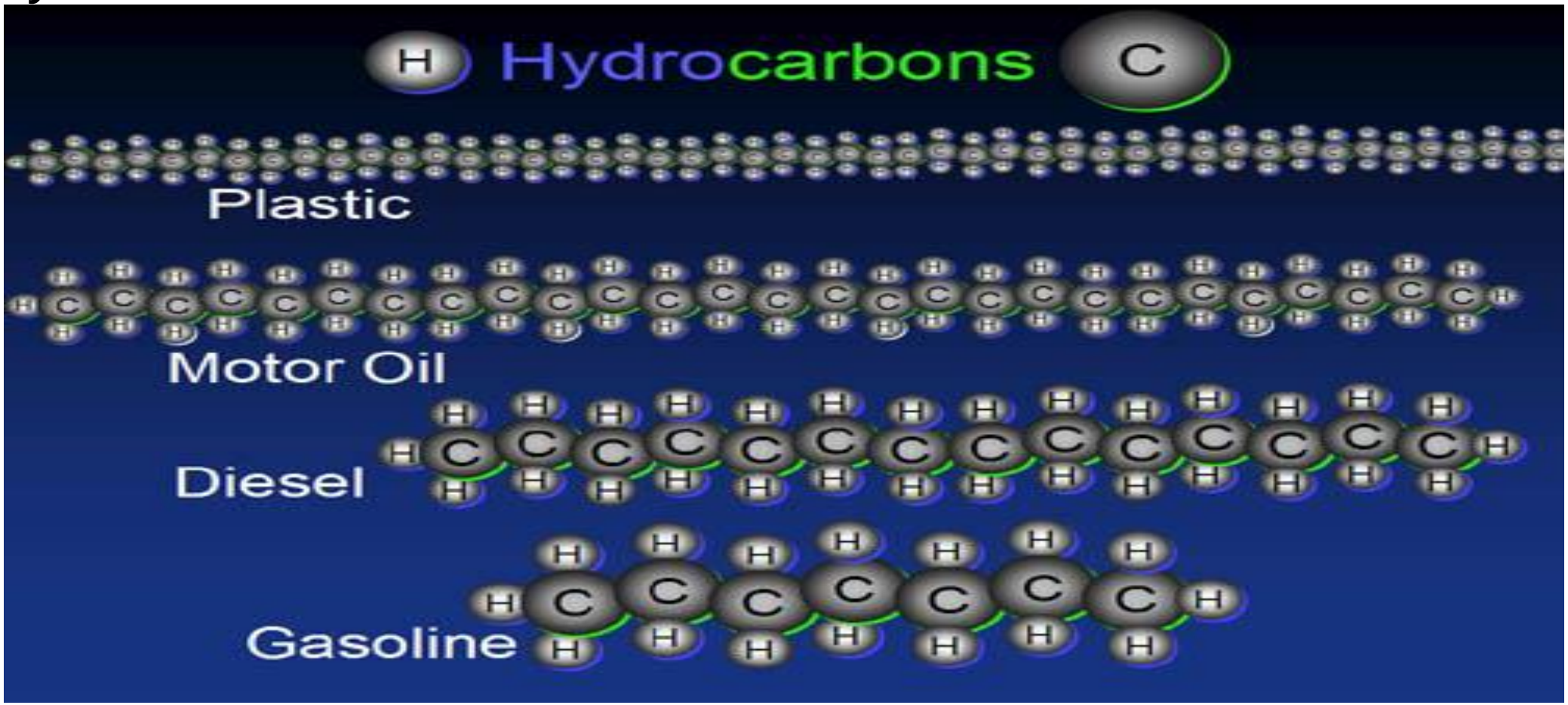
methane CH_4		
ethane C_2H_6		
propane C_3H_8		
butane C_4H_{10}		

Names of some Alkenes (Homologs)

Number of carbons	Molecular Formula	Name
2	C_2H_4	ethene
3	C_3H_6	propene
4	C_4H_8	butene
5	C_5H_{10}	pentene
6	C_6H_{12}	hexene
7	C_7H_{14}	heptene
8	C_8H_{16}	octene
9	C_9H_{18}	nonene
10	$C_{10}H_{20}$	decene

What are hydrocarbons?

- All organic compounds contain carbon. Those that contain only carbon and hydrogen are called hydrocarbons.



