Question Set 11

SHORT ANSWER QUESTIONS

Q. Answer the following questions in brief : ***(2 or 3 marks)***

[**Note :** There are twelve subquestions of short answers each carrying two marks in Section – B or three marks in Section – C in Board's question paper and you have to solve any ***eight*** in each section. The questions involve definitions with explanation, properties, laws, two numericals, etc.]

Chapter 1. Solid State

Q. 1. Calculate the number of particles and unit cells in 'x' g of metallic crystal.

Ans. Consider 'x' gram of a metallic crystal of molar mass M and density ρ. If the unit cell of the crystal has edge length 'a' then, volume of unit cell $= a^3$.

Mass of one metal atom $= \frac{M}{N_A}$. If 'n' number of atoms are present in one unit cell then

Mass of unit cell $= \frac{n \times M}{N_A}$.

If 'a' is the edge length of the unit cell then

Volume of unit cell $= a^3$

Density of unit cell $= \rho = \frac{n \times M}{N_A} \times \frac{1}{a^3}$

$\therefore\ M = \frac{\rho \times N_A \times a^3}{n}$

B Molar mass M gram contains N_A particles

$\therefore\ x$ gram contains $\frac{x \times N_A}{M}$ particles.

Substituting the value M

(1) Number of particles in x g crystal $= \frac{x \times N_A}{\rho \times N_A \times a^3/n}$

$$= \frac{x \times n}{\rho \times a^3} \text{ particles}$$

(2) Number of unit cells in x g crystal :

B n particles are present in 1 unit cell

$$\therefore \frac{x \times n}{\rho \times a^3} \text{ are present in, } \frac{x \times n}{\rho \times a^3} \times \frac{1}{n} = \frac{x}{\rho \times a^3} \text{ unit cells}$$

(3) Number of unit cells in V volume of crystal $= \frac{V}{a^3}$.

Q. 2. Explain colour of crystals *or* F centres.

Ans. (1) The defect due to anion vacancies imparts colour to the colourless crystal.

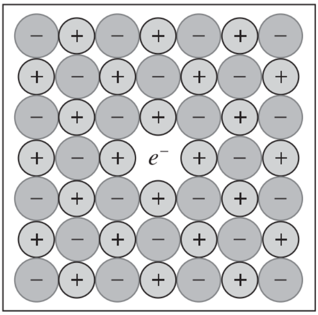
(2) When a colourless crystal of NaCl is heated in the atmosphere of sodium vapour, the sodium atoms are deposited on the crystal surface.

(3) Due to diffusion of Cl^- ions to the crystal surface vacancies are created at their regular sites.

(4) These diffused Cl^- ions combine with Na atoms on the surface forming NaCl along with releasing electrons from sodium atoms.

$$Na + Cl^- \longrightarrow NaCl + e^-$$

(5)



An F-centre in a crystal

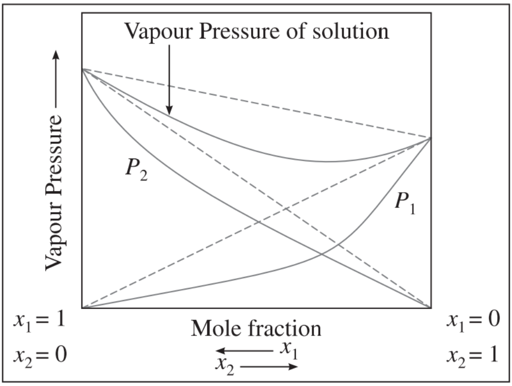
The released electrons diffuse into the crystal and occupy vacant sites of anions Cl^- in the crystal.

The anion vacant sites occupied by electrons are called **F-centres** or colour centres. Due to these colour centres NaCl shows yellow colour.

(6) Now NaCl crystal has excess of Na atoms having nonstoichiometric formula $Na_{1+x}Cl_{1.0}$.

Q. 3. Explain solutions with negative deviations from Raoult's law.

Ans. (1) A solution or a liquid mixture which has lower vapour pressure than theoretically calculated by Raoult's law or lower than those of pure components is called a nonideal solution with negative deviation.



Negative deviations from Raoult's law

(2) In these solutions, the intermolecular interactions between solvent and solute molecules are stronger than solvent-solvent or solute-solute interactions.

(3) For example, solutions of phenol and aniline, chloroform and acetone, etc.

Q. 4. A solvent and its solution containing a nonvolatile solute are separated by a semipermeable membrane. Does the flow of solvent occur in both directions ? Comment giving reason.

Ans. (1) When a solvent and a solution containing a nonvolatile solute are separated by a semipermeable membrane, there arises a flow of solvent molecules from solvent to solution as well as from solution to solvent.

(2) Due to higher vapour pressure of solvent than solution, the rate of flow of solvent molecules from solvent to solution is higher.

(3) As more and more solvent passes into solution due to osmosis, the solvent content increases, and the rate of backward flow increases.

(4) At a certain stage an equilibrium is reached where both the opposing rates become equal attaining an equilibrium.

Q. 5. How is molar mass of a solute determined by osmotic pressure measurements ?

Ans. Consider V dm^3 (litres) of a solution containing W_2 mass of a solute of molar mass M_2 at a temperature T.

Number of moles of solute, $n_2 = \frac{W_2}{M_2}$.

The osmotic pressure π is given by

$$\pi = \frac{W_2 RT}{M_2 V}$$

$$\therefore \ M_2 = \frac{W_2 RT}{\pi V}$$

By measuring osmotic pressure of a solution, the molar mass of a solute can be calculated.

Since osmotic pressure can be measured more precisely, it is widely used to measure molar masses of the substances.

