(iii) The weight of Avogadro number of particles of a sample is its _____.

(iv) _____ is the cause for rusting of Fe.

(v) In combustion C is converted to _____.

(vi) Formation of a positive ion from an atom is _____.

III. True / False

(i) $2CO + O_2 \longrightarrow 2CO_2$ is a combination redox reaction.

(ii) It is also a combustion reaction .

(iii) It is also a substitution reaction.

(iv) In this reaction C is oxidised.

(v) Oxygen is oxidising agent.

IV. Subjective Type Questions

1. How many electrons are there is 18 gm of water ?
2. Balance the following reaction :

   $C_4H_{10} + O_2 \longrightarrow CO_2 + H_2O$

3. Out of NO, N_2O_3, N_2O_4 and N_2O_5 which has N in highest oxidation number ?
4. Out of 1 gm O, 1 gm O_2 and 1 gm O_3 which has maximum number of oxygen atoms ?
5. Which of the following can not act as oxidising agent ?

   $KMnO_4$, H_2SO_4, H_2S.
6. Arrange the following in order of :

   (a) increasing oxidation no. of N: NH_3, N_3H, N_2O, NO, N_2O_5

   (b) decreasing oxidation no.: HXO, HXO_3, HXO_2, HXO_4

ANSWERS

I. Multiple Choice Questions :

1. (b) 2. (c) 3. (c) 4. (d) 5. (b)
6. (d) 7. (a) 8. (b) 9. (d)

II. Fill in the blanks :

(i) oxidising (ii) decreases (iii) molecular weight (iv) Corrosion
(v) CO_2 (vi) oxidation

III. True / False

(i) False (ii) True (iii) False (iv) True (v) True

IV. Answers :

1. 6.023×10^{24} 2. $C_4H_{10} + 13/2O_2 \longrightarrow 4CO_2 + 5H_2O$ 3. N_2O_5
4. All have same no. of oxygen atoms. 5. H_2S. 6. (a) increasing oxidation no. of N

$\overset{-3}{N}H_3, \overset{-1/3}{N_3}H, \overset{+1}{N_2}O, \overset{+2}{N}O, \overset{+5}{N_2}O_5$

$NH_3 < N_3H < N_2O < NO < N_2O_5$

(b) decreasing oxidation no.

$H\overset{+1}{X}O, H\overset{+5}{X}O_3, H\overset{+3}{X}O_2, H\overset{+7}{X}O_4$

$HXO_4 > HXO_3 > HXO_2 > HXO$

Double Salts : A compound of two salts whose aqueous solution shows the tests for all constituent ions is called double salt e.g.

Mohr Salt $FeSO_4.(NH_4)_2SO_4.6H_2O$

Potash Alum $K_2SO_4.Al_2(SO_4)_3.24H_2O$

Complex Salts : A compound whose solutions does not give tests for the constituent ions is called a complex salt. e.g.

$K_4[Fe(CN)_6]$

$Li(AlH_4)$

pH:

It may be defined in number of ways.

(i) The pH value of a solution is equal to the negative power to which 10 must be raised in order to express $[H^+]$ concentration

$[H^+] = 10^{-PH}$.

(ii) It can also be defined as the negative logrithm of its $[H^+]$ ion concentrations

$pH = -\log[H^+]$

pH values do not give instantaneous idea above the relative strengths of the solution

pOH :

It may be defined as the negative logarithms of hydroxyl ions concentration

$pOH = -\log(OH^-)$.

Ionic product of water

$[H^+][OH^-] = 10^{-14} = K_w$

$-\log[H^+](+)-\log[OH^-] = 14 = pK_w$

$\Rightarrow$ $pH + pOH = pK_w = 14$.

Some Important Chemicals

Bleaching Powder ($CaOCl_2$)

Preparation

In Hasen-Clever Plant

$Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$

Properties

(1) It is yellowish white solid having chlorine like smell

(2) Bleaching powder decomposes to form O_2

$2CaOCl_2 \xrightarrow{CoCl_2} 2CaCl_2 + O_2$

(3) When reacted with H_2O liberates Cl_2.

$CaOCl_2 + H_2O \rightarrow Ca(OH)_2 + Cl_2$

(4) Bleaching powder is decomposed to Cl_2 by dilute H_2SO_4.