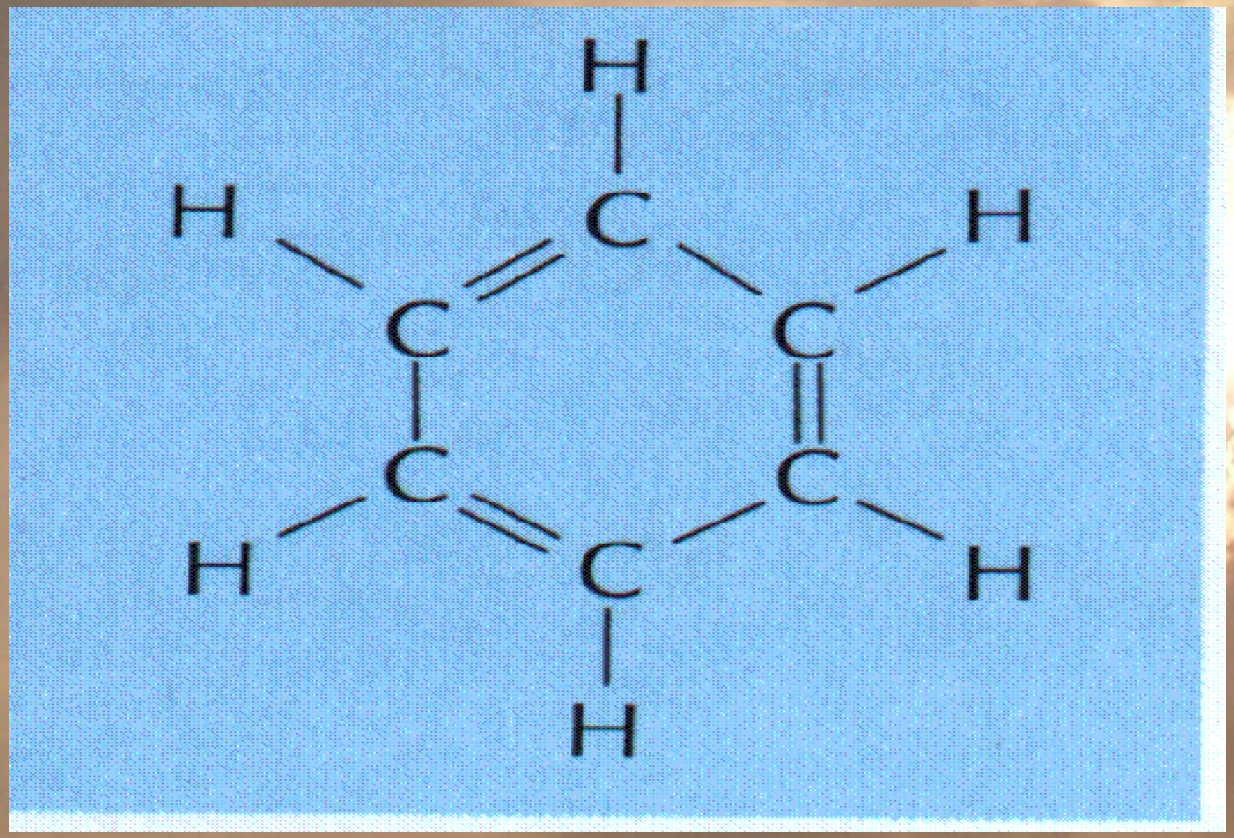
Benzene

- The final homologous hydrocarbon that is very stable.
- They are often called aromatic compounds.
- They are distinguished by alternating double and single bonds throughout a molecule.
- A Benzene molecule is illustrated by the following formula:

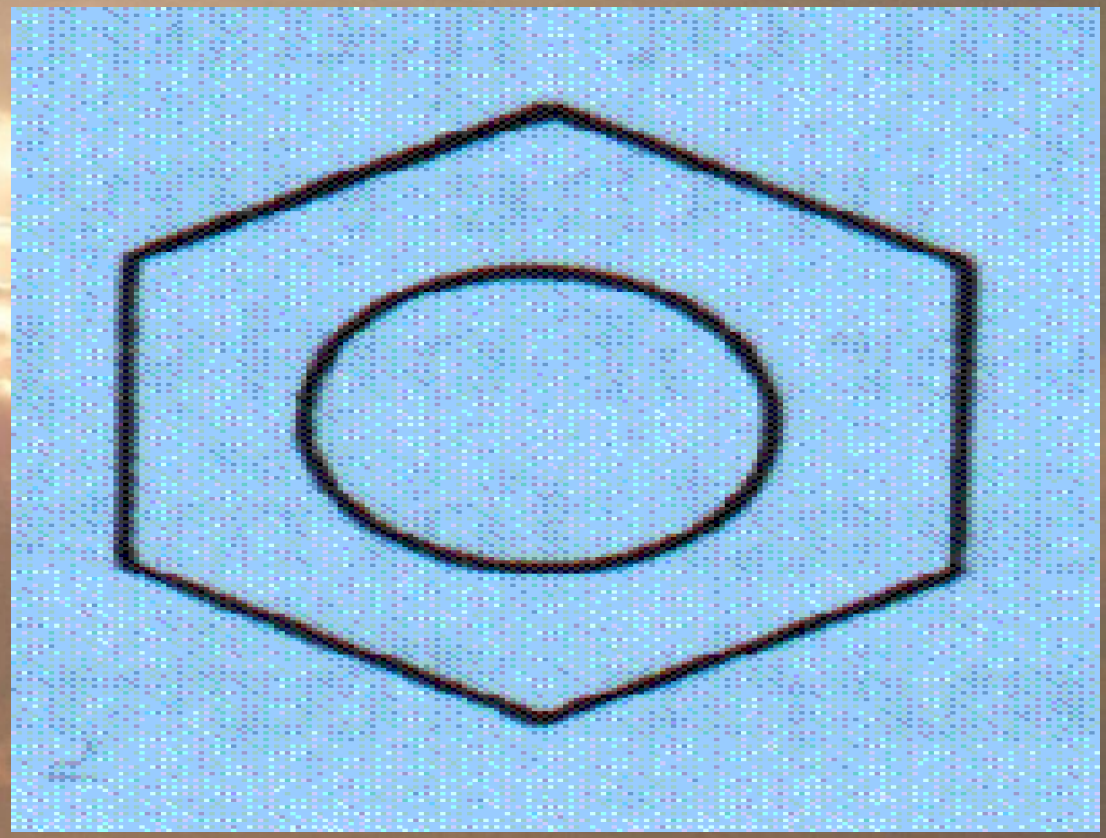
$$C_nH_{2n-6}$$

Benzene

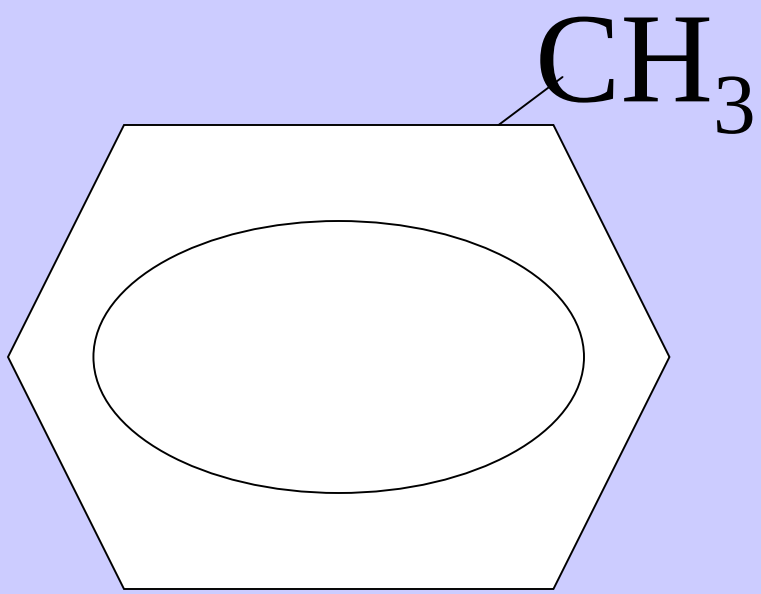
They can be written as…..



or



Benzene



Methyl Benzene or Toluene

Alkyl halides (A class of Organic Compound)

The alkyl halides are also known as halo alkanes

- These are important compounds in organic synthesis reactions. For the purposes of nomenclature the halogens F, Cl,Br, I are treated as fluoro (not flouro), chloro, bromo and iodo side groups.

Halogen Substituents

When a halogen is connected to a parent chain of a hydrocarbons it is given the following prefixes:

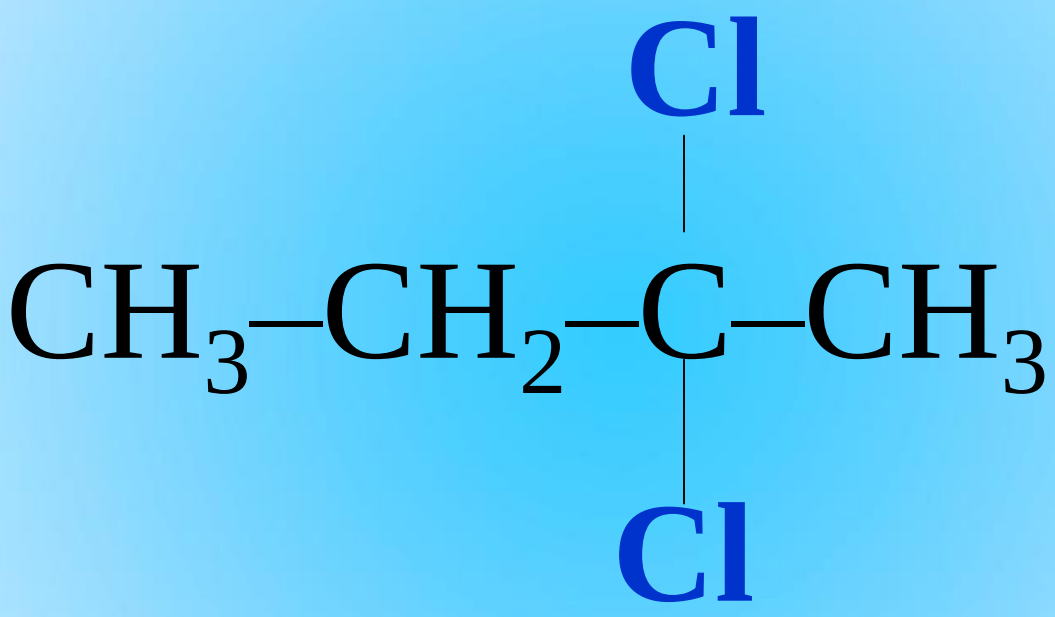
Cl = Chloro

Br = Bromo

F = Fluoro

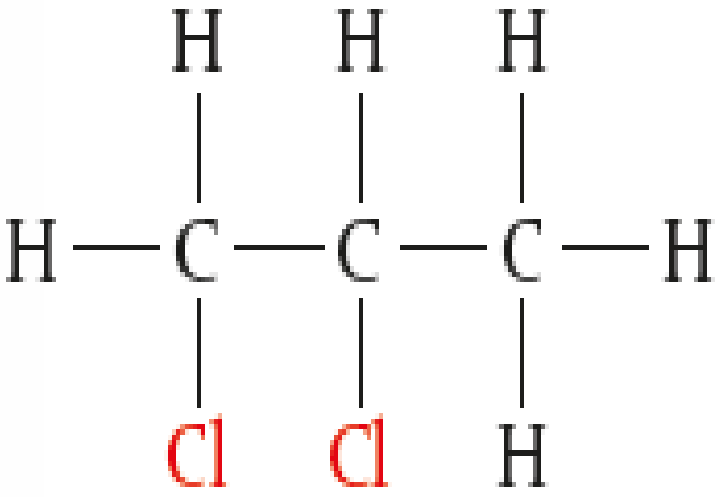
I = Iodo

Halogen Substituents (Alkyl Halides)

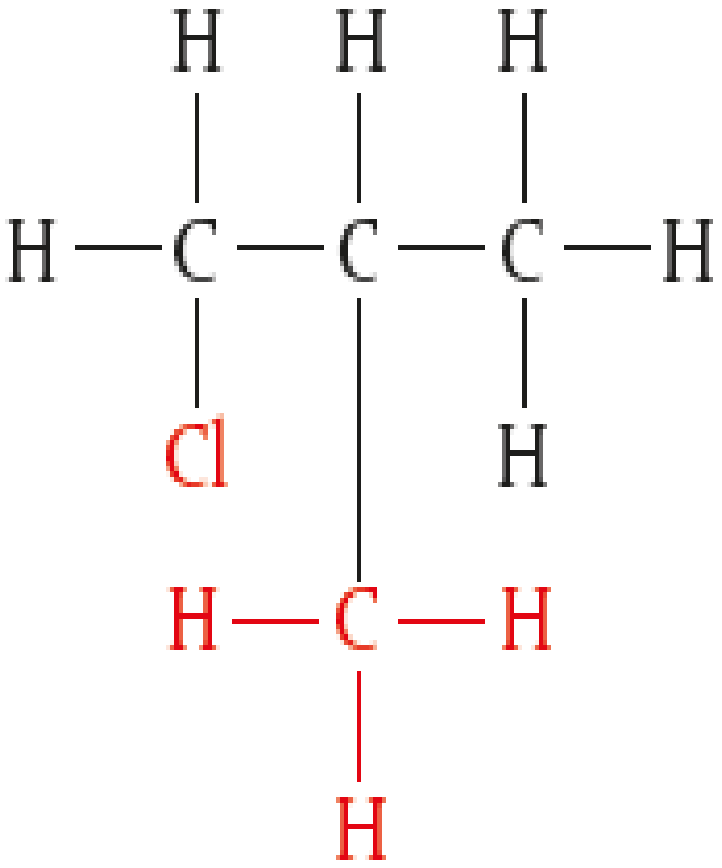


2,2 dichlorobutane

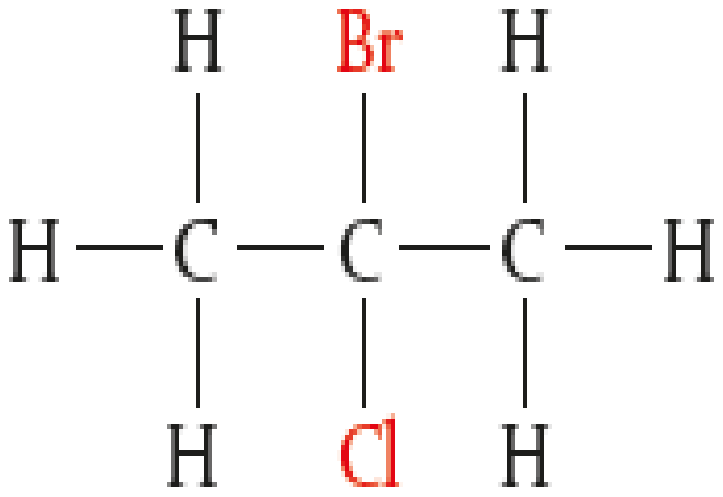
Halo-Alkanes



1,2-dichloropropane



1-chloro-2-methylpropane



2-bromo-2-chloropropane

Functional Groups

- Organic compounds are classified by the presence of characteristic functional groups
- A functional group is defined as an atom or a group of atoms that effectively determines the chemical properties of an organic compound.
- A functional Group is a particular arrangement of a few atoms on a hydrocarbon that results in specific chemical and physical properties for that type or class of organic molecules

Functional Groups

- Organic compounds are classified into groups based on the functional group which they contain.

