

Mastermind Career Institute

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Class X Chemistry (Part-2) **I.I.T.Foundation, N.T.S.E. & Olympiad** **Study Package**

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Subject : Chemistry

Class : X (CBSE)

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CARBON AND

ITS COMPOUNDS

12.1 INTRODUCTION:

Organic compounds: The compounds like urea, sugars, fats, oils, dyes, proteins vitamins etc., which were isolated directly or indirectly from living or indirectly from living organism such as animals and plants were called organic compounds. The branch of chemistry which deals with the study of these compounds is called **ORGANIC CHEMISTRY**.

12.2 BONDING IN CARBON = THE COVALENT BOND :

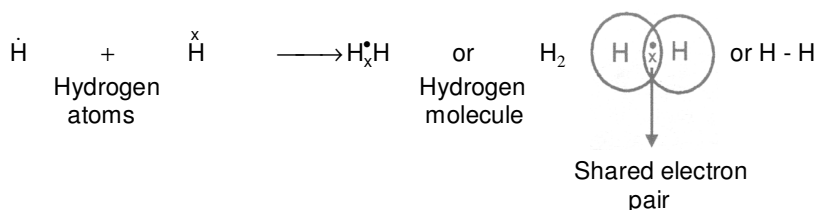
Most carbon compounds are poor conductors of electricity. The boiling and melting points of the carbon compounds are low. Forces of attraction between these molecules of organic compounds are not very strong/ As these compound are largely non conductors of electricity hence the bonding in these compound does not give rise to any ions.

The reactivity of elements is explained at their tendency to attain a completely filled outer shell, that is, attain noble gas configuration. Element forming ionic compounds achieve this by either gaining or losing electrons from the outermost shell. In the case of carbon, it has four electrons in its outermost shell and needs to gain or lose four electrons to attain noble gas configuration. It is were to gain or lose electrons –

- (i) it could gain four electrons forming **C⁴⁻ anion**. But it would be difficult for the nucleus with six protons to hold on to ten electrons, that is, four extra electrons.
- (ii) It could lose four electrons forming **C⁴⁺ cation**. But it would require a large amount of energy to remove four electrons leaving behind a carbon cation with six protons in its nucleus holding on to just two electrons.

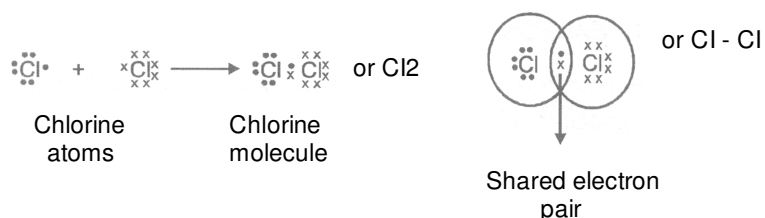
12.2 (a) Some Simple Molecules Formed by the Sharing of Valence Electrons are s follows:

(i) Hydrogen molecules: This is the simplest molecule formed by sharing of electrons. The atomic number of hydrogen is 1 and it has only one electron in its outermost K shell. It required only one more electron to complete the K shell. So, when two hydrogen atoms approach each other, the single electron of both the atoms form a shared pair. This may be represented as:

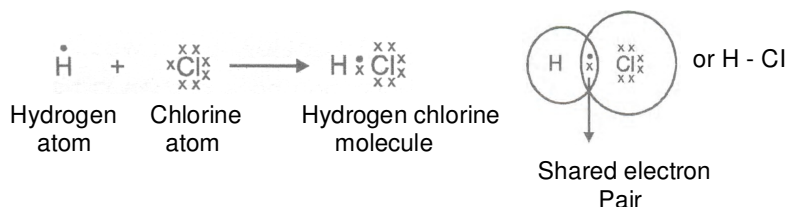


According to **Lewis notation**, the electrons in the valence shell are represented by dots and crosses. This method was proposed by **G.N.Lewis** and is known as Lewis representation or Lewis structure. The shared pair of electron (show x) is said to constitute a single bond between the two hydrogen atoms and is represented by a line between the two atoms. Pictorially, the molecule can be represented by drawing two **overlapping circles** around the symbols of the atoms and showing the shared pair of electrons in the overlapping part.

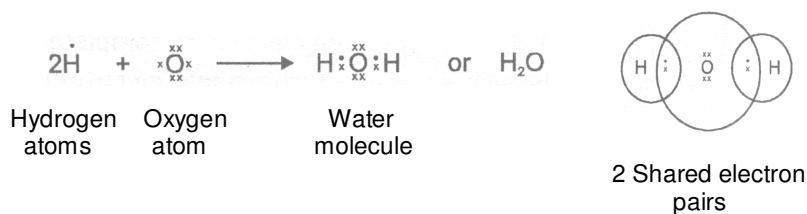
(ii) Chlorine molecule : Each chlorine atom has seven electrons in its outermost shell. When the two chlorine atoms come close together, an electron of both the atoms is shared between them.



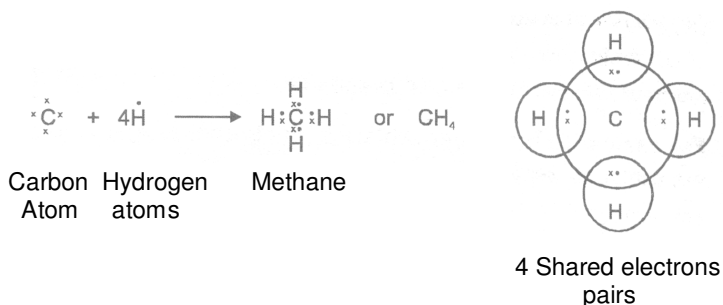
(iii) Hydrogen chloride molecule: It may be note that a covalent bond is not only formed between two similar atoms, but it may be formed between dissimilar atoms also. For example, hydrogen and chlorine form a covalent bond between their atoms. In HCl, hydrogen atom (1) has only one electron in its valence shell and chlorine atom (2,8,7) has seven electrons in its valence shell. Therefore, by mutual sharing of electron pair between hydrogen and a chlorine atom. Both the atoms acquit nearest noble gas configuration.



(iv) Formation of water molecule (H₂O) : Each hydrogen atom has only one electron in its outermost shell. Therefore, each hydrogen atom required one more electron to achieve the stable configuration of helium (nearest noble gas). The oxygen atom has the electronic configuration 2,6 and has six electrons in its outermost shell. It needs two electrons to complete its octet. Therefore, one atom of oxygen shares its electrons with two hydrogen atoms.



(v) Formation of methane molecule (CH₄) : Methane (CH₄) is a covalent compound containing covalent bonds. Carbon atom has atomic number 6. Its electronic configuration is 2,4. It has four electrons in its valence shell and needs 4 more electrons to get the stable noble gas configuration. Hydrogen atom has one electron and needs one more electron to get stable electronic configuration of nearest noble gas, helium. Therefore, one atom of carbon shares its four electrons with four atoms of hydrogen to form four covalent bonds.

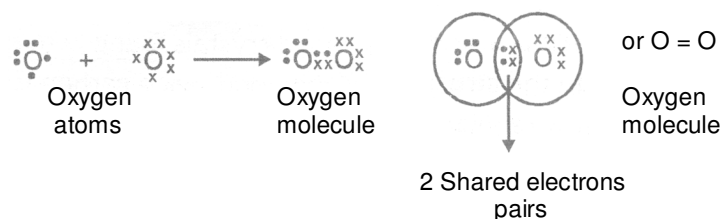


12.2 (b) Different Kinds of Covalent Bonds :

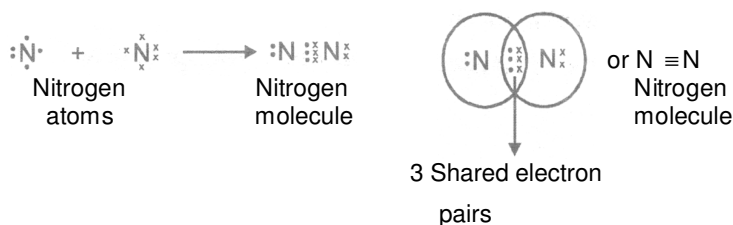
Electron pair shared between two atoms results in the formation of a covalent bond. This shared pair is also called bonding pair of electron.

- If two atoms share one electron pair, bond is known as single covalent bond and is represented by one dash (-)
- If two atoms share two electron pairs, bond is known as double covalent bond and is represented by two dashed (=).
- If two atoms share three electron pairs, bond is known as triple covalent bond and is represented by three dashes (≡).

(i) Formation of double bond (oxygen molecule) : Two oxygen atoms combine to form oxygen molecule by sharing two electron pairs. Each oxygen atom (2, 6) has six electrons in the valence shell. It required two electrons to acquire nearest noble gas configuration. Therefore, both the atoms contribute two electrons each for sharing to form oxygen molecule. In the molecule, two electron pairs are shared and hence there is a double bond between the oxygen atoms.



(ii) Formation of triple bond (Nitrogen molecule) : Nitrogen atom has five electrons in its valence shell. In the formation of a nitrogen molecule, each of the following atoms provide three electrons to form three electrons pairs for sharing. Thus, a triple bond is formed between two nitrogen atoms.



12.2 (c) Characteristic Properties of Covalent Compounds:

The important characteristic properties of covalent compounds are :

(i) Covalent compounds consist of molecules: The covalent compounds consist of molecules. They do not have ions. For example - hydrogen, oxygen, nitrogen etc. consist of H_2 , O_2 and N_2 molecules respectively.

(ii) Physical state : Weak Vanderwaal's forces are present between the molecules of covalent compounds. So, covalent compounds are in **gaseous or liquid state at normal temperature and pressure.**

For example: Hydrogen, chlorine, methane, oxygen, nitrogen are gases while carbon tetrachloride, ethyl alcohol, ether, bromine etc. are liquids. Glucose, sugar, urea, iodine etc. are some solid covalent compounds.

(iii) Crystal structure - Covalent compounds exhibit both **crystalline and non crystalline** structure.

(iv) Melting point and boiling point: Energy required to break the crystal is less due to the presence of **weak Vanderwaal's force**, so their melting and boiling points are less.

(v) Electrical conductivity - Covalent compounds are **bad conductors** of electricity due to the **absence of free electrons or free ions.**

(vi) Solubility : Due to the **non - polar nature** of covalent compounds they are soluble in **non - polar solvents like benzene, carbon tetrachloride** etc. and insoluble in **polar solvents like water** etc.

12.3 ALLOTROPIC FORMS OF CARBON :

Allotropy is the property by virtue of which an element exist in more than one form and each form has different physical properties but identical chemical properties. These different forms are called allotropes. The two common allotropic forms of carbon are diamond and graphite.

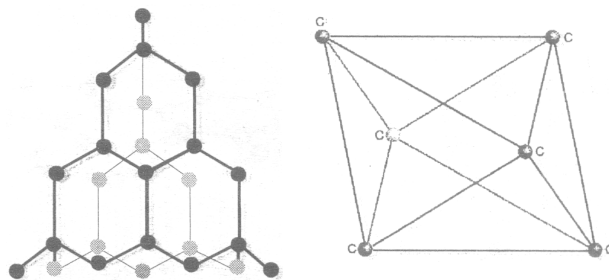
12.3 (a) Damon :

(i) Structure of Diamond : Diamond crystals found in nature are generally octahedral (eight faced). In the structure of diamond, each carbon is linked to four other carbon atoms forming regular tetrahedral arrangement and this network of carbon atoms extends in three dimensions and is very rigid. This strong bonding is the cause of its hardness and its high density. This regular, symmetrical arrangement makes the structure very difficult to break. To separate one carbon atom from the structure, we have to break four strong covalent bonds.



Store in your memory

Elements in which atoms are bonded covalently found in solid state. For example diamond, graphite, sulphur etc.



Three dimensional tetrahedral structure

(ii) Properties of Diamond :

- (A) It occurs naturally in free state and has octahedral shape.
- (B) It is the hardest natural substance known.
- (C) It has high specific gravity (about 3.5).
- (D) It is transparent, colourless and brittle solid.
- (E) It has a high refractive index (about 2.4).
- (F) It is non-conductor of electricity.

(iii) Uses of Diamond :

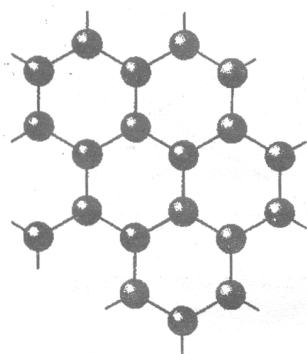
- (A) They are used in jewellery because of their ability to reflect and refract light.
- (B) Diamond is used in cutting glass and drilling rocks.
- (C) Diamond has an extraordinary sensitivity to heat rays and due to this reason, it is used for making high precision thermometers.
- (D) Diamond has the ability to cut out harmful radiations and due to this reason it is used for making protective windows for space probes.
- (E) Diamond dies are used for drawing thin wires. Very thin tungsten wires of diameter less than one-sixth of the diameter of human hair have been drawn using diamond dies.
- (F) Surgeons use diamond knives for performing delicate operations.

12.3 (b) Graphite:

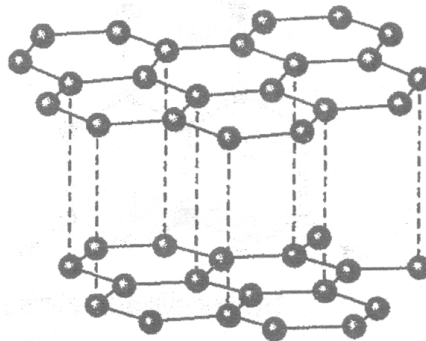
Graphite is an allotrope of carbon, which is black or bluish grey with a metallic lustre and or greasy feel. It occurs in igneous and metamorphic rocks, such as marble.

(i) Structure of Graphite :

Each carbon is bonded to only three neighboring carbon atoms in the same plane forming layers of hexagonal networks separated by comparatively larger distance. The different layers are held together by weak forces, called vanderwaal's forces. The layers can therefore, easily slide over one another. This makes graphite lubricating, soft and greasy to touch.



One layer



Showing how the layers fit together

Within each layer of graphite, every carbon atom is joined to three others by strong covalent bonds. This forms a pattern of interlocking hexagonal rings. The carbon atoms are difficult to separate from one another. So graphite also has high melting point.

However, the bonds between the layers are weak. The layers are able to slide easily over one another, rather like pack of cards. This makes graphite soft and slippery. When we write with a pencil, layers of graphite flake off and stick to the paper.

(ii) Properties of Graphite:

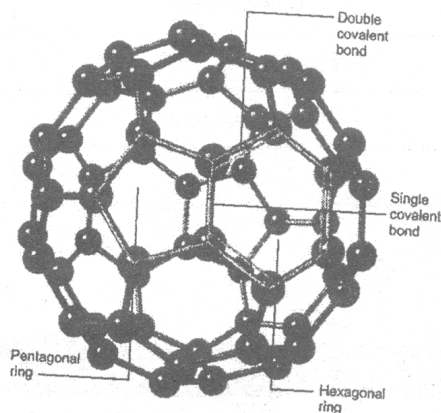
- (A) It is soft and greasy in touch.
- (B) Its specific gravity is 2.25 (generally).
- (C) It is grayish black and opaque.
- (D) It is a good conductor of heat and electricity.
- (E) It occurs in hexagonal layers.
- (F) It is stable and has high melting point.

(iii) Uses of graphite:

- (A) It is used for making pencil lead, printer's ink, black paint etc.
- (B) It is used as dry lubricant for heavy machinery.
- (C) It is used in making crucibles for melting substances.
- (D) It is used as an electrode in batteries and electric furnaces.
- (E) It is used in nuclear reactors as moderator to regulate nuclear reactions.
- (F) It is also used in making artificial diamonds.

