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Chemistry
Chapter 4
Carbon and its compounds

Top concepts:

1. Covalent bond: A covalent bond is a bond formed by sharing of electrons between atoms. In a covalent bond, the shared pair of electrons belongs to the valence shell of both the atoms.

2. Conditions for formation of covalent bond:
   a. The combining atoms should have 4 to 7 electrons in their valence shell.
   b. The combining atoms should not lose electrons easily.
   c. The combining atoms should gain electrons readily.
   d. The difference in electronegativities of two bonded atoms should be low.

3. Properties of covalent compounds:
   a. Physical states: They are generally liquids or gases. Some covalent compounds may exist as solids.
   b. Solubility: They are generally insoluble in water and other polar solvents but soluble in organic solvents like benzene, toluene etc.
   c. Melting and boiling point: They generally have low melting and boiling points.
   d. Electrical conductivity: They do not conduct electrical current.

4. Steps for writing the Lewis dot structures of covalent compounds:
   a. Write the electronic configuration of all the atoms present in the molecule.
   b. Identify how many electrons are needed by each atom to attain noble gas configuration.
   c. Share the electrons between atoms in such a way that all the atoms in a molecule have noble gas configuration.
   d. Keep in mind that the shared electrons are counted in the valence shell of both the atoms sharing it.

5. Electronic configuration of some non- metals:

Name of element	Symbol	Atomic No.	Electrons	Distribution of electrons	Valency	Type of element
Hydrogen	H	1	1	1	1	Non – metal
Carbon	C	6	6	2, 4	4	Non – metal
Nitrogen	N	7	7	2, 5	3	Non – metal
Oxygen	O	8	8	2, 6	2	Non – metal

Fluorine	F	9	9	2, 7	1	Non – metal
Phosphorus	P	15	15	2, 8, 5	3	Non – metal
Sulphur	S	16	16	2, 8, 6	2	Non – metal
Chlorine	Cl	17	17	2, 8, 7	1	Non – metal
Argon	Ar	18	18	2, 8, 8	0	Noble gas

6. Carbon forms covalent bonds.

7. Electronegativity – It is the ability of an atom to attract a shared pair of electrons towards itself.

8. If the atoms forming a covalent bond have different electronegativities, the atom with higher electronegativity pulls the shared pair of electron towards itself. Thus, the atom with the higher electronegativity develops a partial negative charge and the atom with the lower electronegativity develops a partial positive charge. This covalent bond with some polarity is called polar covalent bond.

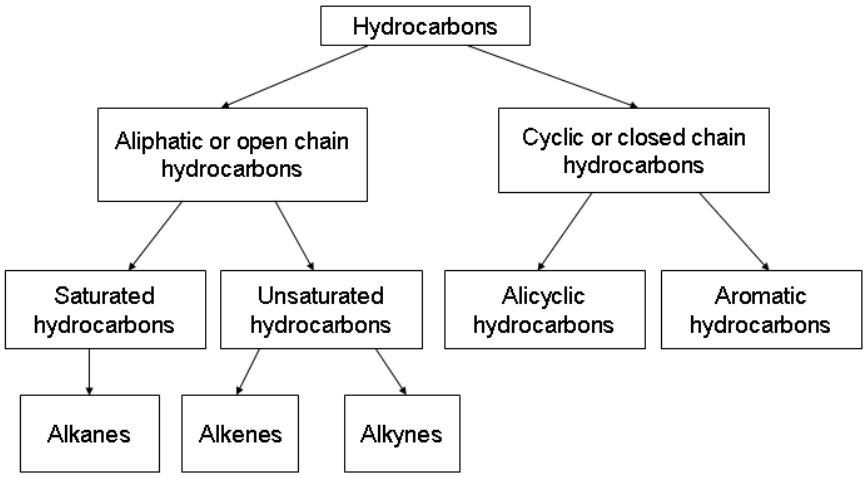
9. Carbon forms a large number of compounds because of two unique properties:
    a. Tetravalency
    b. Catenation

10. Tetravalency of carbon:
    Atomic number = 6
    Electronic configuration: 2, 4
    Valence electrons = 4
    Valency = 4
    So, carbon needs four electrons to attain noble gas configuration. Or in other words, carbon has the ability to form four bonds with carbon or atoms of other mono-valent elements.