Chapter 3. Ionic Equilibria

Q. 6. Explain common ion effect with suitable example.

Ans. A weak electrolyte dissociates partially in aqueous solution to produce cations and anions. Equilibrium exists between ions thus formed and the undissociated molecules.

$$BA \rightleftharpoons B^+ + A^-$$

For such an equilibrium, the dissociation constant K is defined as

$$K = \frac{[B^+] \times [A^-]}{[BA]}$$

K is constant for the weak electrolyte at a given temperature.

Now, if another electrolyte BC or DA is added to the solution of BA, having a common ion either B^+ or A^-, then the concentration of either B^+ or A^- is increased. However, as K is always constant, the increase in the concentration of any one of the ions shifts the equilibrium to left. In other words, the dissociation of BA is suppressed. This is called common ion effect. For example, the dissociation of a weak acid CH_3COOH is suppressed by adding CH_3COONa having common ion CH_3COO^-.

$$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$$

$$CH_3COONa \longrightarrow CH_3COO^- + Na^+$$

Chapter 4. Chemical Thermodynamics

Q. 7. Deduce the mathematical expression of first law of thermodynamics for the following processes :

(1) Isothermal process (2) Adiabatic process.

Ans. (1) Isothermal process : This is a process which is carried out at constant temperature. Since internal energy, U of the system depends on temperature there is no change in the internal energy U of the system. Hence $\Delta U = 0$.

By first law of thermodynamics

$\Delta U = Q + W$

$\therefore\ 0 = Q + W$

$\therefore\ Q = -W$ or $W = -Q$.

(i) Hence in expansion, the heat absorbed by the system is entirely converted into work on the surroundings.

(ii) In compression, the work done on the system is converted into heat which is transferred to the surroundings by the system, keeping temperature constant.

(2) Adiabatic process : In this process, the system does not exchange heat, Q with its surroundings.

$\therefore\ Q = 0$.

Since by first law of thermodynamics

$\Delta U = Q + \mathrm{W}$

$\therefore\ \Delta U = W_{\mathrm{ad}}$.

Hence,

(i) the increase in internal energy ΔU is due to the work done on the system by surroundings. This results in increase in energy and temperature of the system.

(ii) if the work is done by the system on surroundings, like expansion, then there is a decrease in internal energy $(-\Delta U)$ and temperature of the system decreases.

Chapter 5. Electrochemistry

Q. 8. Explain the determination of molar conductivity of a weak electrolyte at infinite dilution or zero concentration using Kohlrausch's law.

Ans. Molar conductivity of a weak electrolyte at infinite dilution or zero concentration cannot be measured experimentally.

Consider the molar conductivity ($\wedge_0$) of a weak acid, CH_3COOH at zero concentration.

By Kohlrausch's law, $\wedge_{0_{CH_3COOH}} = \lambda^0_{CH_3COO^-} + \lambda^0_{H^+}$, where $\lambda^0_{CH_3COO^-}$ and $\lambda^0_{H^+}$ are the molar ionic conductivities of CH_3COO^- and H^+ ions respectively.

If $\wedge_{0_{CH_3COONa}}$, $\wedge_{0_{HCl}}$ and $\wedge_{0_{NaCl}}$ are the molar conductivities of CH_3COONa, HCl and NaCl respectively at zero concentration, then by Kohlrausch's law

$$\wedge_{0_{CH_3COONa}} = \lambda^0_{CH_3COO^-} + \lambda^0_{Na^+}$$

$$\wedge_{0_{HCl}} = \lambda^0_{H^+} + \lambda^0_{Cl^-}$$

$$\wedge_{0_{NaCl}} = \lambda^0_{Na^+} + \lambda^0_{Cl^-}$$

Now,

$$\begin{aligned}\wedge_{0_{CH_3COONa}} + \wedge_{0_{HCl}} - \wedge_{0_{NaCl}} &= \left[\lambda^0_{CH_3COO^-} + \lambda^0_{Cl^-}\right] + \\ &\quad \left[\lambda^0_{H^+} + \lambda^0_{Cl^-}\right] - \left[\lambda^0_{Na^+} + \lambda^0_{Cl^-}\right] \\ &= \lambda^0_{CH_3COO^-} + \lambda^0_{H^+} \\ &= \wedge_{0_{CH_3COOH}}\end{aligned}$$

Hence, from $\wedge_0$ values of strong electrolytes, $\wedge_0$ of a weak electrolyte CH_3COOH, at infinite dilution can be calculated.

Q. 9. Explain the electrolysis of molten NaCl.

Ans. (1) Construction of an electrolytic cell : It consists of a vessel containing molten (fused) NaCl. Two graphite (carbon) inert electrodes are dipped in it, and connected to an external source of direct electric current (battery). The electrode connected to a negative terminal of the battery is a cathode and that connected to a positive terminal is an anode.

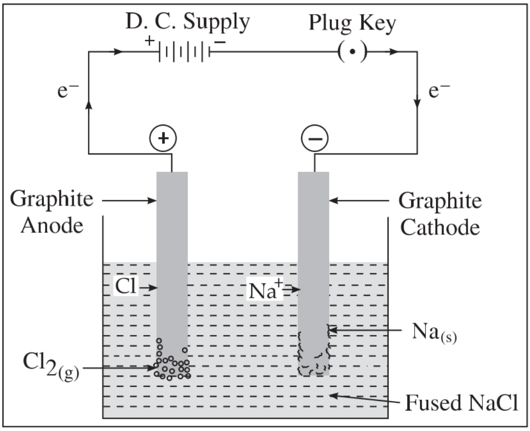
(2) Working of the cell :

(A) In the external circuit, the electrons flow through the wires from anode to cathode of the cell.

(B) The fused NaCl dissociates to form cations (Na^+) and anions (Cl^-).

$NaCl_{(fused)} \longrightarrow Na^+_{(l)} + Cl^-_{(l)}$

Na^+ migrate towards cathode and Cl^- migrate towards anode.