12.3 (c) Fullerenes:

(i) **Structure:** Fullerene is naturally occurring allotrope of carbon in which 60 carbon atoms are linked to form a stable structure. Previously, only two forms of carbon (diamond and graphite) were known. The third allotrope of carbon, called fullerene was discovered in 1985 by Robert Curl, Herald Kroto and Richard Smalley.



STRUCTURE OF FULLERENE

The correctly suggested the cage structure as shown in the figure and named the molecule Buckminster fullerene after the architect Buckminster Fuller, the inventor of the Geodesic dome, which resembles the molecular structure of C_{60} . Molecules of C_{60} have a highly symmetrical structure in which 60 carbon atoms are arranged in a closed net with 20 hexagonal faces and 12 pentagonal faces. The pattern is exactly like the design on the surface of a soccer ball. C_{60} has been found to form in sooting flames when hydrocarbons are burned.

All the fullerenes have even number of atoms, with formulae ranging upto C_{400} and higher. These materials offer exacting prospects for technical application. For example, because C_{60} readily accepts and donates electrons, it has possible application in batteries.

(ii) **Uses of Fullerenes :** It is hoped fullerenes or their compounds may find used as -

- (A) superconductors
- (B) semiconductors
- (C) lubricants
- (D) catalysts
- (E) as highly tensile fibers for construction industry.
- (F) inhibiting agents in the activity of the AIDS virus.

12.3 (d) Explaining Conduction in Carbon :

In diamond, all four electrons in the outer shell of each carbon atom are used to make covalent bonds. This means that there are no free electrons and so diamond is an insulator. In graphite, only three of the outer shell electrons are used in bonding to other carbon atoms. This leaves one electron per atom free to move, so graphite acts as an electrical conductor.

12.3 (e) Difference Between Properties of Diamond and Graphite :

| Property | Diamond | Graphite |
|--------------------------------------|----------------------------|-----------------------|
| Hardness | Hardest natural substance | Very Soft |
| Density | 3.5 g/cm ³ | 2.4 g/cm ³ |
| Tendency to conduct electric current | Bad conductor | Good conductor |
| Colour | Pure diamond is colourless | Black |
| Transparency | Transparent | Opaque |
| Occurrence | Rare | Abundant |

DAILY PRACTICE PROBLEMS # 12

OBJECTIVE DPP - 12.1

- Which of the following is an allotropic form of carbon ?
 (A) Diamond (B) Graphite (C) Fullerene (D) All of these
- Diamond is not a good conductor of electricity because -
 (A) it is very hard.
 (B) its structure is very compact.
 (C) it is not water soluble.
 (D) it has no free electrons to conduct electric current.
- In a double covalent bond number of electron pairs shared are -
 (A) 2 (B) 3 (C) 4 (D) 6
- Which of the following compound contain single covalent bond ?
 (A) Oxygen (B) Nitrogen (C) Methane (D) Carbon dioxide
- Carbon dioxide molecule contains -
 (A) single covalent bond (B) double covalent bond
 (C) triple covalent bond (D) ionic bond
- Covalent bond between atoms is formed by -
 (A) loss of electrons (B) gain of electrons
 (C) sharing of electrons (D) loss and gain of electrons both
- Covalent compounds can be dissolved in -
 (A) benzene (B) ether (C) alcohol (D) all of these

8. Covalent compounds are -
(A) good conductors of electricity.
(B) bad conductors of electricity.
(C) semiconductors of electricity.
(D) none of these.
9. Which of the following allotrope of carbon is used in making crucibles ?
(A) Diamond (B) Graphite (C) Fullerene (D) Coke
10. Structure of diamond is -
(A) linear (B) tetrahedral (C) trigonal (D) hexagonal

SUBJECTIVE DPP - 12.2

1. Why do atoms take part in bond formation ?
2. Write the Lewis dot structure of PH_3 .
3. Name one electrovalent and one covalent compound containing chlorine.
4. An element 'X' has four valence electrons, while an element 'Y' has six valence electrons. What type of bond is expected to be formed between the two? Draw the structure of the compound.
5. Name a carbon containing molecule in which two double bonds are present.

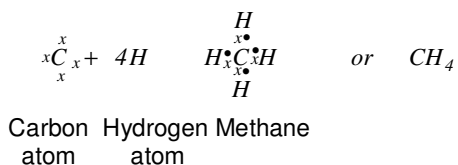
CARBON AND ITS COMPOUNDS

13.1 VERSATILE NATURE OF CARBON :

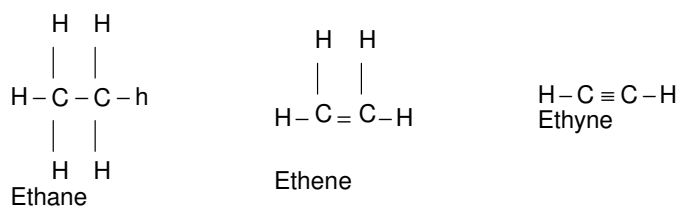
About 3 million organic compounds are known today. The main reasons for this huge number of organic compounds are =

(i) Catenation : The property of self linking of carbon atoms through covalent bonds to form long straight or branched chains and rings of different sizes is called catenation. Carbon shows maximum catenation in the periodic table due to its small size, electronic configuration and unique strength of carbon - carbon bonds.

(ii) Tetravalency of carbon : Carbon belongs to group 14 of periodic table. Since the atomic number of carbon is 6. The electronic configuration of carbon atom is 2,4. It has four electrons in the outermost shell. Therefore, its valency is four. Thus carbon forms four covalent bonds in its compounds. A methane molecule (CH_4) is formed when four electrons of carbon are shared with four hydrogen atoms are shown below.



(iii) Tendency to form multiple bond : Due to small size of carbon it has a strong tendency to form multiple bond (double & triple bonds) by sharing more than one electron pair. As a result, it can form a variety of compound. For example -

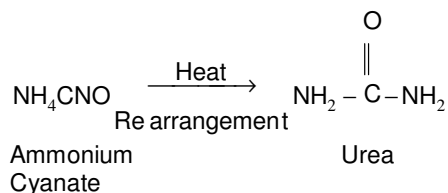
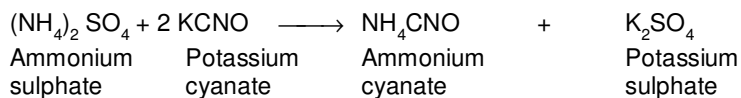


13.2 VITAL FORCE THEORY OF BERZELIUS HYPOTHESIS :

Organic compounds cannot be synthesized in the laboratory because they require the presence of a mysterious force (called vital force) which exists only in living organisms.

13.3 WOHLER'S SYNTHESIS :

In 1828, Friedrich Wohler synthesized urea (a well known organic compound) in the laboratory by heating ammonium cyanate. Urea is the first organic compound synthesized in the laboratory.



13.4 HYDROCARBONS :

13.4 (a) Introduction :

The organic compounds containing only carbon and hydrogen are called hydrocarbons. These are the simplest organic compounds and are regarded as parent organic compounds. All other compounds are considered to be derived from them by the replacement of one or more hydrogen atoms by other atoms or groups of atoms. The major source of hydrocarbons is petroleum.

13.4 (b) Types of Hydrocarbons:

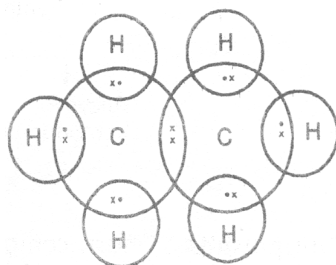
The hydrocarbons can be classified as :

(i) Saturated hydrocarbons.

(A) Alkanes : Alkanes are saturated hydrocarbons containing only carbon - carbon and carbon - hydrogen single covalent bonds.

For e.g. : CH_4 (Methane)

C_2H_6 (Ethane)



Electron dot structure of ethane

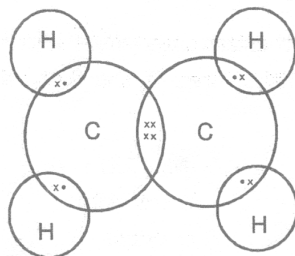
(ii) Unsaturated hydrocarbons :

(A) Alkenes : These are unsaturated hydrocarbons which contain carbon - carbon double bond. They contain two hydrogen less than the corresponding alkanes.

General formula: $\text{C}_n\text{H}_{2n+2}$

For e.g. : C_2H_4 (Ethene)

C_3H_6 (Propene)

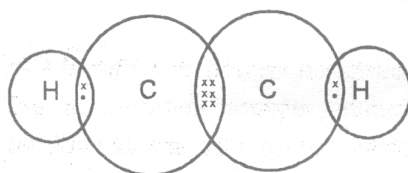


Electron dot structure of ethane

(B) Alkynes : They are also unsaturated hydrocarbons which contain carbon - carbon triple bond. They contain four hydrogen atoms less than the corresponding alkanes.

General formula : C_nH_{2n}

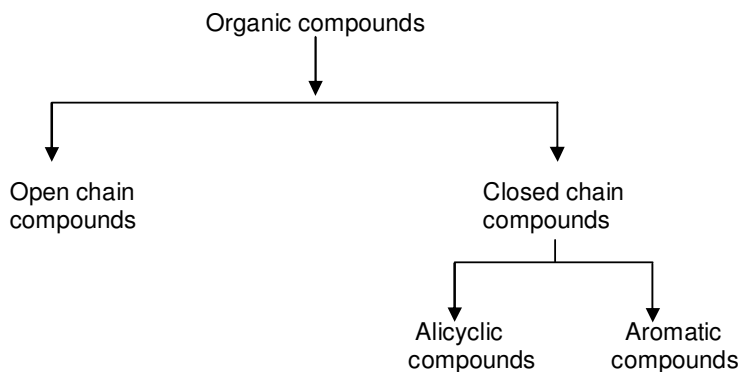
For e.g. : C_2H_6 (Ethane)
 C_3H_8 (Propane)



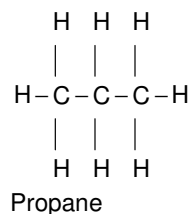
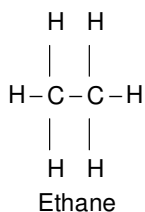
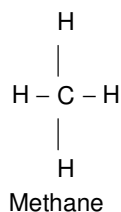
Electron dot structure of ethane

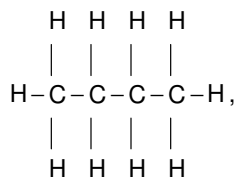
13.4 (c) Classifications of Organic Compounds:

The organic compounds are very large in number on account of the self - linking property of carbon called catenation. These compounds have been further classified as open chain and cyclic compounds.

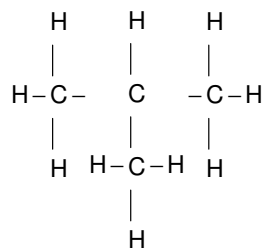


(i) Open chain compounds : These compounds contain an open chain of carbon atoms which may be either straight chain or branched chain in nature. Apart from that, they may also be saturated or unsaturated based upon the nature of bonding in the carbon atoms. For example.





Butane



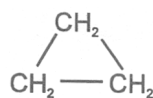
2-Methylpropane

Butane is a straight chain alkane while 2- Methylpropane is branched chain in nature.

(ii) Closed chain or Cyclic compounds : Apart from the open chains, the organic compounds can have cyclic or ring structures. A minimum of three atoms are needed to form a ring. These compounds have been further classified into following types.

(A) Alicyclic compounds : Those carboxylic compounds which resemble aliphatic compounds in their properties are called alicyclic compounds.

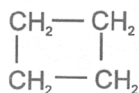
For eg.



or



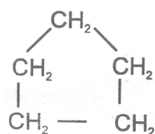
Cyclopropane



or



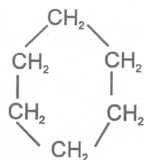
Cyclobutane



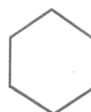
or



Cyclopentane



or



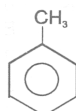
Cyclohexane

(B) Aromatic compounds : Organic compounds which contain one or more fused or isolated benzene rings are called aromatic compounds.

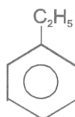
For eg.



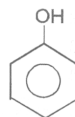
Benzene



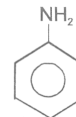
Toluene



Ethyl benzene



Phenol



Anilien

13.5 HOMOLOGOUS SERIES :

Homologous series may be defined as a series of similarly constituted compounds in which the members possess similar chemical characteristics and the two consecutive members differ in their molecular formula by $-CH_2$.

13.5 (a) Characteristics of Homologous Series :

(i) All the members of series can be represented by the same generally formula.

For eg. General formula for alkane series is C_nH_{2n+2} .

(ii) Any two consecutive members differ in their formula by a common difference of $-CH_2$ and differ in molecular mass by 14.

(iii) Different member in a series have a common functional group.

For eg. All the members of alcohol family have $-OH$ group.

(iv) The members in any particular family have almost identical chemical properties. Their physical properties such as melting point, boiling point, density etc. show a regular gradation with the increase in the molecular mass.

(v) The members of a particular series can be prepared almost by the identical methods.

13.5 (b) Homologues :

The different members of a homologous series are known as homologues.

For example :

(i) Homologous series of alkanes

General formula : C_nH_{2n+2} .

| Value of n | Molecular formula | IUPAC name |
|------------|-------------------|------------|
| n = 1 | CH_4 | Methane |
| n = 2 | C_2H_6 | Ethane |
| n = 3 | C_3H_8 | Propane |

(ii) Homologous series of alkenes

| Value of n | Molecular formula | IUPAC name | Common name |
|------------|-------------------|---------------|---|
| n = 1 | C_2H_4 | Ethane | Ethylene |
| n = 3 | C_3H_6 | Propane | Propylene |
| n = 4 | C_4H_8 | But - 1 - ene | α - Butylenes ($H_3C - CH_2 - HC = CH_2$) |

(iii) Homologous series of alkynes

General formula : C_nH_{2n-2}

| Value of n | Molecular formula | IUPAC name | Common name |
|------------|-------------------|---------------|--|
| n = 2 | C_2H_2 | Ethyne | Acetylene |
| n = 3 | C_3H_4 | Propyne | Methyl acetylene |
| n = 4 | C_4H_6 | But - 1 - yne | Ethyl acetylene ($CH_3 - CH_2 - C \equiv CH$) |

DAILY PRACTICE PROBLEM # 13

OBJECTIVE DPP - 13.1

1. The general formula for saturated hydrocarbon is -
 (A) C_nH_{2n+2} (B) C_nH_{2n} (C) C_nH_{2n-2} (D) C_nH_{2n-n}
2. Select the alkyne from the following -
 (A) C_4H_8 (B) C_5H_8 (C) C_7H_{19} (D) None of these
3. The first compound to be prepared in the laboratory was -
 (A) methane (B) ethyl alcohol (C) acetic acid (D) urea
4. In order to form branching, an organic compound must have a minimum of -
 (A) four carbon atoms (B) three carbon atoms
 (C) five carbon atoms (D) any number of carbon atoms
5. The number of C - H bonds in ethane (C_2H_6) molecule is -
 (A) four (B) six (C) eight (D) ten
6. The main reason for this huge number of organic compounds are -
 (A) catenation (B) tetravalency of carbon
 (C) tendency to form multiple bonds (D) all of these
7. Which of the following is a saturated hydrocarbon ?
 (A) C_2H_6 (B) C_2H_4 (C) C_2H_5 (D) All of these
8. Which of the following is not an open chain compound ?
 (A) methane (B) ethane (C) Toluene (D) Butyne
9. Which of the following is an aromatic compound?
 (A) Cyclohexane (B) Ethyne (C) Phenol (D) All of these
10. Which of the following does not belong to alkane ?
 (A) C_2H_4 (B) CH_4 (C) C_2H_6 (D) C_4H_{10}

SUBJECTIVE DPP = 13.2

1. What is the common difference in two consecutive members in a homologous series ?
2. What is catenation? Why does carbon show maximum tendency to catenate ?
3. What are saturated hydrocarbons? Give one example.