$CaOCl_2 + H_2SO_4 \rightarrow CaSO_4 + H_2O + Cl_2$

(5) It reacts with carbondioxide to form calcium carbonate and Cl_2.

$CaOCl_2 + CO_2 \rightarrow CaCO_3 + Cl_2$

(6) The chlorine liberated in above reaction can be used to oxidise I^- to I_2 thereby liberating I_2. This I_2 can be estimated by $Na_2S_2O_3$ thus we can measure the available chlorine in bleaching powder.

$2KI + Cl_2 \rightarrow 2KCl + I_2$

Uses

Bleaching powder is used for the disinfection of drinking water or swimming pool water. For use in outdoor swimming pools, it can be used as a sanitizer in combination with a cyanuric acid stabilizer. The stabilizer will reduce the loss of chlorine because of UV radiation. Calcium does make the water 'hard' and tends to clog up some filters, for this reason Sodium hypochlorite is preferred.

Bleaching powder is also used for bleaching cotton and linen and used in the manufacture of chloroform.

Sodium Hydroxide (NaOH)

Preparation

(1) Soda lime process, causticisation process or Gossage process

$$Na_2CO_3 + Ca(OH)_2 \xrightarrow{80 - 90^oC} 2NaOH + CaCO_3$$

(2) Castner kellner process / Electrolytic process

Electrolyte → Brine (NaCl Solution in water)

Anode → Graphite

Cathode → Iron rods and Mercury acts as intermediate cathode by induction.

Reaction

$NaCl \rightarrow Na^+ + Cl^-$

At anode – $Cl^- \rightarrow Cl + e$

$Cl + Cl \rightarrow Cl_2$

At cathode – $Na^+ + e^- + Hg \rightarrow Na - Hg$

$2Na - Hg + 2H_2O \rightarrow 2NaOH + H_2 + 2Hg$

(sodium amalgam)

Properties

(1) White hygroscopic solid.

(2) Sodium hydroxide decomposes on heating to form sodium, hydrogen and oxygen.

$$2NaOH \xrightarrow{1300^oC} 2Na + H_2 + O_2$$

(3) It reacts with acids to form salt and water

(a) $NaOH + HCl \rightarrow NaCl + H_2O$

(b) $2NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2H_2O$

Formation of sodium chloride

The electronic configuration of Na and Cl atoms along with their nearest noble gases neon and argon are as follows :

Atom	Electronic structure	Noble gases	Electronic structure
$_{11}Na$	$1s^2\ 2s^2\ 2p^6\ 3s^1$	$_{10}Ne$	$1s^2\ 2s^2\ 2p^6$
$_{17}Cl$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$	$_{18}Ar$	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$

Na atom has one electron in the outermost 3s orbital i.e., it has one electron excess in its valence shell, then the neon atom. On the other hand Cl atom has 7 electrons in its valence shell i.e, Cl atom has one electron less in its valence shell than the argon atom. Thus, in order to have the stable inert gas structure, Na atom gives up the solitary $3s^1$ electron to Cl atom and acquires $2s^2\ 2p^6$ i.e., octet configuration. On the other hand, Cl atom takes that electron and acquires the structure of argon. Na atom by transferring its solitary electron becomes Na^+ cation and Cl atom by gaining that electron becomes Cl^- anion.

The cations like Na^+ and anions like Cl^- interact and as a result of electrostatic attraction between Na^+ and Cl^-, stable crystal of sodium chloride is formed. Since NaCl molecule is formed by the outright transfer of electron from Na atom to Cl atom, NaCl is an electrovalent or ionic compound.

Characteristics of Ionic Compounds

(1) **Physical state :** An ion can attract its oppositely charged ion from any direction. This results in three dimensional crystal where the cations and anions are alternatively held together by strong electrostatic force of attraction. Hence ionic compounds are solids at room temperature.

(2) **Hardness :** Ionic compounds are hard, because strong electrostatic forces attract the oppositely charged ions.

(3) **Molecules of ionic compounds are polarised :** Each ion pair ($C^+\ A^-$) in an ionic compound is polar.