Electrolysis of fused sodium chloride

Net cell reaction : In order to maintain the electrical neutrality, the number of electrons gained at cathode must be equal to the number of electrons released at anode. Hence the reduction half reaction is multiplied by 2 and both reactions, oxidation half reaction and reduction half reaction are added to obtain a net cell reaction.

$$2Na^+_{(l)} + 2e^- \longrightarrow 2Na_{(s)} \qquad \text{(Reduction half reaction)}$$

$$2Cl^-_{(l)} \longrightarrow Cl_{2(g)} + 2e^- \qquad \text{(Oxidation half reaction)}$$

$$2Na^+_{(l)} + 2Cl^-_{(l)} \longrightarrow 2Na_{(s)} + Cl_{2(g)} \qquad \text{(Overall reaction)}$$

Results of electrolysis :

(i) A molten silvery white Na is formed at cathode which floats on the surface of molten NaCl.

(ii) A pale green Cl_2 gas is liberated at anode.

Chapter 6. Chemical Kinetics

Q. 10. What is the relationship between coefficients of reactants in a balanced equation for an overall reaction and exponents in rate law. In what case the coefficients are the exponents ?

Ans. Explanation : Consider the following reaction

$a\text{A} + b\text{B} \longrightarrow$ products

If the rate of the reaction depends on the concentrations of the reactants A and B, then, by rate law

$R \propto [\text{A}]^a\ [\text{B}]^b$

$\therefore\ R = k\ [\text{A}]^a\ [\text{B}]^b$

where $[\text{A}]$ = concentration of A and

$[\text{B}]$ = concentration of B

The proportionality constant k is called the velocity constant, rate constant or specific rate of the reaction.

a and b are the exponents or the powers of the concentrations of the reactants A and B respectively when observed experimentally.

The exponents or powers may not be necessarily a and b but may be different x and y depending on experimental observations. Then the rate R will be

$R = k\ [\text{A}]^x \times [\text{B}]^y$

For example, if $x = 1$ and $y = 2$, then

$R = k[\text{A}] \times [\text{B}]^2$

Q. 11. Define and explain the term order of a chemical reaction.

Ans. Order of a chemical reaction : The order of a chemical reaction is defined as the number of molecules (or atoms) whose concentrations influence the rate of the chemical reaction.

OR

The order of a chemical reaction is defined as the sum of the powers (or exponents) to which the concentration terms of the reactants are raised in the rate law expression for the given reaction.

Explanation :

Consider a reaction, $n_1\text{A} + n_2\text{B} \longrightarrow$ Products

where n_1 moles of A react with n_2 moles of B.

The rate of this reaction can be expressed by the rate law equation as, $R = k[\text{A}]^{n_1}\ [\text{B}]^{n_2}$.

where k is the rate constant of the reaction, hence, the order of the reaction is

$n = n_1 + n_2$, (observed, experimentally).

If $n = 1$, the reaction is called the first order reaction, if $n = 2$, it is called the second order reaction, etc.

If $n = 0$, it is called the zero order reaction, e.g. photochemical reaction of $H_{2(g)}$ and $Cl_{2(g)}$.

Q. 12. Define and explain the term elementary reaction.

Ans. Many reactions take place in a series of steps. Such reactions are called complex reactions. Each step taking place in a complex reaction is called elementary reaction. This shows that a complex reaction is broken down in a series of elementary chemical reactions.

By adding all the elementary steps of a complex reaction we get the overall reaction.

The mechanism of a reaction is decided from the sequence of the elementary steps that are added to give overall reaction.

Elementary reaction : It is defined as the reaction which takes place in a single step and cannot be divided further into simpler chemical reactions.

The order and molecularity of the elementary reaction are same.

Some reactions take place in one step and cannot be broken down into simpler reactions. For example,

$$C_2H_5I_{(g)} \longrightarrow C_2H_{4(g)} + HI_{(g)}$$

$$O_{3(g)} \longrightarrow O_{2(g)} + O_{(g)}$$

Q. 13. What are pseudo-first order reactions ? Give one example and explain. Why it is pseudo-first order?

Ans. Pseudo-first order reaction : A reaction which has higher order true rate law but experimentally found to behave as first order is called pseudo-first order reaction.

Explanation : Consider an acid hydrolysis reaction of an ester like methyl acetate.

$$CH_3COOCH_{3(aq)} + H_2O_{(l)} \xrightarrow{H^+_{(aq)}} CH_3COOH_{(aq)} + CH_3OH_{(aq)}$$

Since the reaction involves two substances, ester and water, it is a bimolecular reaction and the true rate law should be

$$\text{Rate} = k' [CH_3COOCH_3] \times [H_2O]$$

Hence the reaction is expected to follow second order kinetics. However experimentally it is found that the reaction follows first order kinetics.

This is because solvent water being in a large excess, its concentration remains constant. Hence, $[H_2O] = \text{constant} = k''$

$$\begin{aligned}\text{Rate} &= k'[CH_3COOCH_3] \times [H_2O]\\ &= k'[CH_3COOCH_3] \times k''\\ &= k' \times k'' \times [CH_3COOCH_3]\end{aligned}$$

If $k' \times k'' = k$, then $\text{Rate} = k[CH_3COOCH_3]$. This indicates that second order true rate law is forced into first order rate law. Therefore this bimolecular reaction which appears of second order is called pseudo-first order reaction.

Q. 14. Chemical reaction occurs in the following steps :

(i) $NO_{2(g)} + F_{2(g)} \longrightarrow NO_2F_{(g)} + F_{(g)}$ **(slow)**

(ii) $F_{(g)} + NO_{2(g)} \longrightarrow NO_2F_{(g)}$ **(fast)**

(a) Write the equation of overall reaction.

(b) Write down rate law.