CARBON AND ITS COMPOUNDS

14.1 NOMENCLATURE OF ORGANIC COMPOUNDS :

Nomenclature means the assignment of names to organic compounds. There are two main systems of nomenclature of organic compounds –

- Trivial system
- IUPAC system (International Union of Pure and Applied Chemistry)

14.1 (a) Basic Rules of Nomenclature of Compounds in IUPAC System :

For naming simple aliphatic compounds, the normal saturated hydrocarbons have been considered as the parent compounds and the other compounds as their derivatives obtained by the replacement of one or more hydrogen atoms with various functional groups.

Each systematic name has first two or all three of the following parts :

(i) **Word root** : The basic unit is a series of word root which indicate linear or continuous number of carbon atoms.

(ii) **Secondary suffix** : Suffixes added after the primary suffix to indicate the presence of a particular functional group in the carbon chain are known as secondary suffixes.

14.1 (b) Name of Straight Chain Hydrocarbons

The name of straight chain hydrocarbon may be divided into two parts

(i) Word root (ii) Primary suffix

(i) **Word roots for carbon chain lengths :**

| Chain length | Word root | Chain length | Word root |
|----------------|-----------|-----------------|-----------|
| C ₁ | Meth- | C ₈ | Hex – |
| C ₂ | Eth – | C ₇ | Hept – |
| C ₃ | Prop – | C ₆ | Oct – |
| C ₄ | But – | C ₅ | Non – |
| C ₅ | Pent - | C ₁₀ | Dec - |

(ii) Primary suffix :

| Class of Compounds | Primary suffix | General name |
|--|----------------|--------------|
| $\begin{array}{c} \diagup \text{C} - \text{C} \diagdown \\ \text{Saturated} \end{array}$ | -ane | Alkane |
| $\begin{array}{c} \diagup \text{C} = \text{C} \diagdown \\ \text{Unsaturated} \end{array}$ | -ene | Alkene |
| $\begin{array}{c} (-\text{C} \equiv \text{C}-) \\ \text{Unsaturated} \end{array}$ | -yne | Alkyne |

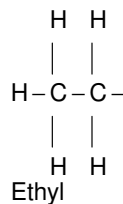
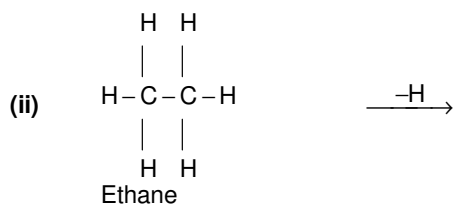
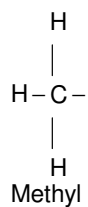
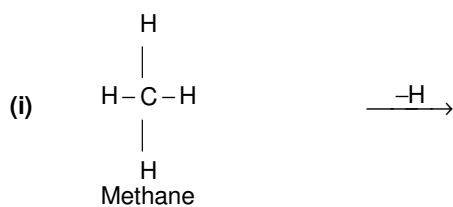
Examples :

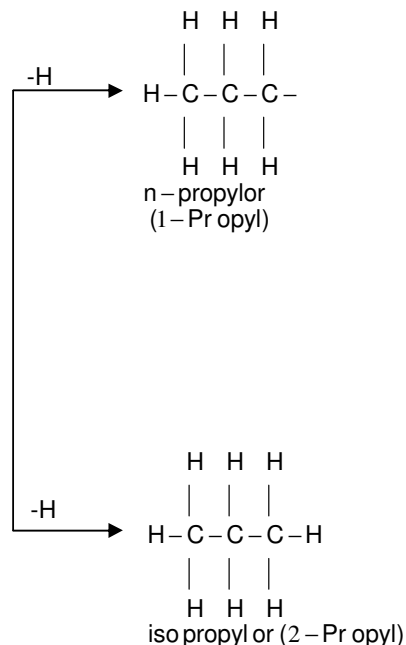
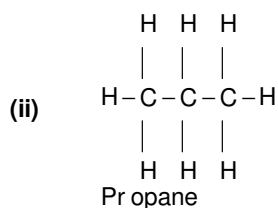
| Molecular formular | Word root | Primary suffix | IUPAC Name |
|---|-----------|----------------|------------|
| CH ₄ | Meth - | -ane | Methane |
| CH ₃ -CH ₃ | Eth - | -ane | Ethane |
| CH ₃ CH ₂ CH ₃ | Prop - | -ane | Propane |
| CH ₃ CH ₂ CH ₂ CH ₃ | But - | -ane | Butane |
| CH ₂ =CH ₂ | Eth - | -ene | Ethene |
| CH ₃ -CH=CH ₂ | Prop - | -ene | Propene |
| CH ₃ -C≡CH | Prop - | -yne | Propyne |

14.1 (c) Names of Branched Chain Hydrocarbon :

The carbon atoms in branched chain hydrocarbons are present as side chain. These side chain carbon atoms constitute the alkyl group or alkyl radicals. An alkyl group is obtained from an alkane by removal of a hydrogen. General formula of an alkyl group = C_nH_{2n+1}
An Alkyl group is represented by R.

For eg.





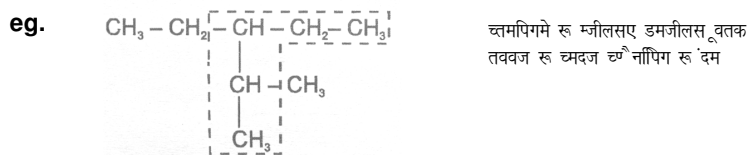
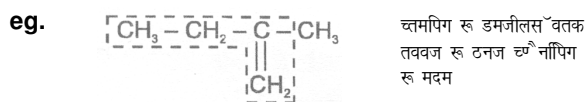
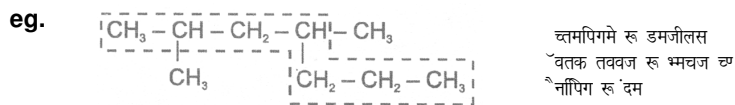
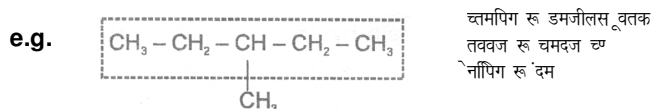
14.1 (d) A Branched Chain Hydrocarbon is Named Using the Following General IUPAC Rules :

Rule 1 : Longest chain rule : Select the longest possible continuous chain of carbon atoms. If some multiple bond is present, the chain selected must contain the multiple bond.

(i) The number of carbon atoms in the selected chain determines the **word root**.

(ii) Saturation or unsaturation determines the primary suffix (P. suffix).

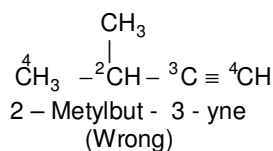
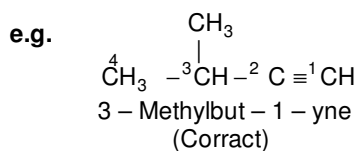
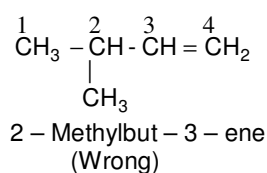
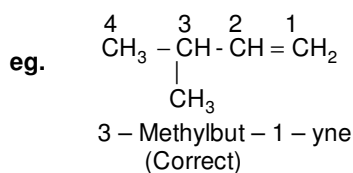
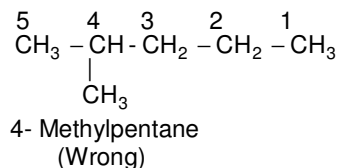
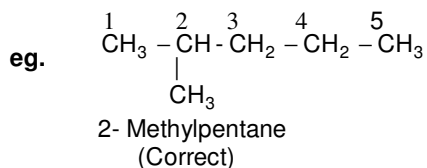
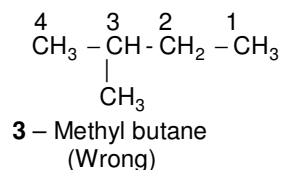
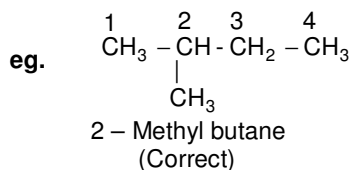
(iii) Alkyl substituents are indicated by prefixes.



Rule 2 : Lowest number Rule : The chain selected is numbered in terms of arabic numerals and the position of the alkyl groups are indicated by the number of the carbon atom to which alkyl group is attached.

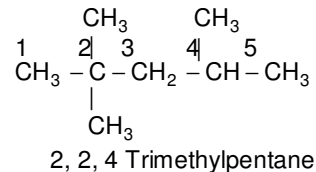
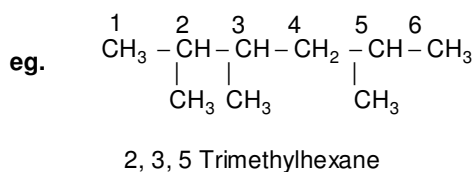
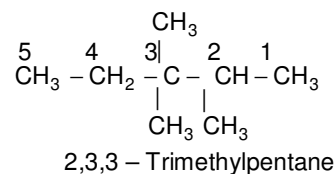
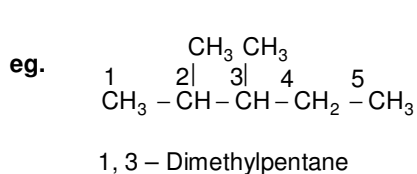
(i) The numbering is done in such a way that the substituents carbon atom has the lowest possible number.

(ii) If some multiple bond is present in the chain, the carbon atoms involved in the multiple bond should get lowest possible numbers.

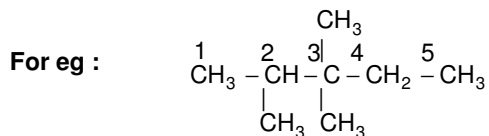


The name of the compound, in general, is written in the following sequence. (Position of substituents) - (prefixes) (word root) (p - suffix)

Rule : 3 Use of prefixed di, tri etc. : If the compound contains more than one similar alkyl groups, their positions are indicated separately and an appropriate numerical prefix, di, tri, etc., is attached to the name of the substituents. The positions of the substituents are separated by commas.



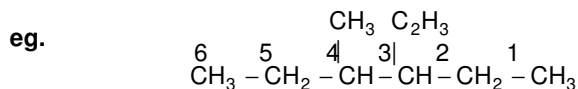
Rule 4 : Alphabetical arrangement of prefixes : If there are different alkyl substituents present in the compound their names are written in the alphabetical order. However, the numerical prefixes such as di, tri etc. are not considered for the alphabetical order.



3 - Ethyl - 2, 3 - dimethylpentane

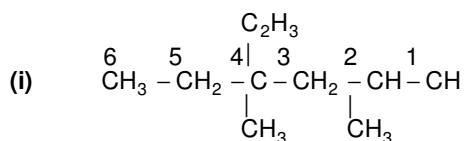
Rule 5 : Naming of different alkyl substituents at the equivalent positions :

If two alkyl substituents are present at the equivalent position then numbering of the chain is done in such a way that the alkyl group which comes first in alphabetical order gets the lower position.



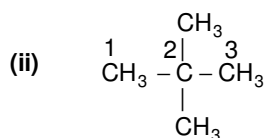
3 - Ethyl - 4 - methylhexane

14.1 (e) Some More Example :



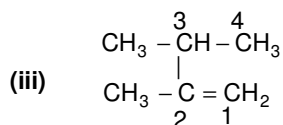
Word root : Hex
 Primary suffix : ane
 Substituents : two methyl & one ethyl groups

IUPAC name : 4- Ethyl - 2,4 - dimethylhexane

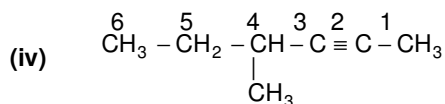


Word root : Prop
 P. Suffix : ane
 Substituents : two methyl groups

IUPAC name : 2,2- Dimethylpropane



Word root : But
 P. Suffix : ene
 Substituents : two methyl groups
IUPAC name : 2, 3 - Dimethylbut - 1 - ene



4 - Methylhex - 2 - yne

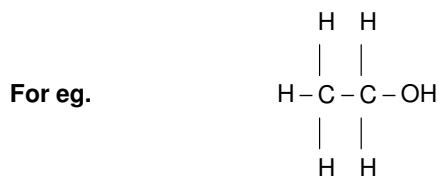
14.2 FUNCTIONAL GROUP :

14.2 (a) Introduction :

An atom or group of atoms in an organic compound or molecule that is responsible for the compound's characteristic reactions and determines its properties is known as **functional group**. An organic compound generally consists of two parts -

(i) Hydrocarbon radical

(ii) Functional group



Hydrocarbon radical

Functional group

- Functional group is the most reactive part of the molecule.
- Functional group determines the chemical properties of an organic compound.
- Hydrocarbon radical determines the physical properties of the organic compound.

14.2 (b) Main Functional Groups :

(i) **Hydroxyl group (-OH)** : All organic compounds containing -OH group are known as alcohols.
For e.g. Methanol (CH_3OH), Ethanol ($\text{CH}_3 - \text{CH}_2 - \text{OH}$) etc.

(ii) **Aldehyde group (-CHO)** : All organic compounds containing CHO group are known as aldehydes.
For e.g. Methanol (HCHO), Ethanol (CH_3CHO) etc.

(iii) **Ketone group (-CO-)** : All organic compounds containing -CO- group are known as ketones.
For e.g. 2- Propanone (CH_3COH_3), 2-Butanone ($\text{CH}_3\text{COCH}_2\text{CH}_3$) etc.

(iv) **Carboxyl group (-COOH)** : All organic acids contain carboxyl group. Hence they are also called carboxylic acids.

For e.g. CH_3COOH (Ethanoic acid)
 $\text{CH}_3\text{CH}_2\text{COOH}$ (Propanoic acid)

(v) **Halogen group (x= F, Cl, Br, I)** : All organic compounds containing -X(F, Cl, Br or I) group are known as halides.

For e.g. Chloromethane (CH_3Cl), Bromomethane (CH_3Br) etc.

14.2 (c) Nomenclature of Compounds Containing Functional Group :

In case some functional group (other than $C=C$ and $C\equiv C$) is present, it is indicated by adding secondary suffix after the primary suffix. The terminal 'e' of the primary suffix is removed if it is followed by a suffix beginning with 'a', 'e', 'i', 'o', 'u'. Some groups like -F, -Cl, -Br and -I are considered as substituents and are indicated by the prefixes.