(4) **Conductor of electric current:** In solid state ionic compounds do not conduct electricity. This is because of the fact that the ions are stationary in the ionic crystal and the cations and anions are held together by strong electrostatic force. But ionic compounds are good conductors of electricity in the fused (molten) state or in solution. The freely moving ions permit electrical conductance.

(5) **High M.P. and B.P. :** Their melting points and boiling points are high and they are less volatile. Thus, NaCl melts at 820ºC and boils at 1600ºC.

Occurrence of metals

(a) The metals K, Ca, Na, Mg, Al, are strongly electro-positive and hence very active. They react readily with oxygen, carbon di-oxide and moisture of air. Consequently these metals are never found as free or in native state in nature. These metals occur in nature in the form of their compounds.

(b) The metals such as Zn, Fe, Sn, Pb, are moderately reactive. These metals are also not found in nature in free state, but they occur in nature as various types of compounds such as oxides, carbonates, sulphides etc.

(c) The metals such as Cu, Hg, Ag, Au, Pt are weakly electro-positive and hence less reactive. They are not attacked by oxygen, moisture or CO_2 of atmosphere. Consequently these metals are found in free state. Some of the forms in which metals occur in nature are given in following table.

Reactivity Series

In chemistry, the reactivity series is a series of metals, in order of reactivity from highest to lowest. It is used to determine the products of single displacement reactions, whereby metal A will replace another metal B in a solution if A is higher in the series.

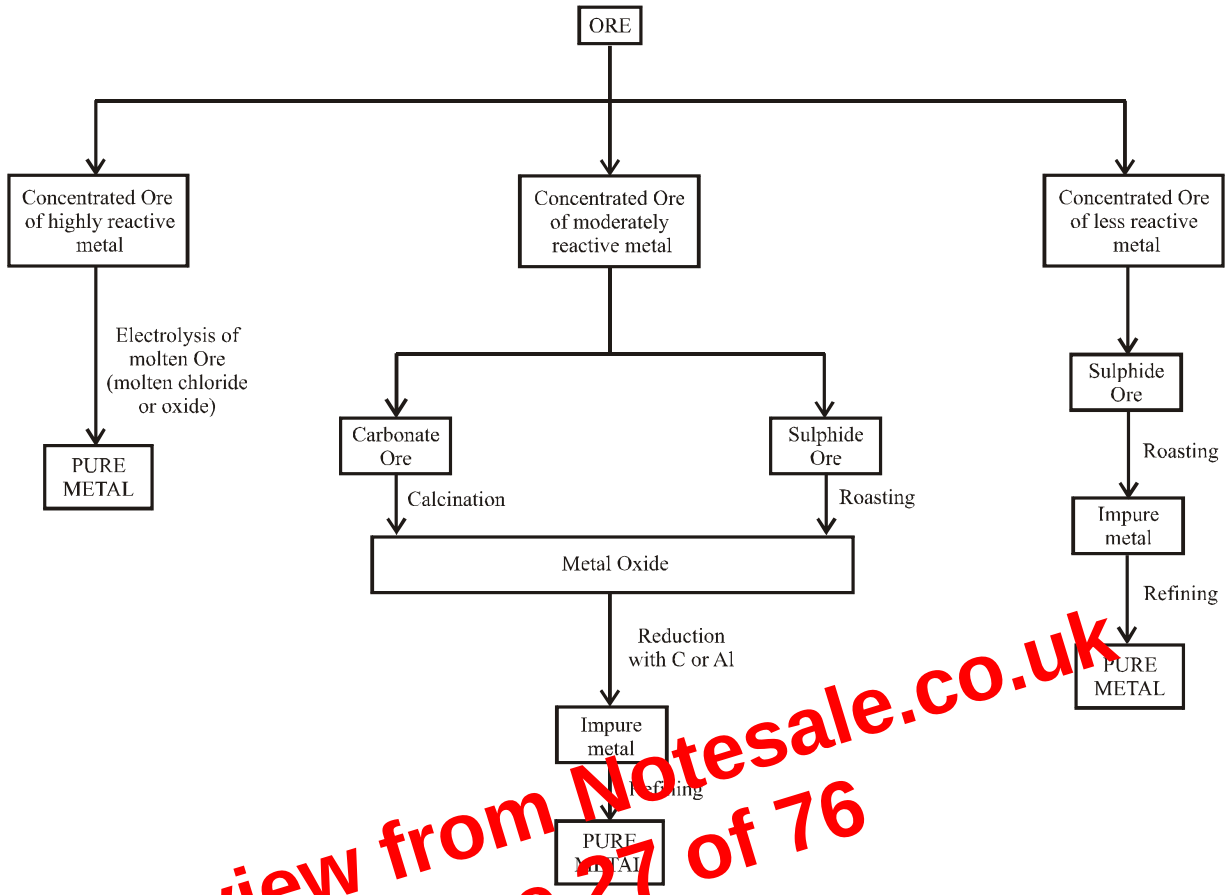
Metals	Metal Ion	Reactivity
K	K^+	reacts with water
Na	Na^+	
Ca	Ca^{2+}	
Li	Li^+	
Ba	Ba^{2+}	
Sr	Sr^{2+}	
Mg	Mg^{2+}	reacts with acids
Al	Al^{3+}	
Mn	Mn^{2+}	
Zn	Zn^{2+}	
Cr	Cr^{2+}	
Fe	Fe^{2+}	
Cd	Cd^{2+}	
Co	Co^{2+}	
Ni	Ni^{2+}	
Sn	Sn^{2+}	
Pb	Pb^{2+}	
H_2	H^+	included for comparison
Sb	Sb^{3+}	highly unreactive
Bi	Bi^{3+}	
Cu	Cu^{2+}	
Hg	Hg^{2+}	
Ag	Ag^+	
Au	Au^{3+}	
Pt	Pt^+	