(c) Identify the reaction intermediate. ***(July '22)***

Ans. (a) Overall reaction : $2NO_{2(g)} + F_{2(g)} \longrightarrow 2NO_2F_{(g)}$

(b) Rate law : $\text{Rate} = k[NO_2] \times F_2$

(c) Reaction intermediate is $F_{(g)}$.

Chapter 7. Elements of Groups 16, 17 and 18

Q. 15. Discuss the structure of sulphur dioxide.

Ans. (1) SO_2 molecule has a bent V-shaped structure with S – O – S bond angle 119.5° and bond dissociation enthalpy is 297 kJ mol^{-1}.

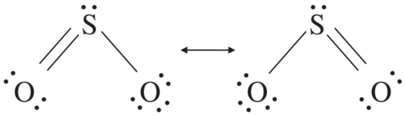
(2) Sulphur in SO_2 is sp^2-hybridized forming three hybrid orbitals. Due to lone pair electrons, bond angle is reduced from 120° to 119.5°.

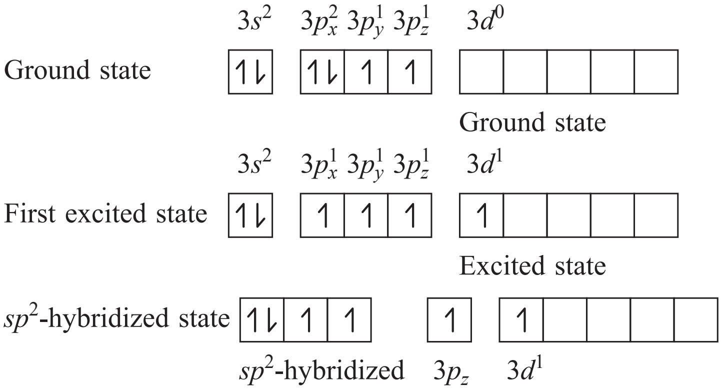
(3) In SO_2, each oxygen atom is bonded to sulphur by a σ and a π bond.

(4) σ bonds between S and O are formed by sp^2–p overlapping.

(5) One of π bonds is formed by $p\pi$–$p\pi$ overlapping while other π bond is formed by $p\pi$–$d\pi$ overlap.

(6) Due to resonance both the bonds are identical having observed bond length 143 pm.





Partially filled $3p^1_z$ and $3d^1$ orbitals overlap to form π bonds with oxygen atoms.

Q. 16. What is the action of concentrated H_2SO_4 on (i) CaF_2 (ii) cane sugar? ***(Sept. '21)***

Ans. (i) $CaF_2 + H_2SO_{4(conc.)} \longrightarrow CaSO_4 + 2HF$.

(ii) $\underset{\text{(sugar)}}{C_{12}H_{22}O_{11}} \xrightarrow{\text{conc. } H_2SO_4} 12C + 11H_2O$.

Q. 17. What are the general compositions of interhalogen compounds?

Ans. (1) The general compositions of interhalogen compounds are XX′, XX'_3, XX'_5 and XX'_7 where halogen X is more electropositive and has larger size than another halogen X′. For example, ClF, BrF_3.

XX′	**XX'_3**	**XX'_5**	**XX'_7**
ClF	ClF_3	ClF_5	IF_7
BrF	BrF_3	BrF_5	
BrCl	IF_3	IF_5	
ICl	ICl_3 (unstable)		

(2) As the ratio of radii of X and X′ increases, the number of atoms of X′ per molecule of interhalogen compound increases. For example, iodine having the largest size with fluorine with the smallest size forms stable IF_7.

Q. 18. Write the names and electronic configurations of first two elements of group 17. ***(March '22)***

Ans. (a) Fluorine : $1s^2\ 2s^2\ 2p^5$.

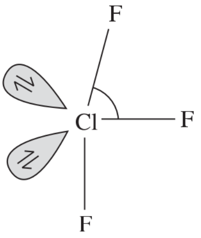
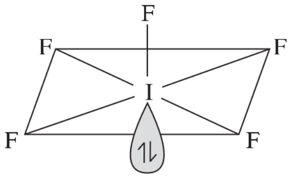
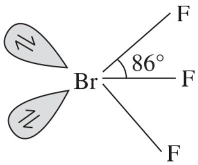
(b) Chlorine : $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$.

Q. 19. Draw structure of :

(a) Chlorine trifluoride (b) Chlorine pentafluoride

(c) Bromine trifluoride.

Ans.

Molecule	**Structure**
(a) Chlorine trifluoride	
(b) Chlorine pentafluoride	
(c) Bromine trifluoride	

Chapter 8. Transition and Inner Transition Elements

Q. 20. Why do the *d*-block elements form coloured compounds ?

Ans. (1) Compounds (or ions) of many *d*-block elements or transition metals are coloured.

(2) This is due to the presence of one or more unpaired electrons in $(n-1)$ *d*-orbital. The transition metals have incompletely filled $(n-1)$ *d*-orbitals.

(3) The energy required to promote one or more electrons within the *d*-orbitals involving *d*-*d* transitions is very low.

(4) The energy changes for *d*–*d* transitions lie in visible region of electromagnetic radiation.

(5) Therefore transition metal ions absorb the radiation in the visible region and appear coloured.

(6) Colour of ions of *d*-block elements depends on the number of unpaired electrons in $(n-1)$ *d*-orbital. The ions having equal number of unpaired electrons have similar colour.

(7) The colour of metal ions is complementary to the colour of the radiation absorbed.

Q. 21. Why does $CuSO_{4(aq)}$ solution turns blue litmus red?

(July '22)

Ans. $CuSO_4$ is a salt of weak base $Cu(OH)_2$ and strong acid H_2SO_4. Hence in aqueous solution it undergoes hydrolysis.

$CuSO_{4(aq)} + {}_2H_2O \longrightarrow Cu(OH)_2 \downarrow + H_2SO_4$

Due to H_2SO_4 solution of $CuSO_4$ reacts acidic and turns blue litmus red.