Some groups like $-\overset{O}{\parallel}C-$, $-\overset{O}{\parallel}C-OH$, and $-OH$ are considered as functional groups and are indicated by suffixes.

| Class | Functional Group | General Formula | Prefix | Suffix | IUPAC Name |
|-----------------|--|--|---------------|-------------------|-----------------|
| Carboxylic acid | $\begin{array}{c} O \\ \parallel \\ -C-OH \end{array}$ | $\begin{array}{c} O \\ \parallel \\ R-C-OH \\ (R=C_nH_{2n+1}) \end{array}$ | Carboxy | - oic acid | Alkanoic acid |
| Ester | $\begin{array}{c} O \\ \parallel \\ -C-OR \end{array}$ | $\begin{array}{c} O \\ \parallel \\ R-C-O-R' \\ (R \neq R') \end{array}$ | Carbalkoxy | Alkyl (r;) - oate | Alkyl alkanoate |
| Aldehyde | - CHO | R - CHO | Formyl or oxo | - al | Alkanal |
| Ketone | $\begin{array}{c} -C- \\ \parallel \\ O \end{array}$ | $\begin{array}{c} R-C-R \\ \parallel \\ O \end{array}$ | oxo | - one | Alkanal |
| Alcohol | -OH | R - OH | Hydroxy | - ol | Alkanol |
| Alkenes | $C=C$ | C_nH_{2n} | - | - ene | Alkene |
| Alkynes | $C\equiv C$ | C_nH_{2n-2} | - | - yne | Alkyne |
| Halides | -X (X = F, Cl, Br, I) | R - X | Halo | - | Haloalkane |

14.2 (d) Naming of an Organic Compound Containing Functional Group :

Step 1 : Select the longest continuous chain of the carbon atoms as parent chain. The selected chain must include the carbon atom involved in the functional groups like -COOH, -CHO etc., or those which carry the functional groups like -OH, -Cl etc.

Step 2 : The presence of carbon - carbon multiple bond decides the primary suffix.

Step 3 : The secondary suffix is decided by the functional group.

Step 4 : The carbon atoms of the parent chain are numbered in such a way so that the carbon atom of the functional group gets the lowest possible number. In case the functional group does not have the carbon atom, then the carbon atom of the parent chain attached to the functional group should get the lowest possible number.

Step 5 : The name of the compound is written as -
Prefixes - word root - primary suffix - secondary suffix

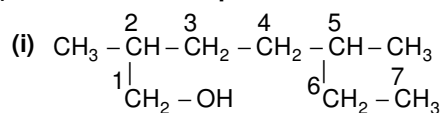


Store in your memory

The number of carbon atoms in the parent chain decides the word root.

| S.No. | Compound | Common name | Derived name | IUPAC | Structure |
|-------|--|-------------------------------|-------------------|----------------|--|
| 1 | CH ₃ - OH | Methyl alcohol or Wood spirit | Carbinol | Methanol | <pre> H H-C-O-H H </pre> |
| 2 | CH ₃ - CH ₂ - OH | Ethyl alcohol | Methyl carbinol | Ethanol | <pre> H H H-C-C-O-H H H </pre> |
| 3 | CH ₃ - CH ₂ - CH ₂ - OH | n-Propyl alcohol | Ethyl carbinol | 1-Propanol | <pre> H H H H-C-C-C-O-H H H H </pre> |
| 4 | $\begin{array}{c} \text{CH}_3 - \text{CH} - \text{OH} \\ \\ \text{CH}_3 \end{array}$ | Isopropyl alcohol | Dimethyl carbinol | 2-Propanol | <pre> H H H-C- C -O-H H H-C-H H </pre> |
| 5 | CH ₃ - CH ₂ - CH ₂ - CH ₂ - OH | n-Butyl alcohol | n-Propyl carbinol | 1-Butanol | <pre> H H H H H-C-C-C-C-O-H H H H H </pre> |
| 6 | HCOOH | Formic acid | - | Methanoic acid | <pre> O H-C-O-H </pre> |
| 7 | CH ₃ COOH | Acetic acid | - | Ethanoic acid | <pre> H O H-C-C-OH H </pre> |
| 8 | CH ₃ - CH ₂ - COOH | Propionic acid | - | Propanoic acid | <pre> H H O H-C-C-C-O-H H H </pre> |
| 9 | CH ₃ - CH ₂ - CH ₂ - COOH | Butyric acid | - | Butanoic acid | <pre> H H H O H-C-C-C-C-OH H H H </pre> |
| 10 | CH ₃ - CH ₂ - CH ₂ - CH ₂ - COOH | Valeric acid | - | Pentanoic acid | <pre> H H H H O H-C-C-C-C-C-OH H H H H </pre> |

14.2 (e) Some More Example :



Longest chain contains carbon : 7

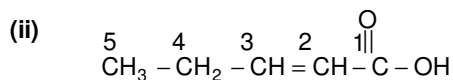
Word root : Hept

primary suffix : ane

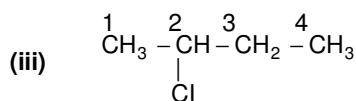
Functional group : - OH

Secondary suffix : - ol

IUPAC Name : 2,5 - Dimethylheptan -1 - ol



Word root : Pent
 Primary suffix : ene
 Secondary suffix : -oic acid
 Position of double bond : 2nd
IUPAC name : Pent - 2 - en - 1 - oic acid

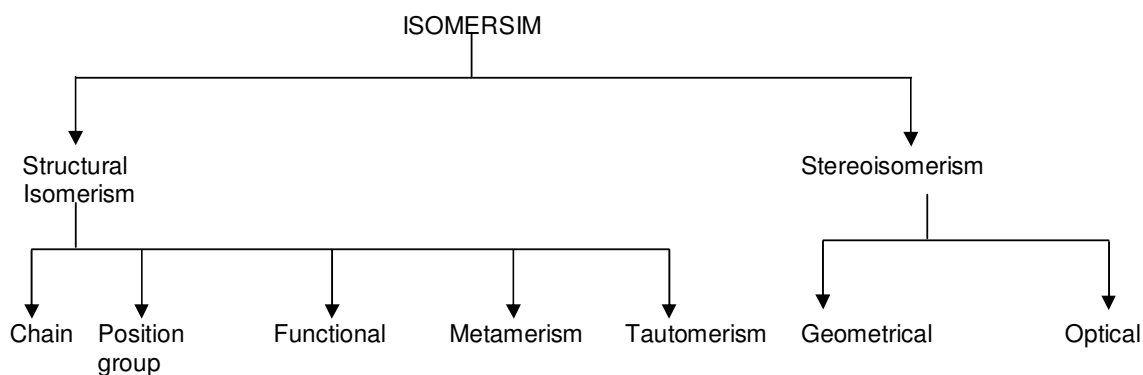


Word root : But
 Primary suffix : ane
 Prefix : chloro
IUPAC name : 2 - Chlorobutane

14.3 ISOMERS & ISOMERSISM :

14.3 (a) Introduction :

Such compounds which have same molecular formula but different in some physical or chemical properties are known as isomers and the phenomenon is known as isomerism.



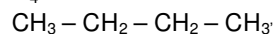
14.3 (b) Structural Isomerism:

Such compounds which have same molecular formula but different structural arrangement of atoms in their molecules are known as structural isomers and the phenomenon is known as structural isomerism.

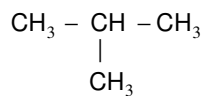
(i) Chain isomerism : The isomerism in which the isomers differ from each other due to the presence of different carbon chain skeletons in known as chain isomerism.

For eg:

(A)

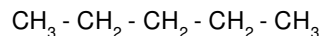


n - Butane

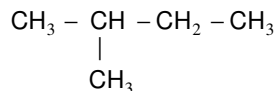


2- Methylpropane
(Isobutane)

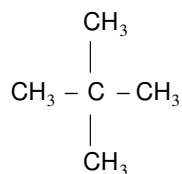
(B)



n - Pentane

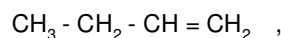


2- Methylbutane (isopentane)

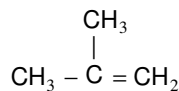


2,2 - Dimethylpropane (neo - pentane)

(C)



But - 1 - ene

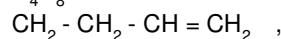


2 - Methylpropene

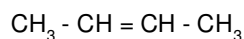
(ii) Position isomerism: In this type of isomerism, isomers differ in the structure due to difference in the position of the multiple bond or functional group.

For eg.

(A)

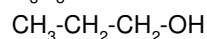


But - 1 - ene

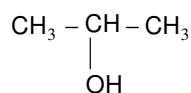


But-2-ene

(B)



Propane - 1 - ol



Propane - 2 - ol

(iii) Functional group isomerism : In this type of isomerism, isomers differ in the structure due to the presence of different functional groups.

For eg.

- (A) C_3H_8O
 $CH_3 - CH_2 - O - CH_3$
 Methoxy ethane
- and
- $CH_3 - CH_2 - CH_2 - OH$
 Propane - 1 - ol
- (B) C_4H_6
 $CH_3 - CH_2 - C \equiv CH$
 But-1-yne
- and
- $CH_2 = CH - CH = CH_2$
 Buta - 1, 3-diene
 [or 1, 3 - Butadiene]

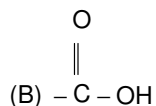
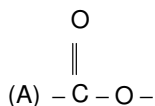
DAILY PRACTICE PROBLEMS # 14

OBJECTIVE DPP - 14.1

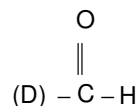
- The general formula for an ester (where R represents an alkyl group) is -
 (A) ROH (B) R-COOH (C) R-COOR (D) RH
- The functional group, present in $CH_3COOC_2H_5$ is -
 (A) ketonic (B) aldehydic (C) ester (D) carboxylic
- IUPAC name of CH_3CH_2OOH is -
 (A) wood spirit (B) methyl carbinol (C) ethanol (D) ethyl alcohol
- The IUPAC name of the compound having the formula $(CH_3)_3CCH = CH_2$ is -
 (A) 3,3-trimethyl -1-propane (B) 1,1,1-trimethyl-1-butene
 (C) 3,3-dimethyl-1-butene (D) 1,1-dimethyl-1,3-butene
- The IUPAC name of $(CH_3)_2CHCH_3$ is -
 (A) 2-methylpropane (B) 2,2-dimethylethane
 (C) trimethylmethane (D) none of these
- The IUPAC name of the following compound is -
 $CH_2 = CH - CH(CH_3)_2$
 (A) 1,1-dimethyl -2 propane (B) 3-methyl -1-butene
 (C) 2-vinyl propane (D) 1-isopropyl ethylene
- IUPAC name of second member of homologous series of carboxylic acids is -
 (A) methanoic acid (B) ethanoic acid (C) propanoic acid (D) butanoic acid
- The IUPAC name of $CH_3 - C(CH_3)(OH)CH_2 - CH(CH_3)CH_3$ is -
 (A) 2,4-dimethyl pentan -2-ol (B) 2,4-dimethyl pentan -4-ol
 (C) 2,2-dimethyl butane (D) butanol -2-one

9. The IUPAC name of $(\text{CH}_3)_2\text{CHCH}_2\text{CH}_2\text{Br}$ is
 (A) 1-bromopentane (B) 2-methyl-4-bromo pentane
 (C) 1-bromo -3- methyl butane (D) 2-methyl -3- bromo pentane

10. The functional group in an alcohol is -



(C) -OH



SUBJECTIVE DPP - 14.2

- In an organic compound, which part largely determines its physical & chemical properties ?
- Give IUPAC name of the following compounds -
 (a) $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{OH}$
 (b) $\begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH}_3 \\ | \\ \text{OH} \end{array}$
 (C) How are these two compounds related to each other ?
- Draw the structures of the following compounds -
 (a) simplest ketone (b) next higher homologue of butanoic acid
 (c) acetic acid (d) n-butly alcohol
- Name a functional group which can never occupy terminal position.
- Give the IUPAC names of -
 (a) $\text{CH}_3 - \text{CH}_2 - \text{Br}$
 (b) $\text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{C} \equiv \text{CH}$
- How many structural isomers are possible for pentane? Draw these.
- Name the isomerism exhibited by the following pairs of compounds -
 (a) Proponal & Propanone
 (b) 1- Propanol & 2- Propanol

CARBON AND ITS COMPOUNDS

CL - 15

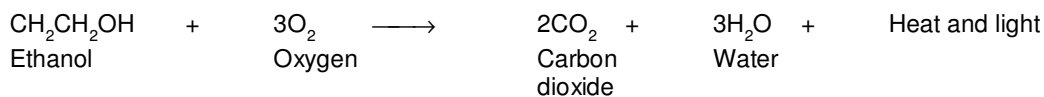
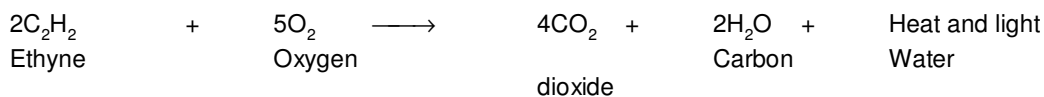
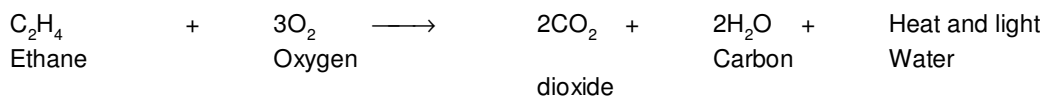
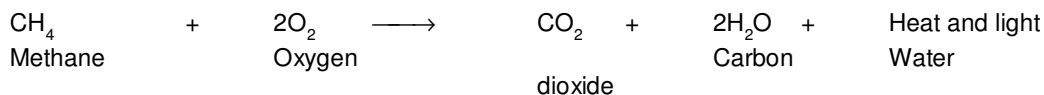
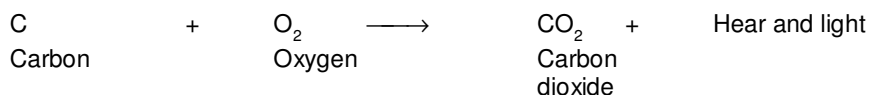
15.1 CHEMICAL PROPERTIES OF CARBON COMPOUNDS :

The important chemical properties of organic compounds are discussed below :

15.1 (a) Combustion:

Carbon in all its allotropic forms burns in air or oxygen to give carbon dioxide and releases energy in the form of heat and light.

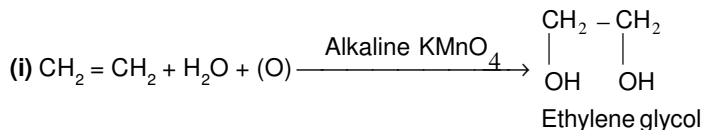
Most carbon compound also release a large amount of heat and light on burning.



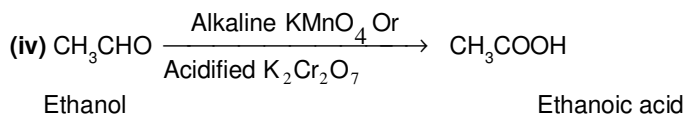
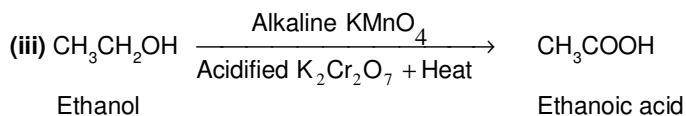
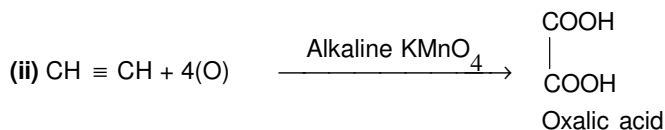
Saturated hydrocarbons will generally give a clean flame while unsaturated carbon compounds will give a yellow flame with lots of black smoke. This results in a sooty deposit on the metal plate. However, limiting the supply of air results in incomplete combustion of even saturated hydrocarbons giving a sooty flame.