A metal can replace metals listed below it in the activity series, but not above. For example, sodium is highly active and thus able to replace hydrogen from water:

$$2\ Na\ (s) + 2\ H_2O\ (l) \rightarrow 2\ NaOH\ (aq) + H_2\ (g)$$

Metals that can replace hydrogen within acids but not water are listed in the middle of the activity series, for example zinc replaces hydrogen in sulfuric acid:

$$Zn\ (s) + H_2SO_4\ (aq) \rightarrow ZnSO_4\ (aq) + H_2\ (g)$$



ASSIGNMENTS

Multiple Choice Questions

1. A metal which occurs in free state is
   (a) calcium (b) iron (c) silver (d) sodium

2. Strong electro-positive metals are generally extracted by
   (a) carbon reduction of the oxide ore
   (b) by the electrolysis of the aqueous solution of chlorides
   (c) by the electrolysis of fused chlorides
   (d) by self reduction process

3. Floatation process is used to concentrate
   (a) oxide ores (b) sulphide ores (c) carbonate ores (d) silicate ores

4. A mineral which contain sulphur is
   (a) magnetite (b) calamine (c) zinc blende (d) bauxite

5. Calcination is carried out in absence of
   (a) hydrogen (b) nitrogen (c) air (d) none of these

6. Which is amphoteric oxide ?
   (a) FeO (b) ZnO (c) CO_2 (d) NO

7. Aluminium react with
   (a) cold water (b) hot water
   (c) steam (d) do not react with H_2O

8. Chemical reactivity of metals in decreasing order
   (a) Zn > Cu > Mg > Na (b) Mg > Cu > Zn > Na
   (c) Cu > Zn > Na > Mg (d) Na > Mg > Zn > Cu

9. Which of the reaction will not occur ?
   (a) $MgSO_4$ (aq) + Cu(s) $\longrightarrow$ $CuSO_4$(aq) + Mg(s)
   (b) $CuSO_4$(aq) + Fe(s) $\longrightarrow$ $FeSO_4$(aq) + Cu(s)
   (c) $MgSO_{4(aq)} + Ba_{(s)} \longrightarrow BaSO_{4(aq)} + Mg_{(s)}$
   (d) $FeSO_4$(aq) + Zn(s) $\longrightarrow$ $ZnSO_4$(aq)+ Fe

10. What type of chemical bond is formed between potassium and bromine ?
    (a) Covalent bond (b) Ionic bond (c) Co-ordinate bond (d) Vander wall bond

Fill in the blanks

1. The rocky impurities present in minerals are called _____.
2. In the thermite process _____ is used as reducing agent.
3. Impurities in the ores are usually removed by adding _____.
4. MgO is _____ basic than CuO.
5. Al react with boiling water liberating _____.