Q. 22. Why are compounds of transition metal ions coloured?

(July '22)

Ans. (i) Transition metal ions contain unpaired electrons in *d*-orbitals.

(ii) Hence there arises transition of unpaired electrons on absorption of light in visible region.

(iii) Due to this metal ions are coloured.

Q. 23. What is lanthanoid contraction?

(1 mark) (March '22)

Ans. Lanthanoid contraction : The gradual decrease in atomic and ionic radii of lanthanoids with the increase in atomic number is called lanthanoid contraction.

Q. 24. Write similarities between lanthanoids and actinoids?

(July '22)

Ans. Lanthanoids and actinoids show similarities as follows :

(1) Both, lanthanoids and actinoids show + 3 oxidation state.

(2) In both the series, the *f*-orbitals are filled gradually.

(3) Ionic radius of the elements in both the series decreases with increase in atomic number.

(4) Electronegativity in both the series is low for all the elements.

(5) They all are highly reactive.

(6) The nitrates, perchlorates and sulphates of all elements are soluble while their hydroxides, theorides and carbonates are insoluble.

Q. 25. Why La(OH)$_3$ is the strongest base, while Lu(OH)$_3$ is the weakest base? Write two applications of catalytic properties of transition metal and compounds. ***(Sept. '21)***

Ans. (1) From La to Lu atomic size decreases.

(2) Hence electropositive character decreases.

(3) Basic character decreases.

(4) Hence La(OH)$_3$ is the strongest base, while Lu(OH)$_3$ is the weakest base.

Q. 26. Write two applications of catalytic properties of transition metals and compounds. ***(Sept. '21)***

Ans.

(1) MnO_2 is used as a catalyst in the decomposition of $KClO_3$.

$$2KClO_3 \xrightarrow[\Delta]{MnO_2} 2KCl + 3O_2$$

(2) In the manufacture of ammonia by Haber's process, Mo/Fe is used as a catalyst.

$$N_{2(g)} + 3H_{2(g)} \xrightarrow[\Delta]{Fe} 2NH_{3(g)}$$

(3) In the synthesis of gasoline by Fischer Tropsch process, Co-Th alloy is used as a catalyst.

Chapter 9. Coordination Compounds

Q. 27. State effective atomic number (EAN). *OR*

State and explain effective atomic number (EAN). How is it calculated ?

Ans. Effective atomic number (EAN) : It is the total number of electrons present around the central metal atom or ion and calculated as the sum of electrons of metal atom or ion and the number of electrons donated by ligands.

It is calculated by the formula : EAN $= Z - X + Y$

where $Z =$ Atomic number of metal atom

$X =$ Number of electrons lost by a metal atom forming a metal ion

$Y =$ Total number of electrons donated by all ligands in the complex.

Generally, the value of EAN is equal to the atomic number of the nearest inert element.

Explanation : Consider a complex ion $[Co(NH_3)_6]^{3+}$.

Oxidation state of cobalt is $+3$ hence $X = 3$.

There are six ligands, hence $Y = 2 \times 6 = 12$.

Atomic number of cobalt, $Z = 27$

$\therefore$ EAN $= Z - X + Y = 27 - 3 + 12 = 36$.

Q. 28. Write postulates of Werner theory of coordinate complexes. ***(July '22)***

Ans. The following are the postulates of Werner theory :

Postulate 1 : Unlike metal salts, the metal in a complex possesses two types of valencies :

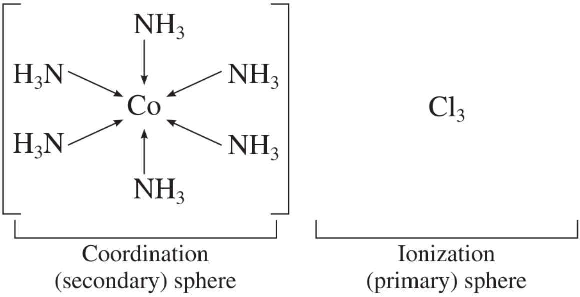
primary (ionizable) valency and secondary (nonionizable) valency.

Postulate 2 : The ionizable sphere consists of entities which satisfy the primary valency of the metal. Primary valencies are generally satisfied by anions.

Postulate 3 : The secondary coordination sphere consists of entities which satisfy the secondary valencies and are nonionizable.

The secondary valencies for a metal ion are fixed and satisfied by either anions or neutral ligands. Number of secondary valencies is equal to the coordination number.

Postulate 4 : The secondary valencies have a fixed spatial arrangement around the metal ion. Two spheres of attraction in the complex $[Co(NH_3)_6]Cl_3$ are shown.



Q. 29. Calculate EAN in the following complexes :

(1) $[Cr(H_2O)_2(NH_3)_2(en)]Cl_3$ (2) $[Ni(en)_2]SO_4$.

Ans.

Complex	**Metal**	**Atomic number of metal Z**	**No. of electrons lost by metal X**	**No. of electrons from ligands Y**	**EAN = Z − X + Y**
(1) $[Cr(H_2O)_2(NH_3)_2(en)]Cl_3$	Cr	24	3	$2H_2O=4$ $2NH_3=4$ $en=4$ $\}$ 12	$24-3+12=33$
(2) $[Ni(en)_2]SO_4$	Ni	28	2	$2en=8$	$28-2+8=34$

Q. 30. Write linkage isomers of a complex having constituents Co^{3+}, $5NH_3$ and NO_2^-.

Ans. (1) NO_2^- is an ambidentate ligand which can be linked through N or O.