15.1 (b) Oxidation :

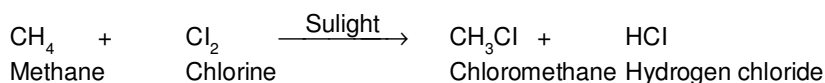
Oxidation is a process in which oxygen is added to a substance. The substances which add oxygen to other substances are called oxidising agents. There are many oxidising agents such as alkaline potassium permanganate (alk. KMnO_4), acidified potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$), nitric acid (HNO_3) etc. which are commonly used in organic chemistry. Some common reactions of oxidation are -



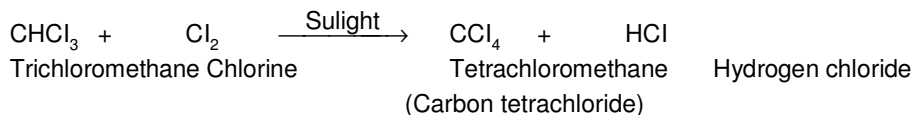
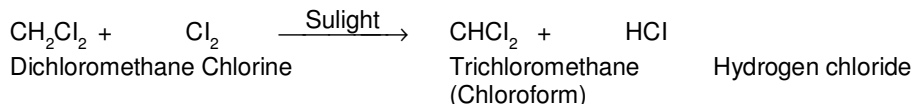
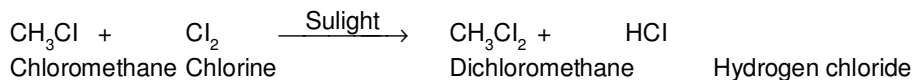
Ethane

**15.1 (c) Substitution Reaction:**

The reaction in which an atom or group of atoms in a molecule is replaced or substituted by different atoms or group of atoms are called substitution reactions. Saturated hydrocarbons are fairly unreactive. For example, chlorine does not react with methane at room temperature. However, in the presence of sunlight the reaction of chlorine and hydrocarbons is fairly fast reaction. It gives a variety of products.

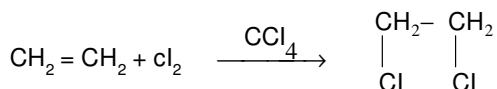


In this reaction H - atom of methane has been replaced by a - Cl atom converting CH_4 to CH_3Cl . However, if Cl_2 is used in excess, all the hydrogen atoms are replaced by chlorine atom one by one.

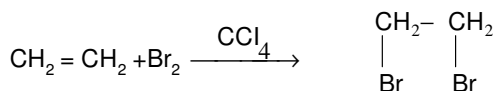


15.1 (d) Addition Reaction:

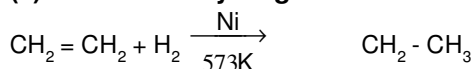
The reactions in which two molecules react to form a single product having all the atoms of the combining molecules are called addition reactions. Unsaturated compounds such as alkenes contain double bond between carbon atoms. Because of the presence of double bond, they undergo addition reaction.

(i) Addition of halogen to alkenes:

Ethane Chlorine 1,2-Dichloroethane

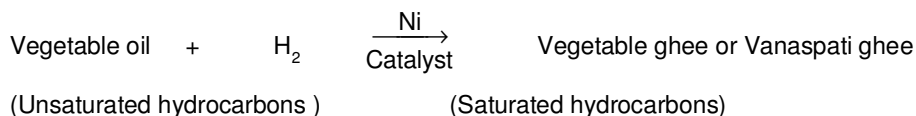


Ethene Bromine 1,2- Dibromoethane

(ii) Addition of hydrogen :

Ethene Hydrogen Ethane

This reaction is called hydrogenation. Hydrogenation reaction is used in the manufacture of vanaspati ghee from vegetable oils. The vegetable oil such as ground nut oil, cotton seed oil and mustard oil contain double bonds (C = C) in their molecules. When reacted with hydrogen in the presence of nickel as catalyst, they are converted into vanaspati ghee which is solid at room temperature like butter or ghee.

**15.2 BURNING OF SUBSTANCES WITH OR WITHOUT SMOKY FLAME :**

When coal or charcoal burns in an 'angithi', sometimes it just glows red and gives out heat without a flame. This is because a flame is only produced when gaseous substances burn. When wood or charcoal is ignited, the volatile substances present vapourise and burn with a flame in the beginning. A luminous flame is also observed when the atoms of the gaseous substances are heated and start to glow. The colour of the flame is characteristic of that element. For example, when a copper wire is heated in the flame of a gas stove, a bluish green colour is obtained.

The incomplete combustion gives soot or smoke which is due to carbon. Saturated hydrocarbons burn with blue non-sooty flame. This is because the percentage of carbon in these compounds is low which gets oxidised completely by the oxygen present in the air.

On the other hand, unsaturated hydrocarbons burn with yellow sooty flame. This is because the percentage of carbon in these compounds is comparatively higher (than saturated compounds). Therefore, all the carbon does not get oxidised completely in the oxygen of the air. Due to incomplete combustion, the flame is sooty due to the presence of unburnt carbon particles.

The fuels such as coal, petroleum have some amount of nitrogen and sulphur in them. On heating, they are burnt to oxides of nitrogen and sulphur, which are released in the atmosphere. These are the major pollutants in the environment.

15.3 FORMATION OF COAL AND PETROLEUM:

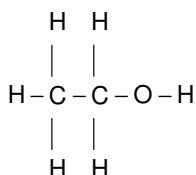
Coal and petroleum are the fossil fuels. These are believed to be formed from biomass which has been subjected to various biological and geological processes inside the earth. Coal is formed from the remains of plants and animals (fossils) which died about millions of years ago. These remains gradually got buried deep in the earth during earthquakes, volcanoes etc. These remains were covered with sand, clay and water. Due to high temperature and high pressure and the absence of air inside the earth, the fossils got converted into coal. This process of conversion of plants and animals buried inside the earth under high temperature and pressure to coal is called **carbonisation**. It is a very slow process and may have taken thousands of years.

Petroleum is formed from the bacterial decomposition of the remains of animals and plants which got buried under the sea millions of years ago. When these organisms died, they sank to the bottom and got covered by sand and clay. Over a period of millions of years, these remains got converted into hydrocarbons by heat, pressure and catalytic action. The hydrocarbons formed rose through porous rocks and got trapped between two layers of impervious rock forming an oil trap.

15.4 SOME IMPORTANT CARBON COMPOUNDS :

15.4 (a) Ethanol or (Ethyl alcohol):

- Ethanol is the second member of the homologous alcoholic series.
- It is also known as methyl carbinol.
- Structural formula.



(i) Properties of Ethanol:

(A) Physical properties.

- Ethanol is colourless liquid having a pleasant smell.
- Ethanol boils at 351 K.
- It is miscible with water in all proportions.
- It is a nonconductor of electricity (it does not contain ions)
- It is neutral to litmus.

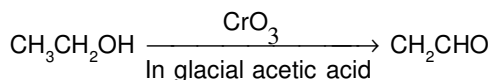
(B) Chemical properties :

- **Combustion :** Ethanol burns in air with a blue flame to form CO_2 & H_2O .

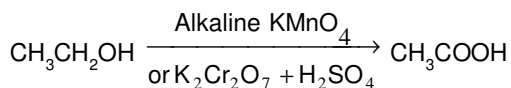


- **Oxidation**

(i) By mild oxidizing agent CrO_3 (Chromic anhydride).

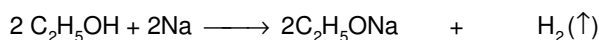


(ii) By strong oxidizing agent ($\text{K}_2\text{Cr}_2\text{O}_7 + \text{H}_2\text{SO}_4$ or alkaline KMnO_4).

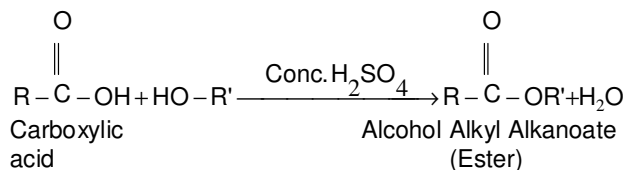


Ethanol Ethanoic acid

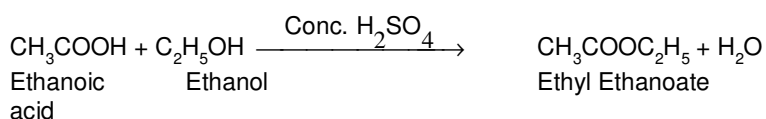
(C) Reaction with sodium: Ethanol reacts with sodium to produce hydrogen gas and sodium ethoxide.



(iv) Reaction with carboxylic acids : [ESTERIFICATION] The process of formation of an ester by the combination of an alcohol with carboxylic acid is known as esterification/

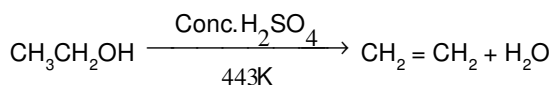


When ethanol reacts with ethanoic acid in presence of concentrated sulphuric acid ethyl ethanoate and water are formed.



Esters are sweet smelling substances and thus are used in making perfumes.

(v) Acton with concentrated sulphuric acid : Ethanol reacts with concentrated sulphuric acid at 443 K to produce ethylene. This reaction is known as acidic dehydration of ethanol because in this reaction, water molecule is removed from ethanol.



Ethanol

The concentrated sulphuric acid may be regarded as a dehydrating agent because it removes water from ethanol.

15.4 (b) Some Important Terms :

(i) **Denatured alcohol** : To prevent the misuse for drinking purpose, the alcohol supplied for industrial purpose is rendered unfit by mixing it with some poisonous substances like methanol, pyridine, copper sulphate etc. It is known as denatured alcohol.

(ii) **Rectified spirit** : Ethanol containing 5 percent water is known as rectified spirit.

(iii) **Absolute alcohol** : Rectified spirit is heated under reflux over quicklime for about 5 to 6 hours and then allowed to stand for 12 hours. One distillation, pure alcohol ($C_2H_5OH = 100\%$) is obtained. This is called absolute alcohol.

(iv) **Power alcohol** : Alcohol, which is used for generating power is called power alcohol. It consists of a mixture of absolute alcohol petrol roughly in the ratio 20 : 80. Since alcohol itself, does not mix with petrol, therefore, a third solvent such as benzene, ether etc. is added as a co-solvent.

15.4 (c) Uses of Ethanol:

(i) Ethanol is a constituent of beverages like beer, wine, whisky and other liquors.

| | | |
|--------|---|------------------|
| Beer | = | 3 - 6% Ethanol |
| Whisky | = | 50% Ethanol |
| Wine | = | 10 - 20% Ethanol |

(ii) Ethanol is used to sterilize wounds and syringes.

(iii) **Antifreeze** : It is a mixture of ethanol and water which has a much lower freezing point than that of water. It is used in radiators of vehicles in cold countries.

(iv) It is used in manufacture of paints, dyes, medicines, soaps and synthetic rubber. Solution of ethanol prepared in pharmaceutical industry are known as **tinctures**.

15.4 (d) Harmful effects of drinking alcohol :

(i) If ethanol is mixed with CH_3OH and consumed, it may cause serious poisoning and loss of eyesight.

(ii) It causes addiction (habit forming) and mixes with blood. It damages liver if taken regularly.

(iii) Higher amount of consumption of ethanol leads to loss of body control & consciousness. It may even cause death.

DAILY PRACTICE PROBLEMS # 15

OBJECTIVE DPP - 15.1

- Sometimes during cooking the bottom of the vessel becomes black from outside. This means that -
 (A) food is not cooked properly. (B) fuel is not burning completely.
 (C) fuel is burning completely. (D) fuel is dry.
- Rectified spirit is -
 (A) 50% ethanol (B) 80% ethanol (C) 95% ethanol (D) 100 % ethanol
- Which of following gives ethane when heated with cons. sulphuric acid ?
 (A) CH_3CHO (B) CH_3COOH (C) CH_3OH (D) $\text{CH}_3\text{CH}_2\text{OH}$
- Which of the following will react with sodium metal ?
 (A) Ethanol (B) Ethanol (C) Ethane (D) Ethane
- Ethanol on complete oxidation gives -
 (A) CO_2 and water (B) acetaldehyde (C) acetic acid (D) acetone
- When ethyl alcohol is heated with conc. H_2SO_4 the product formed is -
 (A) C_4H_8 (B) C_2H_4 (C) C_3H_4 (D) C_2H_2
- When alcohol reacts with sodium metal the gas evolved is-
 (A) O_2 (B) CH_2 (C) CO (D) CO_2
- Power alcohol contains -
 (A) 50% petrol and 50% ethanol
 (B) 80% petrol and 20% ethanol
 (C) 25% petrol and 75% ethanol
 (D) 70% petrol and 30% ethanol

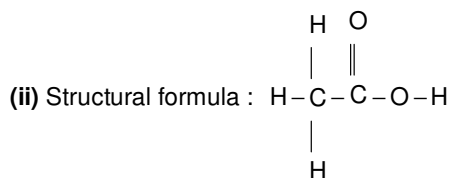
SUBJECTIVE DPP -15.2

- What is denatured alcohol ? How is it prepared ?
- What are the harmful effects of drinking alcohol ?
- What is an antifreeze ?
- Do alcohols give litmus test ?
- Give the important uses of ethyl alcohols.

CARBON AND ITS COMPOUNDS

16.1 ETHANOIC ACID (OR ACETIC ACID) :

(i) Molecular formula : CH_3COOH



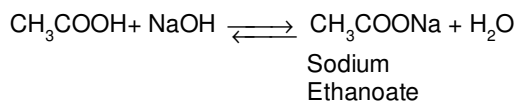
(iii) It dissolves in water, alcohol and ether. Its dissolution in water takes place with the evolution of heat and decrease in volume of the solution.

(iv) The melting point of ethanoic acid is 290 K and hence it often freezes during winter in cold climates. Therefore, it is named as **glacial acetic acid**.

16.1 (b) Chemical properties :

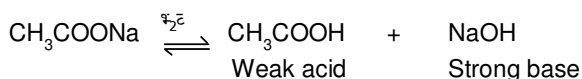
(i) **Acidic character** : Ethanoic acid is a monobasic acid. It has a replaceable hydrogen atom in its -COOH group. Therefore, it neutralizes alkalis.

(A) It reacts with a solution of sodium hydroxide to form sodium ethanoate and water.

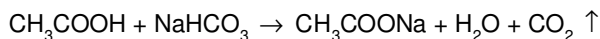
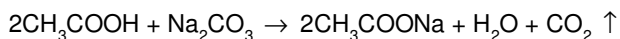


Sodium ethanoate is an ionic compound which dissolves in polar solvents such as water, but does not dissolve in non-polar solvents such as alcohol, propanone etc.

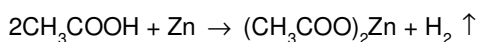
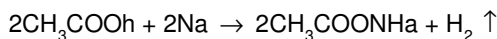
The aqueous solution of sodium ethanoate is alkaline due to hydrolysis.



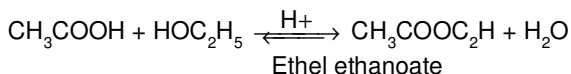
(B) It reacts with sodium carbonate and sodium bicarbonate with the evolution of CO_2 gas.



(C) It reacts with metals like sodium, zinc and magnesium to liberate hydrogen gas.



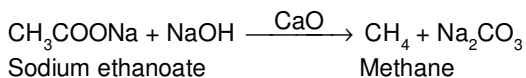
(ii) Ester formation : When ethanoic acid is heated with ethanol in presence of small quantity of conc. H_2SO_4 ethyl ethanoate, a sweet smelling ester, is formed.