- A functional group contains a particular bond between two carbon atoms, e.g. a double bond, or is a particular atom or a particular group of atoms.

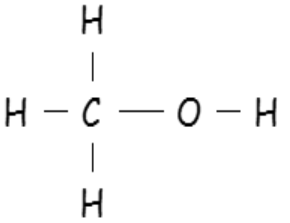
- All members of a group contain the same functional group which determines the properties of that group. The group is known as a homologous series.

Functional Groups

Homologous series	Functional Group		Example
	Structure	Name	
Alkane	none	-	CH_3-CH_3
Alkene		carbon-carbon double bond	$H_2C{=}CH_2$
Alkyne	-C≡C-	carbon-carbon triple bond	HC≡CH

Alcohols

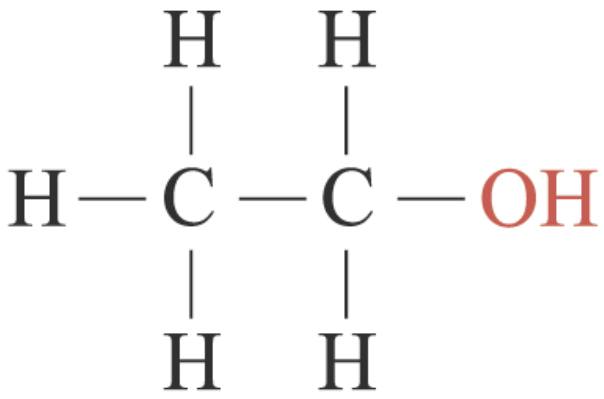
- The names of all alcohols end in **'-ol'**
- The functional group of the alcohols is **–OH** (hydroxyl group)
- Formula of the first member of the homologous series ……**CH_3OH**
- Alcohols are substituted alkanes (as an -H has been replaced
- with an –OH)
- Alcohols are made via hydration of alkenes and fermentation.
- The structural formula of first member of the alkanols is-----



- Alcohols are useful industrial and pharmaceutical solvents.
- First member of homologous series is called …**methanol**
- All alcohols follow the general formula;

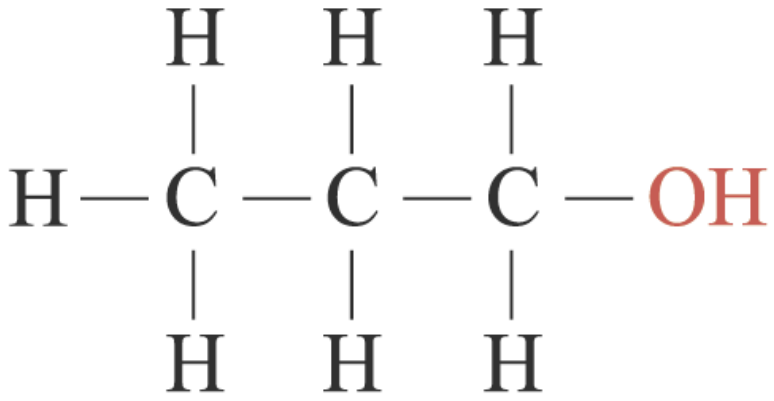
$$C_nH_{2n+1}OH$$

Alcohols



Ethanol

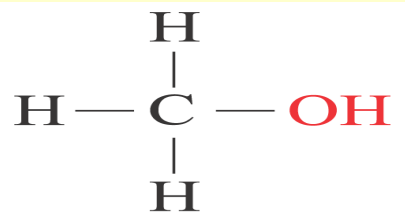
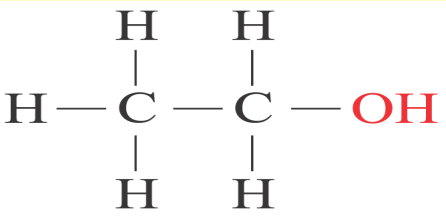
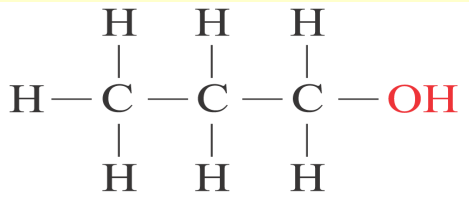
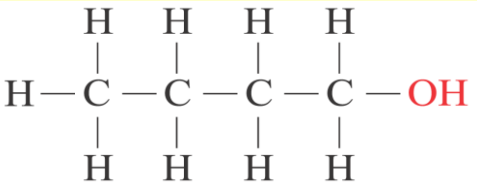
and



Propan-1-ol

- have similar chemical properties
  - ➔ they contain the same functional group –OH
  - ➔ they are classified into the same homologous series — alcohols