(2) The linkage isomers are as follows :

(a) $[Co(NH_3)_5(NO_2)]^{2+}$ Pentaamminenitrocobalt (III) ion

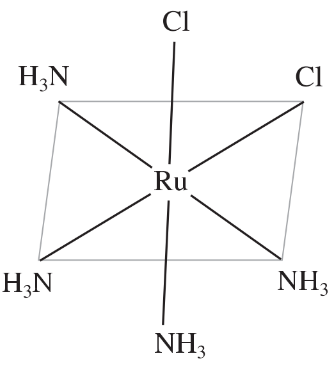
(b) $[Co(NH_3)_5(ONO)]^{2+}$ Pentaamminenitritocobalt (III) ion

Q. 31. Draw isomers in each of the following :

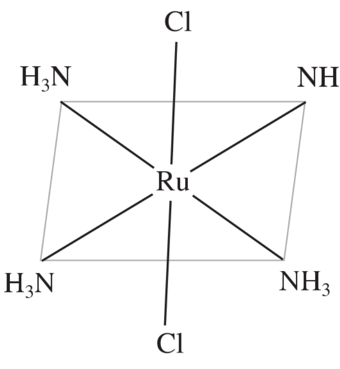
(a) $[Ru(NH_3)_4Cl_2]$ (b) $[Cr(en_2)Br_2]^+$.

Ans. (a) $[Ru(NH_3)_4Cl_2]$

Geometric isomers :



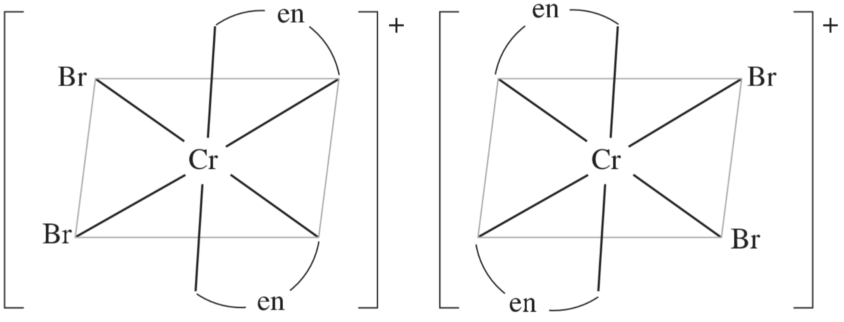
Cis-form



Trans-form

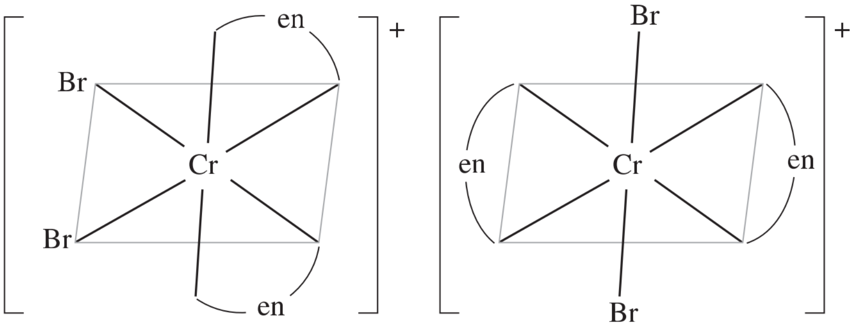
(b) $[Cr(en_2)Br_2]^+$

Optical isomers :



Cis-d-form *Cis-l*-form

Geometric isomers :



Cis-form *Trans*-form

Q. 32. How can stability of the coordination compounds be explained in terms of equilibrium constants?

Ans. Stability of the coordination compounds : The stability of coordination compounds can be explained on the basis of their stability constants. The stability of coordination compounds depends on metal-ligand interactions. In the complex, metal serves as electron-pair acceptor (Lewis acid), while the ligand as Lewis base (since it is electron donor). The metal-ligand interaction can be realized as the Lewis acid-Lewis base interaction. Stronger the interaction greater is stability of the complex.

Consider the equilibrium for the metal-ligand interaction :

$$M^{a+} + nL^{x-} \rightleftharpoons [ML_n]^{a+(-nx)}$$

where a, x, $[a+(-nx)]$ denote the charge on the metal, ligand and the complex, respectively. Now, the equilibrium constant K is given by

$$K = \frac{[ML_n]^{[a+(-nx)]}}{[M^{a+}]\,[L^{x-}]^n}$$

Stability of the complex can be explained in terms of K. Higher the value of K, larger is the thermodynamic stability of the complex, hence K is called stability constant and denoted by K_{stab}.

The equilibria for the complex formation with the corresponding K values are given below :

$$Ag^+ + 2CN^- \rightleftharpoons [Ag(CN)_2]^- \quad K = 5.5 \times 10^{18}$$

$$Cu^{2+} + 4CN^- \rightleftharpoons [Cu(CN)_4]^{2-} \quad K = 2.0 \times 10^{27}$$

$$Co^{3+} + 6NH_3 \rightleftharpoons [Co(NH_3)_6]^{3+} \quad K = 5.0 \times 10^{33}$$

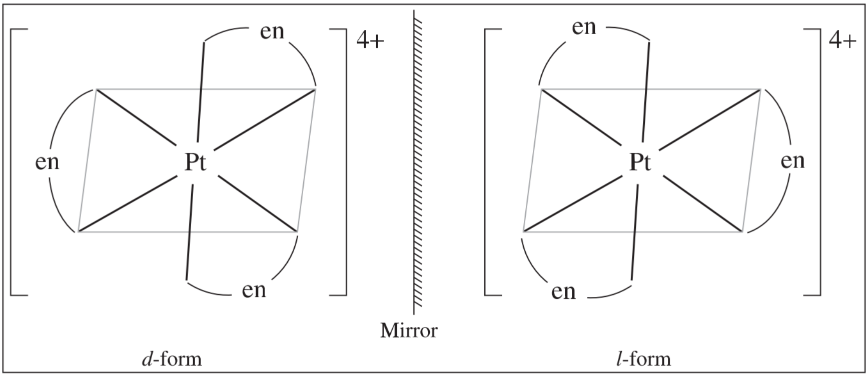
From the above data, the stability of the complexes is

$[Co(NH_3)_6]^{3+} > [Cu(CN)_4]^{2-} > [Ag(CN)_2]^-$.