11. Catenation: Carbon has the unique ability to form bonds with other atoms of carbon, giving rise to large molecules. This property is called catenation.

12. Steps for writing the Lewis dot structures of Hydrocarbons:
    a. Write the electronic configuration of all the atoms present in the molecule.
    b. Identify how many electrons are needed by each atom to attain noble gas configuration.
    c. First complete the noble gas configuration of all the hydrogen atoms by bonding each hydrogen atom with a carbon atom by a single bond.
    d. The remaining valency of each carbon is completed by forming carbon – carbon single, double or triple bonds.
    e. Keep in mind that the shared electrons are counted in the valence shell of both the atoms sharing it.

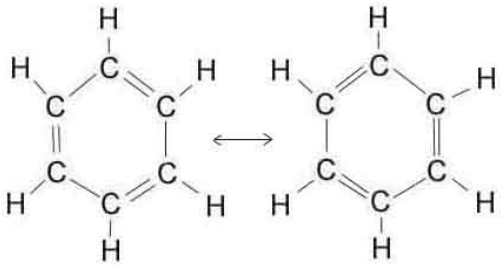
13. Classification of hydrocarbons:



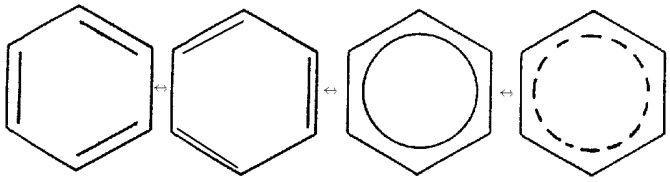
a. Aliphatic or open chain hydrocarbons: These are the carbon compounds which have carbon carbon long open chains. They are classified as:
   i. Saturated hydrocarbons: These hydrocarbons have all carbon – carbon single bonds.
   ii. Unsaturated hydrocarbons: These hydrocarbons have at least one carbon – carbon double or triple bonds.
      - Hydrocarbons with at least one carbon-carbon double bond are called alkenes.
        General formula = C_nH_{2n} where n = number of carbon atoms
      - Hydrocarbons with at least one carbon-carbon triple bond are called alkynes.
        General formula = C_nH_{2n-2} where n = number of carbon atoms

b. Cyclic or closed chain hydrocarbons: These are the hydrocarbons which have carbon carbon closed chain.
   They are classified as:
   i. Alicyclic hydrocarbons: These are the hydrocarbons which do not have benzene ring in their structure.
   ii. Aromatic hydrocarbons: These are the hydrocarbons which have benzene ring in their structure. When hydrogen bonded to carbon of benzene is substituted with halogens, radicals or other functional groups, the derivatives are called aromatic compounds.

14. Benzene: It is an aromatic hydrocarbon which has the molecular formula C_6H_6. It has alternating carbon - carbon single and double bonds.



Benzene can also be represented as:



15.IUPAC name of hydrocarbon consists of two parts:

a. Word root: Number of carbons in the longest carbon chain

Number of carbon atoms	Word root (Greek name)
1	Meth
2	Eth
3	Prop
4	But
5	Pent
6	Hex
7	Hept
8	Oct
9	Non
10	Dec

b. Suffix: Depends on the type of carbon – carbon bond: for single bond, suffix is –ane ; for double bond, suffix is –ene, and for triple bond suffix is –yne

16.Steps to write the IUPAC nomenclature of hydrocarbons:

a. Select the parent carbon chain:
   i. Select the longest carbon chain as the parent chain.
   ii. If a double or a triple bond is present in the carbon chain, it should be included in the parent chain.

b. Number the parent carbon chain from that carbon end such that the double bond, triple bond or side chain gets the lowest number.

c. Identify and name the side chain if any: $-CH_3$ is named as methyl, $-C_2H_5$ is named as ethyl etc. Also identify the position of the side chain.
d. Write the name of the hydrocarbon as:
Position number-name of the side chain word root – Position number- suffix
Example: 2-Methyl but-1-ene
e. Remember if the hydrocarbon is an alkane, the position number of suffix is not written.

17. Types of formula for writing hydrocarbons:
a. Molecular formula: The actual number of each type of atom present in the compound.
b. Structural formula: The actual arrangement of atoms is written
c. Condensed formula: It is the shortened form of the structural formula

18. Conditions for Isomerism:
a. Only alkanes with more than three carbon atoms can have isomers.
b. The side chains cannot be present on the terminal carbons.