True / False

1. All ores are minerals, but all minerals are not ores.
2. Na/K is not found in free state in nature.
3. Metallic sodium is kept under kerosene.
4. Galena is an oxide ore.
5. Metallic Na or Ca is obtained by carbon reduction process.

Subjective Questions

1. Explain the formation of $CaCl_2$
2. The electro-positive character of metals is in the following order –

   Na > Mg > Al > Zn > Fe > H > Cu > Pt.

   Now, answer the following questions :
   (a) Which has more oxidising power - Mg or Fe ?
   (b) Which one can be precipitated from its sulphate solution by adding the other metal - Cu or Zn ?

1. *Addition Reactions*: The reactions in which the attacking reagent adds up to the substrate molecule is called addition reaction.

$$CH_2 = CH_2 + HBr \longrightarrow CH_3 - CH_2 - Br$$

(a) Electrophilic addition reactions

$$CH_2 = CH_2 + Br_2 \longrightarrow \underset{Br}{CH_2} - CH_2 - Br$$

(b) Nucleophilic addition reactions

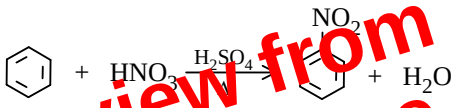
$$CH_3CHO + HCN \longrightarrow CH_3CH\begin{matrix}OH\\CN\end{matrix}$$

(c) Free radical addition reactions

$$CH_3 - CH = CH_2 + HBr \xrightarrow{Peroxide} CH_3CH_2{-}CH_2Br$$

2. *Substitution Reaction* : The replacement of an atom or a group from a molecule by different atom or group is known as substitution reaction

$$CH_3\,OH + HBr \rightarrow CH_3\,Br + H_2O$$



Substitution reactions are of three types

(a) Nucleophilic substitutions reactions. (b) Electrophilic substitution reactions.

(c) Free radical substitution reactions.

3. *Elimination Reactions* : The reactions are essentially the reverse of addition reactions and involve loss of atoms or group of atoms from a molecule to form a multiple linkage. Most commonly, loss of atoms or groups occurs from adjacent carbon atoms to yield an olefin.

$$CH_3CH_2Cl \xrightarrow{alc.KOH} CH_2 = CH_2 + HCl$$

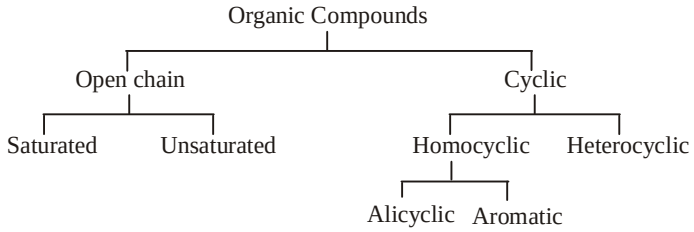
Rearrangement: Rearrangement reactions involve either the migration of functional group to another positions in the molecule containing a double bond or change of the sequences of atoms forming the basic carbon skeleton of the molecule to form a product with the new structure.

e.g. $CH_3 - \underset{X}{CH} - CH = CH_2 \xrightarrow{\Delta} CH_3 - CH = CH - \underset{X}{CH_2}$

$$CH_3CH_2CH_2CH_3 \xrightarrow{AlCl_3} CH_3 - \underset{CH_3}{CH_2} - CH_3$$

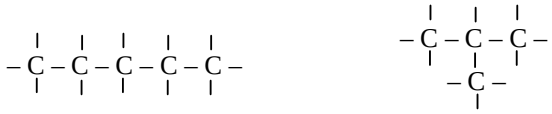
Classifiation of Organic Compounds

The Organic compounds are classified as



Open Chain Compounds

1. These compounds contain straight or branched chain of carbon atoms and are called as open chain or acyclic compounds.

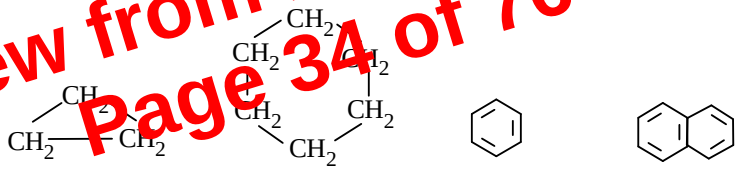


Straight chain Branched chain

They may be two types : (a) Saturated compounds - in which only single bonds are there, e.g., alkanes (b) Unsaturated compounds - in which double or triple bonds are there. e.g. alkenes and alkynes.