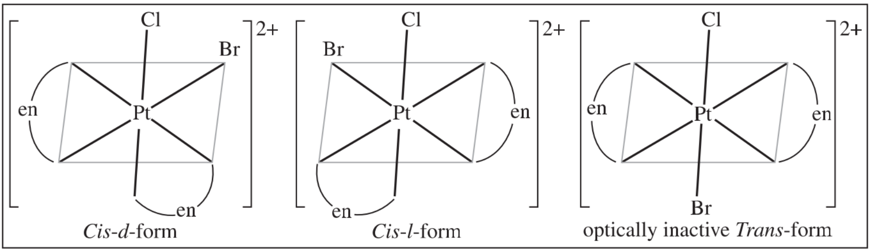
Q. 33. Draw geometric isomers and enantiomers of the following complexes :

(a) $[Pt(en)_3]^{4+}$ (b) $[Pt(en)_2ClBr]^{2+}$.

Ans. The complex $[Pt(en)_3]^{4+}$ has two optical isomers.

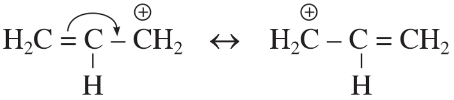


Optical isomers of $[Pt(en)_2ClBr]^{2+}$



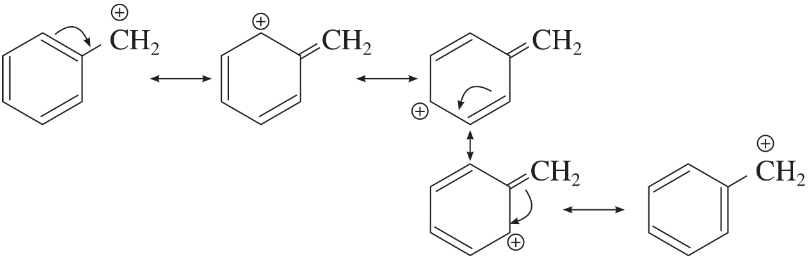
Q. 34. Allylic and benzylic halides show high reactivity towards the S_N1 mechanism than other primary alkyl halides. Explain.

Ans. In allylic and benzylic halide, the carbocation formed undergoes stabilization through the resonance. Hence, allylic and benzylic halides show high reactivity towards the S_N1 reaction. The resonating structures are



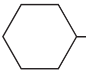
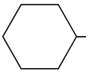
$$H_2C=\underset{|\atop H}{C}-\overset{\oplus}{C}H_2 \leftrightarrow H_2\overset{\oplus}{C}-\underset{|\atop H}{C}=CH_2$$

Resonance stabilization of allylic carbocation

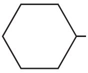
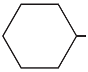


Resonance stabilization of benzylic carbocation.

Q. 35. Which one compound from the following pairs would undergo S_N2 faster ?

(1)  **CH_2Cl and**  **Cl**

(2) $CH_3CH_2CH_2I$ and $CH_3CH_2CH_2Cl$.

Ans. (1) Since  CH_2Cl is a primary halide it undergoes S_N2 reaction faster than  Cl.

(2) Since iodine is a better leaving group than chloride, 1-iodo propane ($CH_3CH_2CH_2I$) undergoes S_N2 reaction faster than 1-chloropropane ($CH_3CH_2CH_2Cl$).

Q. 36. Observe the following and answer the questions given below :

$$CH_2=CH-\ddot{\underset{..}{X}}: \quad {}^{\ominus}CH_2-CH=\overset{\oplus}{\underset{..}{X}}:$$

(1) Name the type of halogen derivative.

(2) Comment on the bond length of C–X bond in it.

(3) Can react by S_N1 mechanism ? Justify your answer.

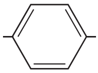
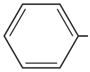
Ans. (1) Vinyl halide.

(2) C–X bond length shorter in vinyl halide than alkyl halide. Vinyl halide has partial double bond character due to resonance.

In vinyl halide, carbon is *sp*^{2}-hybridized. The bond is shorter and stronger and the molecule is more stable.

(3) Yes, It reacts by S_N1 mechanism. S_N1 mechanism involves formation of carbocation intermediate. The vinylic carbocation intermediate formed is resonance stabilized, hence S_N1 mechanism is favoured.

Chapter 11. Alcohols, Phenols and Ethers

Q. 37. What are the electronic effects exerted by – OCH_3 and – Cl ? Predict the acid strength of H_3C – O  **OH and Cl**  **OH relative to parent phenol**  **OH.**

Ans. The electronic effects exerted by – Cl and – OCH_3 are as follows :

(1) Cl being more electronegative atom it pulls the bonding electrons towards itself. This is known as negative inductive effect (– I).

(2) – OCH_3 is less electronegative group which repels the bonding electrons away from it. This is known as positive inductive effect (+ I).

(3) The relative to parent phenol, Cl  OH is more acidic than H_3C – O  OH.

Q. 38. Name the reagents used to convert phenol into

(1) picric acid (2) 2,4,6-tribromophenol (3) benzene

(4) *o*-phenol sulphonic acid.

Ans. (1) The reagent used to convert phenol into picric acid is concentrated nitric acid.

(2) The reagent used to convert phenol into 2,4,6-tribromophenol is bromine water.

(3) The reagent used to convert phenol into benzene is zinc dust.

(4) The reagent used to convert phenol into *o*-phenol sulphonic acid is dilute sulphuric acid.