The first four members of straight-chain alcohols

Number of carbon atom(s)	IUPAC name	Molecular formula	Condensed structural formula	Structural formula
1	Methanol	CH_3OH	CH_3OH	
2	Ethanol	C_2H_5OH	CH_3CH_2OH	
3	Propan-1-ol	C_3H_7OH	$CH_3CH_2CH_2OH$	
4	Butan-1-ol	C_4H_9OH	$CH_3CH_2CH_2CH_2OH$	

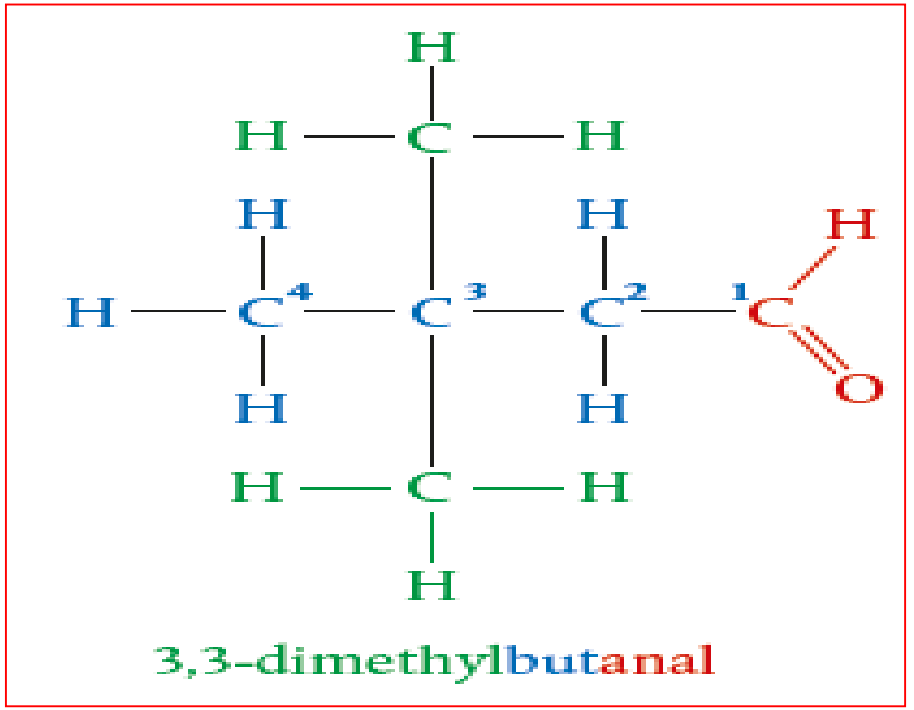
Functional Groups

- **Members in the same series can be represented by a general formula.**

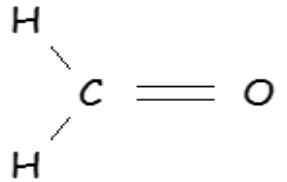
e.g. alkanols: $C_nH_{2n+1}OH$

alkanals: $C_nH_{2n+1}CHO$

alkanoic acids: $C_nH_{2n+1}COOH$



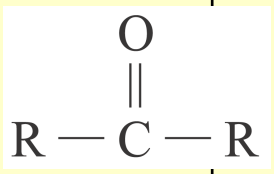
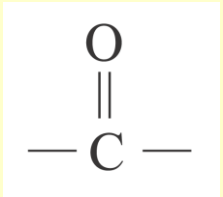
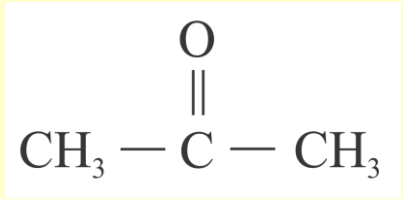
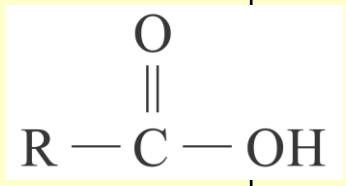
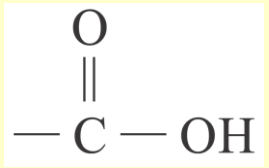
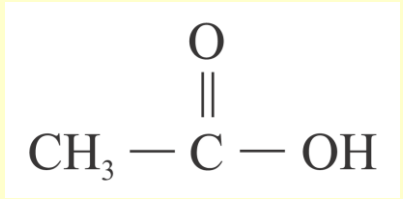
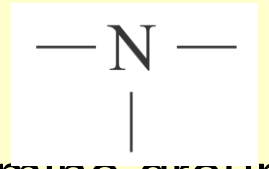
- The structural formula of first member of the alkanals is----