19. How to write different chain isomers of hydrocarbons:
a. First draw the different carbon chains keeping in mind the conditions for isomerism.
b. Complete the tetravalency of carbon by forming single covalent bonds with hydrogens.
c. In the end, check that the molecular formula of each isomer should be same.

20. How to write different position isomers of unsaturated hydrocarbons:
a. First draw the different carbon chains keeping in mind the conditions for isomerism.
b. If it is an alkene draw the first isomer always by drawing a double bond between C_1 and C_2 or if it is an alkyne draw the first isomer always by drawing a triple bond between C_1 and C_2
c. The next isomers will be dawn by drawing the same chain and changing the positions of the double and triple bonds in alkenes and alkynes respectively.
d. Complete the tetravalency of carbon by forming single covalent bonds with hydrogens.
e. In the end, check that the molecular formula of each isomer should be same.

21. Homologous Series: A series of organic compounds in which every succeeding member differs from the previous one by $-CH_2$ or 14 u. The molecular formula of all the members of a homologous series can be derived from a general formula.

22. Properties of a homologous series: As the molecular mass increases in a series, so physical properties of the compounds show a variation, but chemical properties which are determined by a functional group remain the same within a series.

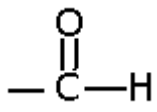
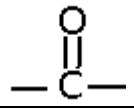
23. Homologous series of alkanes: General formula: C_nH_{2n+2} where n = number of carbon atoms

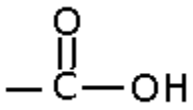
24. Homologous series of alkenes: General formula: C_nH_{2n} where n = number of carbon atoms

25. Homologous series of alkynes: General formula: = C_nH_{2n-2} where n = number of carbon atoms

26. Functional group: An atom or a group of atoms which when present in a compound gives specific properties to it, regardless of the length and nature of the carbon chain is called functional group.
    a. Free valency or valencies of the group are shown by the single line.
    b. The functional group is attached to the carbon chain through this valency by replacing one hydrogen atom or atoms.
    c. Replacement of hydrogen atom by a functional group is always in such a manner that valency of carbon remains satisfied.
    d. The functional group, replacing the hydrogen is also called as hetero atom because it is different from carbon, and can be nitrogen, sulphur, or halogen etc.

27. Some functional groups in carbon compounds:

Heteroatom	**Functional group**	**Formula of the functional group**	**Suffix**
Cl/ Br	Halo- Chloro Bromo	 -Cl -Br	Named as prefix Chloro – Bromo -
Oxygen	Alcohol	-OH	- ol
	Aldehyde		-al
	Ketone		-one

	Carboxylic acid		-oic acid

28. Steps to write the IUPAC name of organic compounds:

i. Select the parent carbon chain:
   1. Select the longest carbon chain as the parent chain.
   2. If a double or a triple bond is present in the carbon chain, it should be included in the parent chain.
   3. If a functional group is present, the carbon chain should include the functional group.

ii. Number the parent carbon chain from that carbon end such that the functional group, double bond, triple bond or side chain gets the lowest number.
Remember here that the aldehyde and carboxylic acid functional group are present on the terminal carbon atom.

iii. Identify the name and position of the functional group, double bond, triple bond or side chain.

iv. The name of the functional group is written with either a prefix or a suffix as given in the above table.

v. If the name of the functional group is to be given as a suffix, the name of the carbon chain is modified by deleting the final 'e' and adding the appropriate suffix. For example, a three-carbon chain with a ketone group would be named in the following manner – Propane – 'e' = propan + 'one' = propanone.

vi. Remember that in the compounds which have carbon containing functional groups, the name of the word root includes the functional group carbon atom also.

vii. If the carbon chain is unsaturated, then the final 'ane' in the name of the carbon chain is substituted by 'ene' or 'yne' as given in the table above. For example, a three-carbon chain with a double bond would be called propene and if it has a triple bond, it would be called propyne.

29. Difference between chemical properties of saturated and unsaturated hydrocarbons:

Saturated hydrocarbons	Unsaturated hydrocarbons
Give a clean blue flame on complete combustion and on incomplete combustion give a yellow sooty flame.	Give a yellow sooty flame on combustion.
Undergo substitution reaction like chlorination	Undergo addition reaction like hydrogenation, addition reaction with bromine in carbon tetrachloride

Are fairly unreactive and inert in the presence of most reagents	Are reactive

30. Catalysts are substances that cause a reaction to occur or proceed at a different rate without the reaction being affected.