This process of ester formation is called **esterification**.

(iii) Decarboxylation :

When sodium ethanoate is heated with soda lime, methane is formed.



The term 'decarboxylation' is used when the elements of carbon dioxide are removed from a molecule.

16.1 (c) Uses :

(i) Dilute aqueous solution (5-8%) of ethanoic acid is called vinegar, which is used to preserve food (sausage, pickles, etc.)

(ii) Pure ethanoic acid is used as a solvent and chemical reagent.

(iii) As cellulose ethanoate, it is used in making photographic films and rayon.

(iv) Ethanoic acid finds application in the preparation of propanone, chloroethanoic acid, ethanoates of metals etc.

(v) It is widely used in the manufacture of textiles.

(vi) It is used in the preparation of white lead.

16.1 (d) Tests for Ethanoic Acid :

(i) Litmus test : Add small amount of blue litmus solution to the given compound. If the blue litmus solution turns red, it indicates that the organic compound is ethanoic acid.

(ii) **Sodium bicarbonate test:** Take a small portion of the organic compound in a test tube and add a pinch of solid sodium bicarbonate. Evolution of carbon dioxide with brisk effervescence shows the presence of carboxylic acid.

(iii) **Ester formation :** When a mixture of ethanoic acid and ethanol is heated in the presence of concentrated sulphuric acid, a fruity smelling ester, ethyl ethanoate, is produced.

16.2 SOAPS AND DETERGENT :

The word '**detergent**' means '**cleansing agent**' and so the detergents are substances which **remove dirt** and have cleansing action in water. According to this definition of detergents, soap is also a detergent and has been used for more than two thousand years. There are two types of detergents :

- (a) Soapy detergents or soaps
- (b) Non - soapy detergents or soapless soaps.

16.3 (a) Soap:

A soap is a **sodium or potassium salt** of some **long chain carboxylic acids** (fatty acid). Sodium salts of fatty acids are known as hard soaps and potassium salts of fatty acid are known as soft soaps. A soap has a large non-ionic hydrocarbon group and an ionic COO^-Na^+ group. The structure of soap can be represented as:

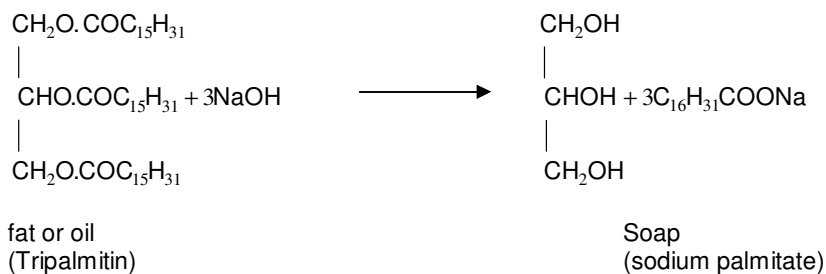


where ~~~~~ represents the hydrocarbon group and \ominus represents negatively charged carboxyl group. Some example so soaps are sodium stearate, $\text{C}_{17}\text{H}_{35}\text{COO}^-\text{Na}^+$, sodium palmitate, $\text{C}_{15}\text{H}_{31}\text{COO}^-\text{Na}^+$ and sodium oleate, $\text{C}_{17}\text{H}_{33}\text{COO}^-\text{Na}^+$.



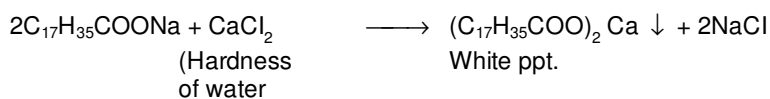
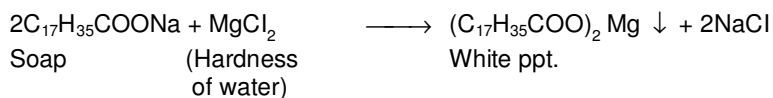
Hard water, which contains salts of magnesium and calcium, reacts with soap to form magnesium and calcium salts of fatty acid.

(i) **Preparation of soap :** Soap is prepared by heating oil or fat of vegetable or animal origin with concentrated sodium hydroxide solution (caustic soda solution). Hydrolysis of fat takes place and a mixture of sodium salt of fatty acids and glycerol is formed. Since the salt of fatty acids thus formed are used as soap so alkaline hydrolysis of oils and fats is commonly known as saponification.



(ii) **Limitation of soaps :** Soap is not suitable for washing clothes with hard water because of the following reasons.

(A) Hard water contains salts of calcium and magnesium. When soap is added to hard water, calcium and magnesium ions of hard water react with soap forming insoluble calcium and magnesium salts of fatty acids.



Therefore, a lot of soap is wasted if water is hard.

(B) When hard water is used, soap forms insoluble precipitates of calcium and magnesium salts, which stick to the cloth being washed. Therefore, it interferes with the cleaning ability of the soap and makes the cleaning process difficult.



These calcium and magnesium salts of fatty acid are insoluble in water and separate as cruddy white precipitate.

16.3 (b) Detergents:

These are also called synthetic detergents or soapless soaps. A synthetic detergent is the **sodium salt of a long chain benzene sulphonic acid or the sodium salt of a long chain alkyl hydrogen sulphate.**

(i) **Preparation of Synthetic Detergents** : Synthetic detergents are prepared by **reacting hydrocarbons** from petroleum with **conc. sulphuric acid** and converting the product into its **sodium salt**.

Example :



Sodium p-dodecyl benzenesulphonate



Sodium lauryl sulphate



Washing powders available in the market contain about 15 to 30 percent detergents by weight.



Store in your memory

Alkaline hydrolysis of oils and fats is commonly known as saponification.

16.3 (c) Comparison Between Properties of Soaps and Detergents :

| S.No | Soaps | Synthetic detergents |
|------|---|--|
| 1 | Soaps are sodium salts of higher fatty acids | Synthetic detergents are sodium alkyl sulphates or sodium alkyl benzene sulphonates with alkyl group having more than ten carbon atoms. |
| 2 | Soaps are prepared from natural oils and fats. | Synthetic detergents are prepared from the hydrocarbons of petroleum. |
| 3 | Soaps form insoluble salts (curdy white ppt.) with calcium and magnesium which are present in hard water and hence, cannot be used in hard water/ | Calcium and magnesium salts of detergents are soluble in water and, therefore, no curdy white precipitates are obtained in hard water and hence, can be used even in hard water. |
| 4 | Soap cannot be used in acidic medium and they are decomposed into carboxylic acids in an acidic medium. | They can be used in acidic medium as they are the salt of strong acids and are not decomposed in acidic medium. |
| 5 | Soaps are biodegradable. | Some of the synthetic detergents are not biodegradable. |

16.3 (d) Advantages of Synthetic Detergents Over Soap :

Synthetic detergents are widely used as cleaning agents these days. Some of their advantages over soaps are :

(i) Synthetic detergents can be used for washing even in hard water. On the other, soaps are not suitable for use with hard water.

(ii) Synthetic detergents can be used even in acidic solutions because they are not readily decomposed in acidic medium. On the other hand, soaps cannot be used in acidic medium because they are decomposed into carboxylic acids in acidic medium.

(iii) Synthetic detergents are more soluble in water than soaps.

(iv) Synthetic detergents have a stronger cleaning action than soaps.

16.3 (e) Cleaning Action of Soaps and Detergents :

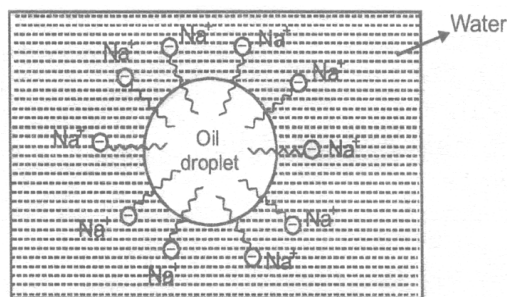
A molecule of soap is made up of two parts : a non polar part consisting of a long chain 12 - 18 carbon atoms and a polar part, $\text{COO}^- \text{Na}^+$. The polar end is water soluble and is thus hydrophilic whereas hydrocarbon part is insoluble in water and is thus hydrophobic. In a soap solution, the hydrocarbon portions of several soap molecules huddle together to form aggregates of molecules (or ions) called micelles. The soap micelles are negatively charged due to the presence of carboxylate ions at the surface. Repulsion between similarly charged micelles keeps them dispersed in the solution.



Store in your memory

The hydrocarbon part is however soluble in non-polar solvents and is sometimes called lipophilic.

(i) Cleansing action of soap : Mostly the dirt is held to any surface such as cloth by the oil or grease which is present there. Now since the oil and grease are not soluble in water, the dirt particles cannot be removed by simply washing the cloth with water. However, when soap is applied, the non polar hydrocarbon part of the soap molecules dissolves in oil droplets while the polar - COO⁻ Na⁺ groups remain attached to water molecules. In this way, each oil droplet gets surrounded by negative charge.



These negatively charged oil droplets cannot coalesce and continue breaking into small droplets. These oil droplets (containing dirt particles) can be washed away with water along with dirt particles. So, the action of soap or detergents is to emulsify oil or grease, this loosens the soil particles of dirt and they are removed.



In a soap molecule hydrophilic polar end in water soluble and hydrophobic hydrocarbon part is insoluble in water.

Soap or detergent helps in cleansing in another way. Not only it emulsifies oil or grease but it also lowers the surface tension of water. As a result of this water wets things more effectively.

When water is added on to the surface of the cloth then water molecules tend to stay as close to each other as possible because of the strong forces of attraction (hydrogen bonding) for each other and do not wet the cloth properly. If some soap solution is added to this away then polar end of soap dissolves in water and non polar hydrocarbon end remains away from the water. Thus, soap molecules arrange themselves between the water molecules on the surface of water and decrease the forces of attraction between the water molecules. Water can now spread on the surface of cloth and can make it wet effectively.

16.3 (f) Synthetic Detergent : A Serious Problem :

It may be noted that in the past, the widespread use of detergents caused pollution of rivers and other water bodies. Earlier the synthetic detergents were made from long chain of hydrocarbons having a lot of branched chains in them. These branched chain detergent molecules were degraded very slowly by the micro organisms present in water bodies like lakes or rivers.

Therefore, they tend to remain in water bodies for a long time and make water unfit for aquatic life. For example, detergents containing phosphates can cause rapid growth of algae and therefore, deplete the dissolved oxygen present in the water of lakes and rivers. As a result of lack of oxygen, fish and other aquatic animals may die. To solve these problems, now-a-days, the detergents are prepared from hydrocarbons which have minimum branching. These are degraded more easily than branched chain detergents. Therefore, these are biodegradable and create less problems.

DAILY PRACTICE PROBLEMS # 16

OBJECTIVE DPP - 16.1

1. Vinegar is -
 (A) 5% aqueous solution of acetic acid
 (B) 20% alcoholic solution of acetic acid
 (C) 100% acetic acid
 (D) none of these

2. Glacial acetic acid is -
 (A) 100% acetic acid free of water. (B) solidified acetic acid.
 (C) gaseous acetic acid. (D) frozen acetic acid.

3. When ethanoic acid is heated with NaHCO_3 the gas evolved is -
 (A) H_2 (B) CO_2 (C) CH_4 (D) CO

4. Which of the following will give a pleasant smell heated with ethyl alcohol, in presence of sulphuric acid -
 (A) CH_3COOH (B) $\text{CH}_3\text{CH}_2\text{OH}$ (C) CH_3OH (D) CH_3CHO

5. During decarboxylation of ethanoic acid with soda lime ($\text{NaOH} + \text{CaO}$), CO_2 is removed as -
 (A) CO_2 (B) CO (C) Na_2CO_3 (D) CaCO_3

6. A by product of soap industry is -
 (A) sodium hydroxide (B) sodium palmitate
 (C) glycerol (D) Both B & C

7. Which one of the following statements is incorrect about soaps :
 (A) Soaps are biodegradable.
 (B) Soaps are sodium salts of higher fatty acids.
 (C) Soaps are prepared from natural oils & fats.
 (D) Soaps can be used in acidic solutions.

8. Which of the following is not correctly matched ?
 (A) Hard soaps - sodium salts of fatty acids.
 (B) Soft soaps - potassium salts of fatty acids.
 (C) Hydrophilic - water insoluble
 (D) None of these

9. Cleansing action of soaps includes :
- (A) formation of micelles.
 - (B) emulsification of oil or grease.
 - (C) lowering of surface tension of water.
 - (D) all of the above.
10. Washing powders contain detergent in the following range -
- (A) 10 - 15 % (B) 15 - 30% (C) 50 - 60 % (D) 40 - 50 %

SUBJECTIVE DPP - 16.2

1. Although both acid and base are obtained from the salt of ethanoic acid, yet the overall aqueous solution of sodium ethanoate is alkaline. Give reason.
2. Complete the following reactions -
- (a) $\text{CH}_3\text{COOH} + \text{NaHCO}_3 \longrightarrow$
- (b) $\text{HCOOH} + \text{CH}_3\text{OH} \xrightarrow[\text{H}_2\text{SO}_4]{\text{Conc.}}$
3. Describe the following
- (i) power alcohol (ii) denatured spirit
4. Why are detergents preferred over soaps ?
5. Give the chemical reaction involved in the preparation of soaps.

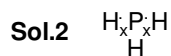
ANSWERS

OBJECTIVE DPP - 12.1

| Ques | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|------|---|---|---|---|---|---|---|---|---|----|
| Ans. | D | D | A | C | B | C | D | B | B | B |

SUBJECTIVE DPP - 12.1

Sol.1 To achieve the configuration of nearest noble gas element.



Sol.3 Sodium chloride (NaCl) & Chlorine gas (Cl₂)

Sol.4 Covalent, Y = X = Y

Sol.4 O = C = O (CO₂)

OBJECTIVE DPP - 13.1

| Ques | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|------|---|---|---|---|---|---|---|---|---|----|
| Ans. | A | B | D | A | N | D | A | C | C | A |

SUBJECTIVE DPP - 13.2

Sol.1 (a) Functional group isomerism (b) Position isomerism

Sol.2 The common difference is -CH₂.

OBJECTIVE DPP - 14.1

| Ques | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|------|---|---|---|---|---|---|---|---|---|----|
| Ans. | C | C | C | C | A | B | B | A | C | C |

SUBJECTIVE DPP - 13.2

Sol.1 Functional group

Sol.2 (a) Propan-1-ol (b) propan-2-ol (c) Position isomers

Sol.3 (a) CH₃COCH₃ (b) CH₃CH₂CH₂CH₂COOH
(c) CH₃COOH (d) CH₃CH₂CH₂CH₂OH

Sol.4 Ketone group (- CO -)

Sol.5 (a) 1- Bromoethane (b) 1- Hexyne

OBJECTIVE DPP - 15.1

| | | | | | | | | |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|
| Ques | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Ans. | B | C | D | A | C | B | B | B |

SUBJECTIVE DPP - 15.2

Sol.3 It is a mixture of ethanol and water which has a much lower freezing point than that of water. It is used in radiators of vehicles in cold countries.

Sol.4 No, because they are neutral in nature.

OBJECTIVE DPP - 16.1

| | | | | | | | | | | |
|-------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| Ques | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Ans. | A | A | B | A | C | C | D | C | D | B |

SUBJECTIVE DPP - 16.2

Sol.1 Sodium ethanoate is a salt of strong base and weak acid.

Sol.2 (a) CH_3COONa , CO_2 , H_2O

(b) HCOOCH_3 , H_2O

PERIODIC TABLE

& PERIODICITY IN PROPERTIES

17.1 DEFINITION :

A periodic table may be defined as the table giving the arrangement of all the known elements according to their properties so that elements with similar properties fall with the same vertical column and elements with dissimilar properties are separated.