Functional Groups: Carboxylic Acids

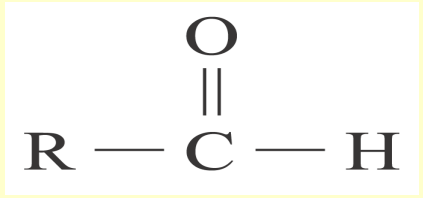
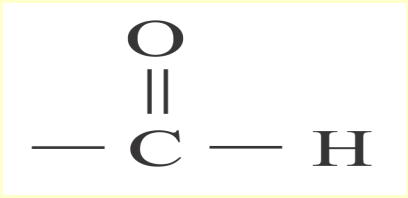
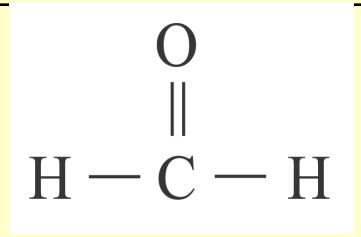
- The names of all carboxylic acids end in '-**oic acid**'
- The functional group of the carboxylic acids is **-COOH (carboxyl group)**
- This carboxyl group is **always** attached to the end carbon.
- Carboxylic acids react like other acids
- General Formula; $C_n H_{2n+1} COOH$

Functional Groups

Family	General formula	Functional group	Example	
			Formula	IUPAC name
Ketone		 carbonyl group		Propanone
Carboxylic acid		 carboxyl group		Ethanoic acid
Amine	RNH_2 R_2NH R_3N	 amino group	CH_3NH_2	Methylamine
Nitrile	$RC{\equiv}N$	$-C \equiv N$ nitrile group	CH_3CN	Ethanenitrile

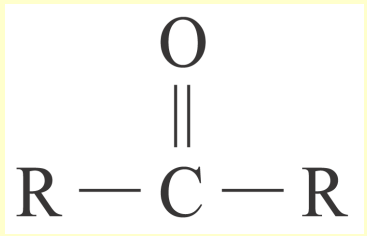
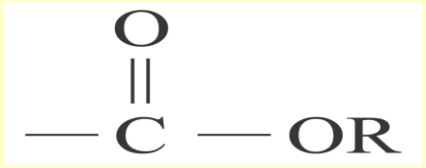
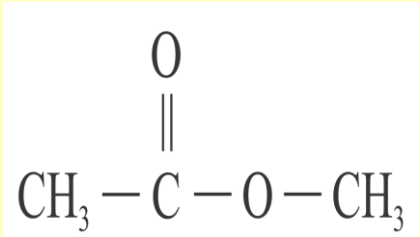
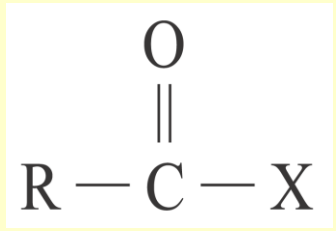
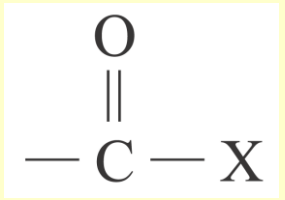
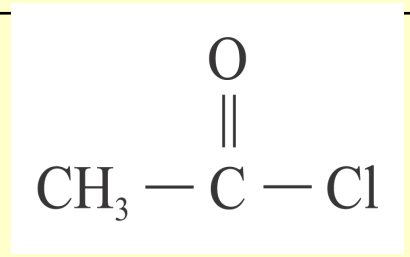
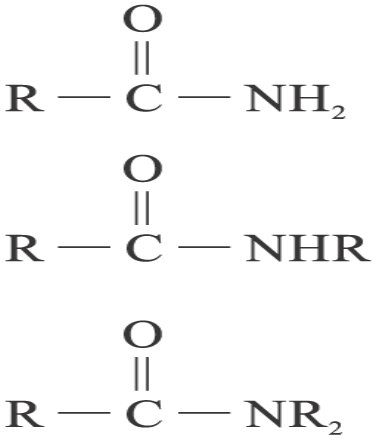
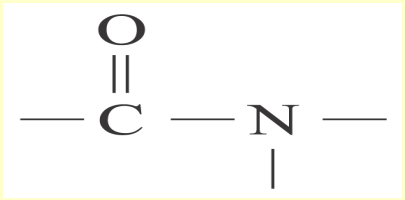
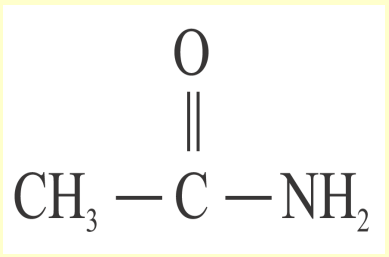
R = $C_nH_{2n+1}-$

Functional Groups

Family	General formula	Functional group	Example	
			Formula	IUPAC name
Haloalkane	RX	— X halo group	CH_3Cl	Chloromethane
Alcohol	ROH	— OH hydroxyl group	CH_3OH	Methanol
Ether	R—O — R	— O — oxy group	CH_3 — O — CH_3	Methoxymethane
Aldehyde		 carbonyl group		Methanal