31. Oxidizing agents are substances which are capable of providing oxygen to other compounds for their oxygen. Example: Alkaline $KMnO_4$, acidified $K_2Cr_2O_7$ etc.

32. Reactions of ethanol:

$$2\ CH_3CH_2OH + 2\ Na \rightarrow 2\ CH_3CH_2ONa + H_2$$

$$2\ CH_3CH_2OH \xrightarrow{\text{Hot conc. } H_2SO_4} CH_2{=}CH_2 + H_2O$$

$$2\ CH_3CH_2OH \xrightarrow[\text{Or acidified } K_2Cr_2O_7 + \text{Heat}]{\text{Alkaline } KMnO_4 + \text{Heat}} CH_3COOH$$

33. Reactions of ethanoic acid:

$$CH_3COOH + NaOH \rightarrow CH_3COONa + H_2O$$

$$CH_3COOH + CH_3CH_2OH \xrightarrow{\text{acid}} \underset{\text{ester}}{CH_3COOCH_2CH_3}$$

$$CH_3COOC_2H_5 + NaOH \longrightarrow CH_3COONa + C_2H_5OH$$

$$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$$

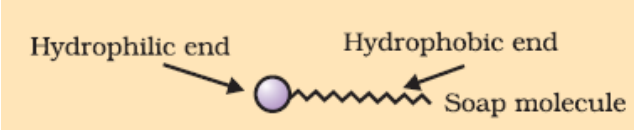
$$2\,CH_3COOH + Na_2CO_3 \longrightarrow 2\,CH_3COONa + H_2O + CO_2$$

$$CH_3COOH + NaHCO_3 \longrightarrow CH_3COONa + H_2O + CO_2$$

34. Catalysts are substances that cause a reaction to occur or proceed at a different rate without the reaction being affected.

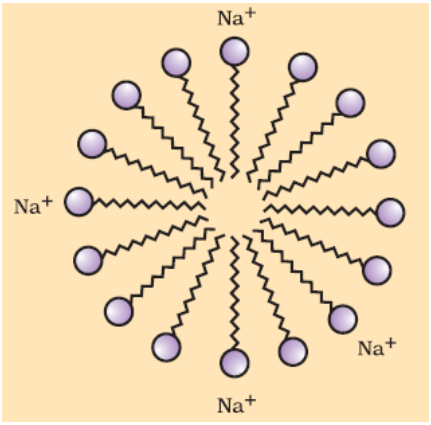
35. Soaps are sodium or potassium salts of long chain carboxylic acids.

36. Structure of soap molecule: The structure of soap molecule consists of a long hydrocarbon tail at one end which is hydrophobic in nature. The other end is the ionic part which is hydrophilic in nature.



37. Cleansing action of soap: When soap is at the surface of water, the ionic end of soap orients itself towards water and the hydrocarbon 'tail' orients itself aligns itself along the dirt. Thus, clusters of molecules are

formed in which the hydrophobic tails are in the interior of the cluster and the ionic ends are on the surface of the cluster. This formation is called a micelle.



Soap in the form of a micelle is able to clean, since the oily dirt will be collected in the centre of the micelle. The micelles stay in solution as a colloid and will not come together to precipitate because of ion-ion repulsion. Now, when water is agitated, the dirt suspended in the micelles is also easily rinsed away.

38. When hard water is treated with soap, scum is formed. This is caused by the reaction of soap with the calcium and magnesium salts, which cause the hardness of water.

39. Detergents are generally ammonium or sulphonate salts of long chain carboxylic acids.

40. Detergents do not form scum with hard water. This is because the charged ends of these compounds do not form insoluble precipitates with the calcium and magnesium ions in hard water. Thus, they remain effective in hard water.

41.

Soaps	Detergents
Soaps are sodium or potassium salts of long chain carboxylic acids.	Detergents are generally ammonium or sulphonate salts of long chain carboxylic acids.
Soaps are not effective for cleaning in hard water.	Detergents are effective for cleaning in hard as well as soft water.
Soaps are biodegradable.	Detergents are non - biodegradable.