17.2 EARLY ATTEMPTS TO CLASSIFY ELEMENTS :

17.2 (a) Metals and Non - Metals :

Among the earlier classification, **Lavoisier** classified the elements as metals and non-metals. However, this classification proved to be inadequate. In 1803, **John Dalton** published a table of relative atomic weights (now called atomic masses). This formed an important basis of classification of elements.

17.2 (b) Dobereiner's Triads :

(i) In 1817, **J.W.Dobereiner** a German Chemist gave this arrangement of elements.

(A) He arranged **elements with similar properties** in the groups of **three** called **triads**.

(B) According to **Dobereiner** the atomic mass of the central element was merely the arithmetic mean of atomic masses of the other two elements.

For e.g.

| Elements of the triad | Symbol | Atomic mass |
|-----------------------|--------|-------------|
| Lithium | Li | 7 |
| Sodium | Na | 23 |
| Potassium | K | 39 |

$$\begin{aligned} \text{Atomic mass of sodium} &= \frac{\text{Atomic mass of lithium} + \text{Atomic mass of potassium}}{2} \\ &= \frac{7 + 39}{2} = 23 \end{aligned}$$

Some examples of triads are given in the table :

| S.No. | Triads | Relative atomic masses | Average of atomic masses of the first and the third element |
|-------|------------|------------------------|---|
| 1 | S, Se, Te | 32, 79, 128 | $\frac{32+128}{2} = 80$ |
| 2 | Cl, Br, I | 35.5, 80, 127 | $\frac{35.5+127}{2} = 81.25$ |
| 3 | Ca, Sr, Ba | 40, 88, 137 | $\frac{40+137}{2} = 88.5$ |

(ii) Limitations of Dobereiner's Classification :

(A) Atomic mass of the three elements of some triads are almost same.

e.g. Fe, Co, ni and Ru, Rh, Pd

(B) It was restricted to few elements, therefore discarded.

17.2 (c) Newlands' Law of Octaves :

In 1866, an English chemist, **John Newlands**, Proposed a new system of grouping elements with similar properties. He tried to correlate the properties of elements with their atomic masses. he arranged the then known elements in the order of **increasing atomic masses**. He started with the element having the lowest atomic mass (hydrogen) and ended at **thorium** which was the 56th element. He observed that every eight element had properties similar to that of the first.

Thus, Newlands suggested that when the elements are arranged in the order of increasing atomic masses, the properties of every eight element are a repetition of that of the first element.



Newland called this relation as a law of octaves due to the similarity with the musical scale.

(i) Newlands' arrangement of elements into 'Octaves':

| Notes of Music | sa (do) | re (re) | ga (mi) | ma (fa) | pa (so) | da (la) | ni (ti) |
|----------------|-----------|---------|---------|-----------|---------|---------|---------|
| Elements | H | Li | Be | B | C | N | O |
| | F | Na | Mg | Al | Si | P | S |
| | Cl | K | Ca | Cr | Ti | Mn | Fe |
| | Co and Ni | Cu | Zn | Y | In | As | Se |
| | Br | Rb | Sr | Ce and La | Zr | - | - |

(ii) Limitations of law of octaves : The law of octaves has the following limitations :

(A) The law of octaves was found to be **applicable only upto calcium**. It was not applicable to elements of higher atomic masses.

(B) Position of hydrogen along with fluorine and chlorine was not justified on the basis of chemical properties.

(C) Newlands **placed two elements in the same slot** to fit elements in the table. He also **placed some unlike elements** under the same slot. For example, cobalt and nickel are placed in the same slot and in the column of fluorine, chlorine and bromine. But cobalt and nickel have properties quite different from fluorine, chlorine and bromine. Similarly, iron which has resemblances with cobalt and nickel in its properties has been placed far away from these elements.

Thus, it was realized that Newlands' law of octaves **worked well only with lighter elements**. Therefore, this classification was rejected.

17.2 (d) Mendeleev's Periodic Table :

The major credit for a systematic classification of elements goes to **Mendeleev**. He has been trying to group the elements on the basis of some fundamental property of the atoms. When Mendeleev started his work, **only 63 elements** were known. He examined the relationship between atomic masses of the elements and their physical and chemical properties.

Among chemical properties, Mendeleev concentrated mainly on the compound formed by elements with oxygen and hydrogen. He selected these two elements because these are very reactive and formed compounds with most of the elements known at that time. The formulae of the compounds formed with these elements (i.e. oxides and hydrides) were regarded as one of the basic properties of an element for its classification.

(i) **Mendeleev's periodic law** : This law states that the physical and chemical properties of the elements are the periodic function of their atomic masses. This means that when the elements are arranged in the order of their increasing atomic masses, the elements with similar properties recur at regular intervals. Such orderly recurring properties in a cyclic fashion are said to be occurring periodically. This is responsible for the name periodic law or periodic table.

(ii) **Merits of Mendeleev's periodic table** : Mendeleev's periodic table was one of the greatest achievements in the development of chemistry. Some of the important contributions of his periodic table are given below :

(A) **Systematic study of elements** : He arranged known elements in order of their increasing atomic masses considering the fact that elements with similar properties should fall in the same vertical column.

(B) **Correction of atomic masses** : The Mendeleev's periodic table could predict errors in the atomic masses of certain elements were corrected. For example, atomic mass of beryllium was corrected from 13.5 to 9. Similarly, with the help of this table, atomic masses of indium, gold, platinum etc. were corrected.

(C) Mendeleev **predicated** the properties of those **missing elements** from the known properties of the other elements in the same group. Eka-boron, eka – aluminum and eka - silicon names were given for scandium, gallium and germanium (not discovered at the time of Mendeleev).



Properties predicted by Mendeleev for missing elements and those found experimentally were almost same.

(D) Position of noble gases : Noble gases like helium (He), neon (Ne) and argon (Ar) were mentioned in many studies. However, these gases were discovered very late because they are very inert and are present in extremely low concentrations. One of the achievements of Mendeleev's periodic table was that when these gases were discovered, they could be placed in a new group without disturbing the existing order.

(iii) Limitations of Mendeleev's periodic table : In spite of many advantages, the Mendeleev's periodic table has certain defects also. Some of these are given below -

(A) Position of hydrogen : Position of hydrogen in the periodic table is **uncertain**. It has been placed in 1A group with alkali metals, but certain properties of hydrogen resemble those of halogens. So, it may be placed in the group for halogens as well/

(B) Position of isotopes : Isotopes are the atoms of the same element having different atomic masses. Therefore, according to Mendeleev's classification these should be placed at different places depending upon their atomic masses. For example, hydrogen isotopes with atomic masses 1, 2 and 3 should be placed at three places. However, isotopes have not been given separate places in the periodic table because of their similar properties.

(C) Anomalous pairs of elements “ In certain pair of elements, the increasing order of atomic masses was not obeyed. In these, Mendeleev placed elements according to similarities in their properties and not in increasing order of their atomic masses.

For example :

- The atomic mass of argon is 39.9 and that of potassium 39.1 But argon is placed before potassium in the periodic table.
- The positions of cobalt and nickel are not in proper order. Cobalt (at. mass = 58.9) is placed before nickel (at. mass = 58.7)
- Tellurium (at. mass = 127.6) is placed before iodine (at. mass = 126.9)/

(D) Some similar elements are separated, in the periodic table. For example copper (Cu) and mercury (Hg), barium (Ba) and lead (Pb). On the other hand some dissimilar elements have been placed together in the same group.

e.g. : Copper (Cu), silver (Ag) and gold (Au) have been placed in group 1 along with alkali metals. Similarly, manganese (Mn) is placed in the group of halogens.

(E) Cause of periodicity : Mendeleev could not explain the cause of periodicity among the elements.

DAILY PRACTICE PROBLESM # 17

OBJECTIVE DPP - 17.1

- The law of octaves was proposed by -
 (A) Newlands (B) Dobereiner (C) Lavoisier (D) Mendeleev
- The early attempt to classify elements as metals and non-metals was made by -
 (A) Mendeleev (B) Newlands (C) Lavoisier (D) Henry Moseley
- The early attempts to classify elements were based on-
 (A) atomic number (B) atomic mass
 (C) electronic configuration (D) none of these
- Cl, Br, I, if this is Dobereiner's triad and the atomic masses of Cl and I are 35.5 and 127 respectively, then the atomic mass of Br is -
 (A) 162.5 (B) 91.5 (C) 81.25 (D) 45.625
- According to Newlands' law of octaves 3rd element will resemble in its properties to-
 (A) ninth element (B) eight element (C) tenth element (D) eleventh element
- New lands could classify elements only upto-
 (A) copper (B) chlorine (C) calcium (D) chromium
- According to Mendeleev's periodic law which properties of the elements are the periodic function of their atomic masses ?
 (A) Physical properties only (B) Chemical properties only
 (C) Physical and chemical properties both (D) none of these
- Mendeleev classified elements in-
 (A) increasing order of atomic number (B) increasing order of atomic masses.
 (C) decreasing order of atomic masses. (D) decreasing order of atomic number.
- Mendeleev's periodic table was divided into -
 (A) seven periods and seven groups (B) eight periods and eight groups.
 (C) seven periods and eight groups (D) eight periods and seven groups.
- Noble gases were included in Mendeleev's periodic table in the -
 (A) 1st group (B) 7th group (C) 8 th group (D) None of these

SUBJECTIVE DPP - 17.2

1. Why did Mendeleev leave the gaps in the periodic table ?
 2. What were the major defects of Mendeleev's classification ?
 3. Why in the law proposed by Newlands called the Law of Octaves ?
 4. A,B,C are the elements of a Dobereiner's triad. If the atomic mass of 'A' is 9 and that of 'C' is 39, what is the atomic mass of elements 'B' ?
 5. Among the halogens F, Cl, Br, and I which does not fit in the Dobereiner's triad ?
 6. What does the word 'Period' signify in the periodic table ?
 7. What is common in the musical notes and the elements arranged by Newlands ?
 8. How many elements were known when Mendeleev gave his periodic table ?
-

PERIODIC TABLE & PERIODICITY IN PROPERTIES

18.1 MODERN PERIODIC TABLE :

18.1 (a) Introduction :

In 1913, an English physicist, **Henry Moseley** showed that the physical and chemical properties of the atoms of the elements are determined by their **atomic number** and not by their atomic masses. Consequently, the periodic law was modified.

18.1 (b) Modern periodic Law (Moseley's Periodic Law):

"Physical and chemical properties of an element are the periodic function of its atomic number". The atomic number gives us the **number of protons** in the nucleus of an atom and this number **increases atomic number**, is called periodicity.

18.1 (d) Cause of Periodicity :

The periodic repetition of the properties of the elements is due to the recurrence of **similar valence shell** (outermost shell) electronic configuration (ns^1) and therefore, have similar properties.

Alkali Metals

| Atomic number | Element | Symbol | Electronic configuration |
|---------------|-----------|--------|--------------------------|
| 3 | Lithium | Li | 2,1 |
| 11 | Sodium | Na | 2,8,1 |
| 19 | Potassium | K | 2,8,8,1 |
| 37 | Rubidium | Rb | 2,8,18,8,1 |
| 55 | Caesium | Cs | 2,8,18,18,8,1 |
| 87 | Francium | Fr | 2,8,18,32,18,8,1 |



Modern periodic table is based on atomic number, not an atomic mass.

PERIODIC TABLE OF THE ELEMENTS

| Period | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | | | | |
|--------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|-------------------|-------------------|--------------------|--------------------|
| 1 | 1 H 1.0079 | | | | | | | | | | | | | | | | | 2 He 4.0026 | | | | |
| 2 | 3 Li 6.941 | 4 Be 9.0122 | | | | | | | | | | | | | | | 5 B 10.811 | 6 C 12.011 | 7 N 14.007 | 8 O 15.999 | 9 F 18.998 | 10 Ne 20.180 |
| 3 | 11 Na 22.990 | 12 Mg 24.305 | | | | | | | | | | | | | | | 13 Al 26.982 | 14 Si 28.086 | 15 P 30.974 | 16 S 32.065 | 17 Cl 35.453 | 18 Ar 39.948 |
| 4 | 19 K 39.098 | 20 Ca 40.078 | 21 Sc 44.956 | 22 Ti 47.867 | 23 V 50.942 | 24 Cr 51.996 | 25 Mn 54.938 | 26 Fe 55.845 | 27 Co 58.933 | 28 Ni 58.693 | 29 Cu 63.546 | 30 Zn 65.38 | 31 Ga 69.723 | 32 Ge 72.64 | 33 As 74.922 | 34 Se 78.96 | 35 Br 79.904 | 36 Kr 83.80 | | | | |
| 5 | 37 Rb 85.468 | 38 Sr 87.62 | 39 Y 88.906 | 40 Zr 91.224 | 41 Nb 92.906 | 42 Mo 95.94 | 43 Tc (99) | 44 Ru 101.07 | 45 Rh 102.91 | 46 Pd 106.42 | 47 Ag 107.87 | 48 Cd 112.41 | 49 In 114.82 | 50 Sn 118.71 | 51 Sb 121.76 | 52 Te 127.60 | 53 I 126.90 | 54 Xe 131.29 | | | | |
| 6 | 55 Cs 132.91 | 56 Ba 137.33 | 57 La 138.91 | 58 Ce 138.91 | 59 Pr 140.91 | 60 Nd 140.91 | 61 Pm (145) | 62 Sm 150.36 | 63 Eu 151.96 | 64 Gd 157.25 | 65 Tb 158.93 | 66 Dy 162.50 | 67 Ho 164.93 | 68 Er 167.26 | 69 Tm 168.93 | 70 Yb 173.04 | 71 Lu 174.97 | | | | | |
| 7 | 87 Fr (223) | 88 Ra (226) | 89 Ac (227) | 90 Th 232.04 | 91 Pa 231.04 | 92 U 238.03 | 93 Np 237 | 94 Pu 244 | 95 Am 243 | 96 Cm 247 | 97 Bk 247 | 98 Cf 251 | 99 Es 252 | 100 Fm 257 | 101 Md 258 | 102 No 259 | 103 Lr 262 | | | | | |

s-Block Elements

p-Block Elements

Transition Metals (d-Block Elements)

Inner - Transition Metals (f-Block Elements)

LANTHANOIDES

ACTINOIDES

18.1 (e) Long Form of Periodic Table :

- (i) The long form of periodic table is based upon **Modern periodic law**. Long form of periodic table is the contribution of **Range, Werner, Bohr and Bury**.
- (ii) This table is also referred to as **Bohr's table** Since it follows Bohr's scheme of the arrangement of elements into four types based on **electronic configuration of elements**.
- (iii) Long form of periodic table consists of **horizontal rows (periods)** and **vertical columns (groups)**.

18.1 (f) Description of Periods :

- (i) A **horizontal row** of a periodic table is called a **period**.
- (ii) There are **seven periods** numbered as 1,2,3,4,5,6 and 7.
- (iii) Each period starts with an **alkali metal** having outermost shell electronic configuration ns^1 .
- (v) Each period ends with a **noble gas** with outermost shell electronic configuration $ns^2 np^6$ except helium having outermost electronic configuration $1s^2$.
- (vi) Each period starts with the filling of a **new energy level**.

(A) 1st period : This period is called very short period because this period contains only 2 elements H and He.

(B) 2nd and 3rd periods : These periods are called short periods because these periods contain 8 elements. 2nd period starts from ${}_3\text{Li}$ to ${}_{10}\text{Ne}$ and 3rd period starts from ${}_{11}\text{Na}$ to ${}_{18}\text{Ar}$.