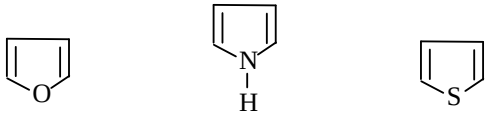
2. **Cyclic** : The compounds in which terminal carbon atoms join with each other to form ring like structures are called as cyclic or closed chain or ring compounds. These are of two types

(*i*) **Homocyclic compounds** where the atoms are mostly carbon and hydrogen only.



Cyclopropane Cyclohexane benzene Naphthalene

(*ii*) **Heterocyclic compounds** are the cyclic compounds which contains at least one heteroatom (O, S, N) in the ring e.g.



Furan Pyrrole Thiophene

The cyclic compounds are further divided into two types :

(*i*) **Alicyclic compounds :** The cyclic compounds which resembles with open chains i.e. aliphatic compounds are called alicyclic compounds e.g.

Cyclopropane Cyclobutane Cyclopentane Cyclohexane

Fill in the blanks

1. Carbon is placed in group _____ of the periodic table.
2. The priority of aldehyde group is _____ than ketone in nomenclature.
3. Benzene is an _____ compound.
4. Ethanol can dissolve _____ compounds.
5. Glacial acetic acid is _____ free acetic acid.

True / False

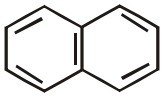
1. Diamond is more stable than graphite.
2. Phenol is aromatic.
3. Oils are unsaturated hydrocarbons.
4. Name of $CH_3 - \underset{\underset{Cl}{|}}{CH} - CH_2 - \underset{\underset{Br}{|}}{CH} - CH_3$ is 2-chloro-4-bromo pentane.
5. Acetic acid can be prepared by the oxidation of ethylalcohol.

Subjective Questions

1. Write name of the following compound :

$$CH_3 - CH_2 - \underset{\underset{CH_3}{|}}{CH} - CH_2 - CH_2 - \underset{\underset{CH_2 - CH_3}{|}}{CH} - CH_2 - CH_3$$

2. Write structure of pent-3-ene-1-yne.
3. Explain the action of soap and detergents ?
4. Carbon shows maximum valency four but other members of its group can show valency up to six. Why?
5. Predict whether the given compound is aromatic or not ?



6. Convert :

(i) Ethanol to ethanoic acid

(ii) Ethyl acetate from Ethanol and ethanoic acid

(iii) Ethanol to ethene

(iv) Ethanoic acid to sodium ethanoate

iv) Dissimilar elements are placed together in the same group like K & Cu in 1st group.

v) Similar elements placed in different groups.

vi) Some higher atomic weight elements placed before the lower atomic weight elements e.g. Ar^{40} precedes K^{39}, $Co^{58.9}$ precedes $Ni^{58.7}$, $Te^{127.6}$ precedes I^{127}, Th^{232} preceds Pa^{231}.

vii) Position of metals and non-metals: Both are placed together in the same group.

viii) Diagonal relationship could not be explained.

ix) Lanthanides and actinides were placed separately at the bottom of the periodic table.

x) No proper position to VIII-th group elements.

xi) Position of noble elements.

xiii) Existence of variable valency could not be explained.

xiv) Cause of periodicity can not be explained.

Classification of elements according to their atomic number

In 1913 Mosley from his observation on the X-ray spectra on a number of elements, came to the conclusion that atomic number is more accurate in the identification of an element than its atomic weight. Moreover the atomic number of an element is its serial number or position number in the periodic table. Hence elements are arranged in the ascending order of their atomic numbers in the modern periodic table.

Modern Periodic Law

a) The properties of elements are the periodic function of their atomic numbers.

b) The properties of the elements depend upon their electronic configuration.