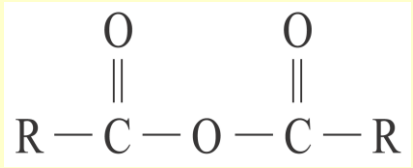
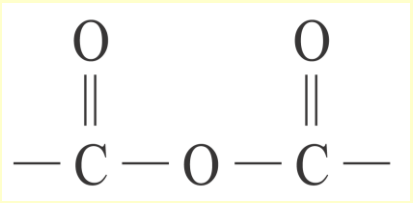
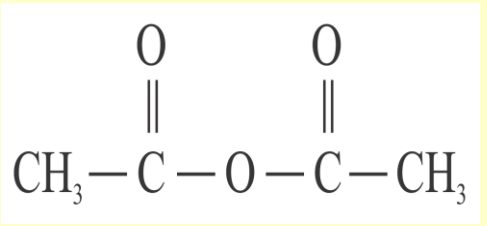
R = C_nH_{2n+1} –

Functional Groups

Family	General formula	Functional group	Example	
			Formula	IUPAC name
Ester		 ester group		Methyl ethanoate
Acyl halide		 acyl halide group		Ethanoyl chloride
Amide		 amide group		Ethanamide

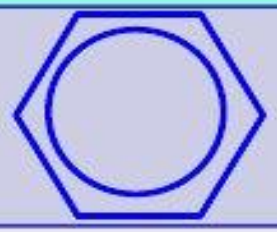
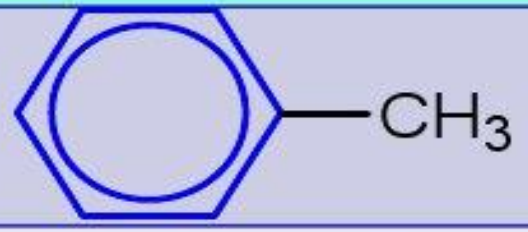
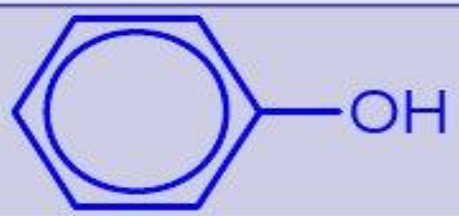
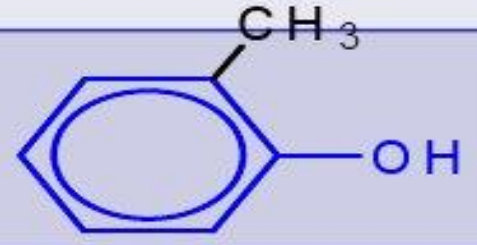
$R = C_nH_{2n+1}-$

Functional Groups

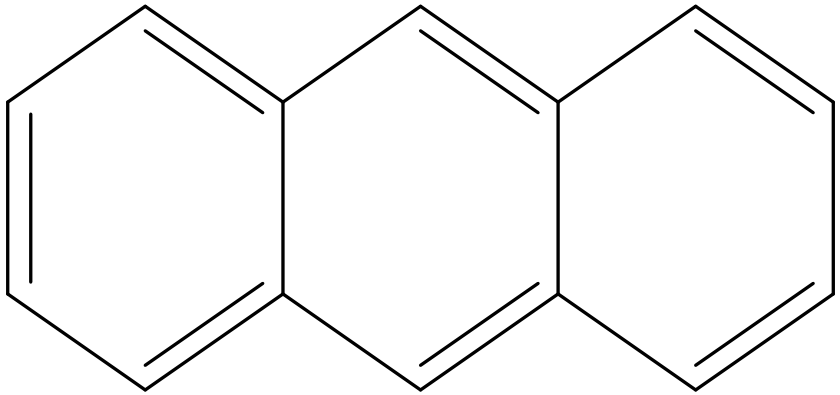
Family	General formula	Functional group	Example	
			Formula	IUPAC name
Acid anhydride		 acid anhydride group		Ethanoic anhydride

$R = C_nH_{2n+1}-$

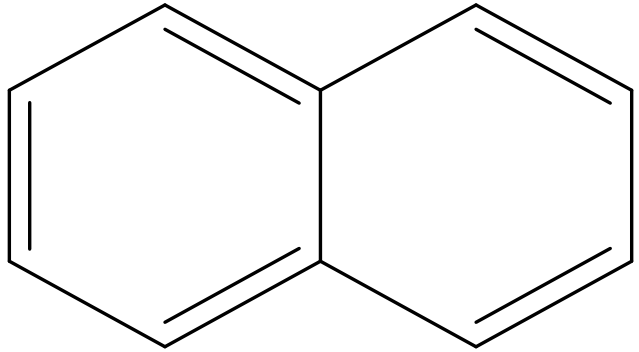
Functional Groups

Homologous series	Functional Group		Example
	Structure	Name	
Aromatic/ Arene		Benzene ring	
Alcohol	-OH	Hydroxyl	CH_3OH
Phenol		Hydroxyl	
Haloalkane	-X (F,Cl,Br,I)	Halogen	CH_3Cl

Aromatic Hydrocarbon



anthracene



naphthalene