(C) 4th and 5th periods : These periods are called long periods because these periods contain 18 elements. 4th period starts from ${}_{19}\text{K}$ to ${}_{36}\text{Kr}$ and 5th period starts from ${}_{37}\text{Rb}$ to ${}_{54}\text{Xe}$.

(D) 6th period : This period is called very long period. This period contains 32 elements. Out of the 32 elements 14 elements belong to **Lanthanoid series** (${}_{58}\text{Ce}$ to ${}_{71}\text{Lu}$). 6th period starts from ${}_{55}\text{Cs}$ to ${}_{86}\text{Rn}$.

(E) 7th period : This period is called as incomplete period. It contains 25 elements. out of the 25 elements 14 elements belong to **Actinoid series** (${}_{90}\text{Th}$ to ${}_{103}\text{Lr}$). 7th period starts from ${}_{87}\text{Fr}$ to ${}_{111}\text{Rg}$.



Modern period table consists of seven periods and eighteen groups.

| Period | No. Of Elements | Called as |
|--------------------------|-----------------|-------------------|
| (1 [*]) n = 1 | 2 | Very short period |
| (2 nd) n = 2 | 8 | Short period |
| (3 rd) n = 3 | 8 | Short period |
| (4 th) n = 4 | 18 | Long period |
| (5 th) n = 5 | 18 | Long period |
| (6 th) n = 6 | 32 | Very long period |
| (7 th) n = 7 | 25 | Incomplete period |

Different elements belonging to a particular period have different electronic configurations and have different number of valence electrons. That is why elements belonging to a particular period have different properties.

18.1 (g) Description of Groups :

- (i) A **vertical column** of elements in the periodic table is called a **group**.
- (ii) There are **eighteen groups** numbered as 1,2,3,4,5,-----13,14,15,16,17,18.
- (iii) A group consists of a series of elements having **similar valence shell electronic configuration** and hence exhibit **similar properties**.

e.g. : Li, Na, K belong to the same group and have 1 electron in their valence shell.

- (iv) The group 18 is also known as **zero group** because the valency of the elements of this group is zero.



the elements of 18th or zero group are called noble gases.

- (v) The elements present in groups 1,2,13 to 17 are called **normal representative** elements.
- (vi) Elements of group 1 and 2 are called **alkali metals** and alkaline **earth metals** respectively.
- (vii) Elements present in group 17 are called **halogens**.



Elements present in a period have different properties, while elements present in a group have similar properties.

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18.1 (h) Merits of Long Form of Periodic Table L

(i) The long form of periodic table is based on **atomic number**. Atomic number is a more fundamental property of an element as compared to atomic mass.



Not two elements can have the same atomic number.

(ii) In the long form of periodic table, different isotopes can be placed at the same place because they have the same atomic number. On the other hand, isobars such as Ar (40) and Ca (40) have to be placed at different places due to their different atomic numbers.

(iii) The long form of periodic table can explain why all the elements in a group have similar properties while the elements in a period have different properties.

The basis for periodicity of elements is the similar electronic configuration of the outermost shell of elements of the same group. The similar electronic configuration of the elements are repeated at regular intervals so the properties of the elements are also repeated at regular intervals.

(iv) It is easy to remember and reproduce the table.

18.1 (i) Limitations of Long Form of Periodic Table :

(i) Position of hydrogen is not accurate.

(ii) Inner transition elements (lanthanoids and actinoids) have been given separate positions below in the periodic table.

DAILY PRACTICE PROBLEMS # 18

OBJECTIVE DPP - 18.1

- Modern periodic law was proposed by-
(A) Mendeleev (B) Henry Mosley (C) Werner (D) Bohr and Bury
- The long form of periodic table consists of -
(A) seven periods & eight groups. (B) seven periods & eighteen groups.
(C) eight periods & eighteen groups. (D) eighteen periods & eight groups.
- In the long form of periodic table lanthanides are placed in the -
(A) 2nd period (B) 5th period (C) 6th period (D) 7th period
- All the members in a group of long form of periodic table have the same-
(A) valency (B) number of valence electrons
(C) chemical properties (D) all of these
- Which of the following pairs of elements belong to the same period of the periodic table ?
(A) C, Mg (B) N, Ar (C) Ca, Cl (D) K, Cu

6. The number of elements in the 4th period of periodic table are -
(A) 8 (B) 18 (C) 10 (D) 32
7. One important merit of modern periodic table is -
(A) it explains why elements in the same group have the same chemical properties.
(B) hydrogen has been placed accurately.
(C) isobars have not been placed separately.
(D) it is based on classifying elements according to their atomic masses.
8. Which of the following properties does not match to the elements of halogen family ?
(A) They have seven electrons in their valence shells.
(B) They are diatomic in their molecular form.
(C) They are highly reactive chemically.
(D) They are metallic nature.
9. Which of the following sets does not belong to a group ?
(A) Li, Na, K (B) N, O, F, (C) Be, Mg, Ca (D) He, Ne, Ar
10. In the modern periodic table which one of the following does not have a appropriate position?
(A) Transition elements (B) Inert gases
(C) Inner transition elements (D) Halogens

SUBJECTIVE DPP - 18.2

1. What is a group and period in a periodic table ?
2. State the modern periodic law.
3. Why are 18th group elements called inert gases ?
4. Name three elements with single electron in their valence shell.
5. Name the metals among first ten elements in the modern periodic tale.
6. Give the name and the electronic configuration of the second alkali metal.
7. What is the similarity in the electronic configurations Mg, Ca and Sr ?
8. On the basis of the periodic classification, identify each set belonging to either a group or a period.
(a) Na, Mg, Al (b) K, RB, Cs (c) N, O, F (d) Ne, Ar, Kr

PERIODIC TABLE & PERIODICITY IN PROPERTIES

19.1 PERIODICITY IN PROPERTIES :

(i) The electronic configuration of the atoms display periodic variations with **increase in atomic number**.

(ii) The elements exhibit periodic variations of physical and chemical properties.

Following are some the important properties of the elements -

(a) Valency

(b) Atomic size

(c) Metallic and non - metallic character

19.1 (a) Valency :

(i) The **valency** of an element may be defined as the combining capacity of the element.

(ii) The electrons present in the outermost shell are called **valence electrons** and these electrons determine the valency of the atom.

Valency of an element is determined by the number of valence electrons in an atom of the element.

The valency of an element = number of valence electrons

(when number of valence electrons are from 1 to 4)

The valency of an element - 8 - number of valence electrons.

(when number of valence electrons are more than 4)

(iii) **Variation of valency across a period** : The number of valence electrons increases from 1 to 8 on moving across a period. The valency of the elements with respect to **hydrogen** and **chlorine** increases from **1 to 4** and then decreases from **4 to zero**. With respect to **oxygen** valency increases from **1 to 7**.

Variation of valency of elements of second and third periods :

Elements of second period

Li Be B C N O F

Valency with respect to H

LiH BeH₂ BH₃ CH₄ NH₃ H₂O HF

(1) (2) (3) (4) (3) (2) (1)

Valency with respect to Cl

LiCl BeCl₂ BCl₃ CCl₄ NCl₃ Cl₂O ClF

(1) (2) (3) (4) (3) (2) (1)



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Valency of elements changes in a period.

Elements of third period :

Na Mg Al Si P S Cl

Valency with respect to H

NaH MgH₂ AlH₃ SiH₄ PH₃ H₂S HCl

(1) (2) (3) (4) (3) (2) (1)

Valency with respect to O

Na₂O MgO Al₂O₃ SiO₂ P₂O₅ SO₃ Si₂O₇

(1) (2) (3) (4) (5) (6) (7)

(iv) **Variation of valency along a group** : On moving down a group, the number of valence electrons remains the **same** and, therefore, all the elements in a group exhibit **the same valency**.

e.g. All the elements of group 1 have valency equal to 1 and those of group 2 have valency equal to 2.



Valency of elements remains same in a group.

19.1 (b) Atomic Size :

The term atomic size refers to the **radius** of an atom. In general atomic size may be considered as the distance between the centre of the nucleus and the outermost shell of an isolated atom.

(i) Variation of atomic size in a period : Within each period, the atomic radii decrease with increase in atomic number.

e.g. Atomic radii decrease from lithium to fluorine in the second period.

Reason : The decrease of atomic radii along a period can be explained on the basis of increase in **nuclear charge**. On moving from left to right across the period, the nuclear charge increases progressively by one unit but the additional electron goes to the **same shell**. As a result the electrons are pulled closer to the nucleus by the **increased nuclear charge**. This causes a **decrease** in atomic size.

Atomic Radii of Elements of Second period

| Element | ${}_3\text{Li}$ | ${}_4\text{Be}$ | ${}_5\text{B}$ | ${}_7\text{N}$ | ${}_8\text{O}$ | ${}_9\text{F}$ | ${}_9\text{F}$ | ${}_{10}\text{Ne}$ |
|-------------------|-----------------|-----------------|----------------|----------------|----------------|----------------|----------------|--------------------|
| Nuclear Charge | + 3 | + 4 | + 5 | + 6 | + 8 | +9 | +9 | + 10 |
| Configuration | $2s^1$ | $2s^2$ | $2s^2 2p^1$ | $2s^2 2p^2$ | $2s^2 2p^3$ | $2s^2 2p^4$ | $2s^2 2p^5$ | $2s^2 2p^6$ |
| Atomic Radii (pm) | 133 | 111 | 88 | 77 | 74 | 72 | 72 | 160 |

The values given in the table, show **abrupt increase** in the atomic size of Ne. This is due to the reason that the values for other elements are **covalent radii** whereas that for Ne it is **Vander Waals radius** because it does not form covalent bond due to its stable configuration.



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Covalent radii is taken when electrons are shared between two elements, while Vander Waals radii is taken in case of gases.

(ii) **Variation of atomic radii within a group** : The atomic radii increase from top to bottom within a group of the periodic table.

Atomic radii of alkali metals and halogens

| Alkali | | | Halogens | | |
|---------|-------------|--------|----------|-------------|--------|
| Element | Atomic (pm) | Radius | Element | Atomic (pm) | Radius |
| Li | 133 | | F | 64 | |
| Na | 157 | | Cl | 99 | |
| K | 201 | | Br | 114 | |
| Rb | 216 | | I | 133 | |
| Cs | 235 | | | | |

Reason :

In moving down a group, the **nuclear charge** increases with increase in atomic number, but at the same time there is a progressive increase in the number of **energy levels**. Since, the effect additional energy level is more pronounced than the effect of increased nuclear charge, the distance of the outermost electron from the nucleus increases on going down the group.

- **Atomic radii increase down the group.**
- **Atomic radii decrease across the period.**

19.2 METALLIC AND NON - METALLIC CHARACTER :

19.2 (a) Metals :

The metals are characterised by their nature of readily giving up the electrons.

(i) Metals comprise of more than 75% of all known elements and most of them appear on the left hand side of the periodic table.

(ii) Metals are usually **solid** at room temperature (except mercury).

(iii) They have **high melting and boiling points** and are **good conductors** of heat and **electricity**.

19.2 (b) Non - Metals :

(i) Non-metals do not lose electrons but take up electrons to form corresponding anions.

(ii) Non-metals are located at the top right hand side of the periodic table.

(iii) Non- metals are usually **solids or gases** (except bromine which is liquid) at room temperature with **low melting and boiling points**.

(iv) They are **poor conductors** of heat and electricity.



Carbon is an exception as one of its allotropic forms, graphite is a good conductors of electricity.

19.2 (c) Metalloids (Semimetals) :

(i) Some elements lying at the border of metallic and non-metallic behaviour possess the properties that are characteristics of **both metals and non - metals**. These elements are called semimetals or metalloids.

(ii) The metalloids comprise of the elements B, Si, Ge, As, Sb, Te and Po.

(iii) **Variation of metallic character across a period :**

Metallic character **decreases** along a period due to increase in ionisation energy.



Non - metallic character increases with increase in atomic number across a period.

(iv) **Variation of metallic character along a group :** Metallic character increases on going down a group from top to bottom. This can be explained in terms of decrease in ionisation energy on going down a group from top to bottom.

NOTE : Metals generally form **cations** by losing electrons from their outermost shell, while non - metals generally form **anions** by accepting one or more electrons.

e.g. Alkali metals form M^+ ions by losing one electron, while alkaline earth metals form M^2+ ions by losing two electrons from their outermost shell.



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Metallic character decreases and non-metallic character increases across a period from left to right, while metallic character increases and non-metallic character decrease down the group.

DAILY PRACTICE PROBLEMS # 19

OBJECTIVE DPP - 19.1

- The difference between ions and atoms is of -
(A) relative size (B) configuration (C) presence of charge (D) All of these
- Which of the following has the largest size ?
(A) Na (B) Na^+ (C) Mg (D) Mg^{+2}
- An element M has a atomic number 9 and atomic mass 19. Its ion will be represented by -
(A) M (B) M^{+2} (C) M^- (D) M^{-2}

4. Which of the following has the maximum non-metallic character ?
(A) F (B) Cl (C) Br (D) I
5. Which of the following is the most reactive halogen ?
(A) F (B) Cl (C) Br (D) I
6. In the third period of the periodic table, the element having smallest size is -
(A) Na (B) Ar (C) Cl (D) Si
7. Which of the following elements has maximum metallic character ?
(A) Li (B) N (C) Na (D) P
8. On moving left to right in a period, in the periodic table, metallic character -
(A) decrease (B) increases
(C) remains same (D) first increase, then decreases
9. On moving from top to bottom in a group, in the periodic table, size of an atom -
(A) increases (B) decreases
(C) remains same (D) first increases, then decreases
10. On moving from top to bottom in a group, in the periodic table, valency -
(A) increase (B) decreases
(C) remains same (D) first increases, then decreases

SUBJECTIVE DPP - 19.2

1. Why does the atomic size decreases from Na to Cl when we move in the third period of the periodic table ?
2. Show the variation of valency with respect to hydrogen in the 2nd period.
3. Which of the following species are isoelectronic in nature >
(i) Ca^{2+} (ii) K (iii) Mg^{2+} (iv) S^{2-} (v) Cl^-
4. What is the valency of the elements that are placed in group 18 ?
5. Name three elements which behave as metalloids.

ANSWERS

OBJECTIVE DPP 17.1

| Qus. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|------|---|---|---|---|---|---|---|---|---|----|
| Ans | A | C | B | C | C | C | C | B | C | D |

SUBJECTIVE DPP 17.2

Sol.4 Atomic mass of the B = 24 **Sol.5** Element F **Sol. 8** 63 elements

OBJECTIVE DPP 18.1

| Qus. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|------|---|---|---|---|---|---|---|---|---|----|
| Ans | B | B | C | D | D | B | A | D | B | C |

SUBJECTIVE DPP 18.2

Sol. 4 Li, Na, K

Sol.5 Li, Be

Sol.6 Second alkali metal = Sodium (Na), Electronic configuration = 2,8,1

Sol.7 All the elements have two electrons in their valence shell.

Sol.8 (a) Period (b) Group (c) Period (d) Group

OBJECTIVE DPP 19.1

| Qus. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|------|---|---|---|---|---|---|---|---|---|----|
| Ans | D | A | C | A | A | C | C | A | A | C |

SUBJECTIVE DPP 19.2

Sol.3 Ca^{+2} , S^{2-} & Cl ions are all isoelectronic in nature because they have 18 electrons.

Sol.4 Zero

Sol.5 B, Si, Ge, As, Sb, Te and Po are the elements which behave as metalloids.