The Modern Periodic Table

The modern periodic table is divided horizontally into periods from left to right whereas vertically it is divided into columns called groups.

i) There are seven periods in this table. The first period contains 2 elements. The second and third periods contain 8 elements each. These two periods are known as short periods. Fourth and fifth periods each contains 18 elements, while sixth period contains 32 elements. Seventh period is incomplete.

ii) There are 18 groups in the modern periodic table.

Let us now examine critically the relation between the electronic configuration of an element and its position in the long form of periodic table.

1. **The first period :** Contains two elements – H and He. Since their principal quantum number is 1(n = 1) which contains only *s*-orbital having maximum occupancy of 2 electrons, this period can not accommodate more than two elements e.g., H = $1s^1$ and He = $1s^2$.

2. **The second period :** The principal quantum number of the second period is two (n = 2). Since this principal quantum number can have two subshells *s* and *p* which can contain maximum of 2 and 6 electrons respectively, the total number of elements in the second period is 8. The period begins with Li ($1s^2$, $2s^1$), and then electrons are filled up one by one and is completed in Ne ($1s^2$ $2s^2$ $2p^6$). Hence 8 elements are there in the second period.

In the above reaction Na has a strong affinity towards Cl atom; similarly Ca atom has strong affinity towards CO_3 radical. Hence is the formation of NaCl and $CaCO_3$. Consequently this pair will not combine to reform sodium carbonate and calcium chloride. This is precisely what happens i.e., they never react under ordinary condition to form $CaCl_2$ and Na_2CO_3.

Large deposit of *TRONA* (Na_2CO_3) are found on the banks of certain saline lakes in Egypt. But the question is, how sodium carbonate is able to crystallize on the banks of these lakes? C.L. Berthelot (1799) explained the above phenomenon by attributing large amount of NaCl present in lake water which forces the following reaction to occur.

$$2NaCl + CaCO_3 = CaCl_2 + Na_2CO_3$$

Hence the reverse reaction also takes place depending on the environment i.e., concentration. He concluded that "the chemical activity of a substance depends on the force of its affinity and upon the mass which is present in a given volume."

Definition : A reaction is said to be reversible when the reactants combine among themselves to form the products which as soon as formed, start reacting among themselves to reform the reactants and attain a state of equilibrium depending upon the concentration and other conditions of the components of reaction. Thus in a reversible reaction there is a natural tendency to approach a state when the speed of the forward reaction becomes equal to the speed of the reverse reaction.

Chemical equilibrium

When an equimolecular mixture of hydrogen and iodine is heated at 440°C in a closed vessel for about two hours or so, 80% hydrogen iodide is formed.

$$H_2 + I_2 = 2HI$$

remaining 20% being mixture of H_2 and I_2.

Now in a similar closed vessel pure HI is kept at 440° C. After a period of about two hours it is observed that 80% HI remains as undissociated and only 20% dissociate at H_2 and I_2.

$$H_2 + I_2 \; f \; 2HI$$

Initially the concentration of H_2 and I_2 was maximum with time the forward reaction proceeds but the concentration of HI remains comparatively low, which indicates a reversible reaction.

$$H_2 + I_2 \rightarrow 2HI, \quad 2HI \rightarrow H_2 + I_2$$

As soon as HI is formed in the first reaction, it starts decomposing into H_2 and I_2. As time is elapsed, the concentration of H_2 and I_2 decreases and the concentration of HI is increased. Consequently the rate of forward reaction decreases and the rate of backward reaction increases. The process continues and the decrease of the rate of the forward reaction and the increase of the rate of the backward reaction reaches a point when the speed of the forward reaction becomes equal to the speed of the backward reaction. The system is then said to attain equilibrium and no further change of concentration of the reactants H_2 and I_2 and the product HI will take place.

Definition : Chemical equilibrium is defined as a state when the velocity or speed of the forward reaction is the same as the velocity or speed of the backward reaction of a reversible reaction.

The following points are to be noted for characterizing a state of equilibrium.

(a) The rates of forward and backward reaction are the same and the two reactions act in opposite direction.

(b) At any instant there is no change in the ratio of the masses of the products and the reactants. Thus it appears as if the reaction has been stopped.