Q. 39. An organic compound with the formula $C_4H_{10}O_3$ shows properties of ether and alcohol. When treated with an excess of HBr yields only one compound 1,2-dibromomethane. Write structural formula of ether and that of alcohol.

Ans. When $C_4H_{10}O_3$ is treated with excess of HBr, a single compound 1,2-dibromoethane is formed.

$$HO-CH_2-CH_2-O-CH_2-CH_2-OH + \underset{\text{(excess)}}{4HBr} \longrightarrow \underset{\text{(1,2-dibromoethane)}}{2Br-CH_2-CH_2-Br} + 3H_2O$$

$\therefore$ the structural formula of $C_4H_{10}O_3$ is

$HO-H_2C-CH_2-O-CH_2-CH_2-OH$

Q. 40. An organic compound gives hydrogen on reaction with sodium metal. It forms an aldehyde having molecular formula C_2H_4O on oxidation with pyridinium chlorochromate. Name the compounds and give equations of these reactions.

Ans. The given molecular formula C_2H_4O of aldehyde is written as CH_3-CHO. Hence the formula of alcohol from which this is obtained by oxidation must be CH_3-CH_2-OH. The two reactions can, therefore, be represented as follows :

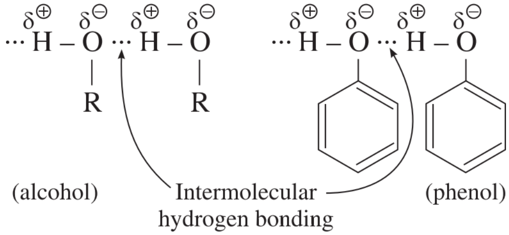
$$\underset{\text{(Ethyl alcohol)}}{2CH_3-CH_2-OH} \xrightarrow{2Na} \underset{\text{(Sodium ethoxide)}}{2CH_3-CH_2O^-Na^+} + H_2\uparrow$$

$$\underset{\text{(Ethyl alcohol)}}{CH_3-CH_2-OH} \xrightarrow[\text{PCC}]{[O]} \underset{\text{(Acetaldehyde)}}{CH_3-CHO} + H_2O$$

Q. 41. Describe the physical properties of alcohols and phenols.

Ans. The properties of alcohols and phenols are mainly due to the hydroxyl group.

(1) Nature of intermolecular forces : Due to presence of $-OH$ groups, alcohols and phenols are polar molecules. The polar $-OH$ groups are held together by the strong intermolecular forces, i.e. hydrogen bonding.



(2) Physical state : Lower alcohols are colourless, toxic liquids having characteristic alcoholic odour. Pure phenol is colourless, toxic, low melting solid having characteristic carbolic or phenolic odour.

(3) Boiling points : The boiling points of alcohols and phenols increase with increase in their molecular mass.

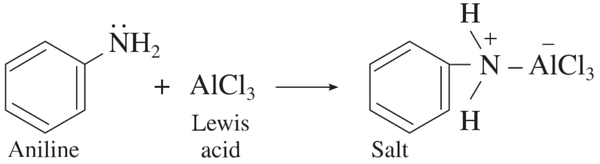
Methyl alcohol : 65 °C	Phenol : 182° C
n-Butyl alcohol : 118 °C	*o*-nitrophenol : 217 °C

(4) Solubility : Solubility of alcohols and phenols in water due to their ability to form intermolecular hydrogen bonding.

Chapter 13. Amines

Q. 42. Why aniline does not undergo Friedel-Craft's reaction using aluminium chloride ?

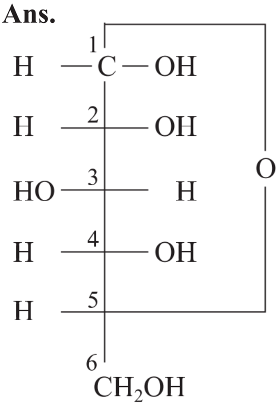
Ans. Aniline does not undergo Friedel-Craft's reaction (alkylation and acetylation) due to salt formation with aluminium chloride (Lewis acid), which is used as catalyst. Due to this, nitrogen of aniline acquires + ve charge and hence acts as strong deactivating effect on the ring and makes it difficult for electrophilic attack.



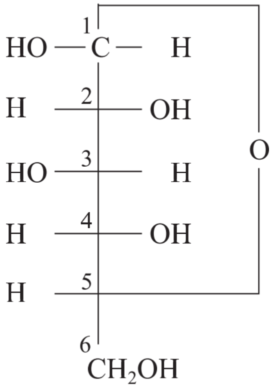
Chapter 14. Biomolecules

Q. 43. Write the structures of α-D-(+)-glucopyranose and β-D-(+)-glucopyranose.

Ans.



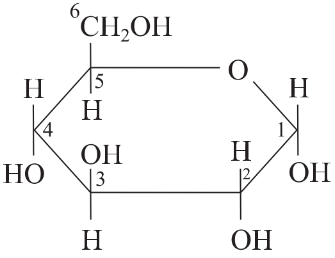
α-D-(+)-Glucopyranose



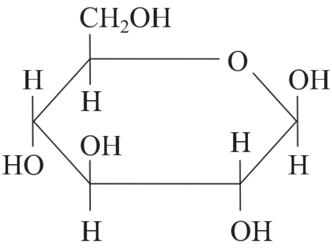
β-D-(+)-Glucopyranose

Q. 44. Write the Haworth projection formula for α-D-(+)-Glucopyranose (*trans*) and β-D-(+)-Glucopyranose (*cis*).

Ans.



α-D-(+)-Glucopyranose (*trans*)



β-D-(+)-Glucopyranose (*cis*)

Q. 45. Write the hydrolysis products of (1) lactose (2) sucrose.

Ans. (1) **Lactose** on hydrolysis in the presence of an acid or enzyme lactose gives one molecule each of glucose and galactose.

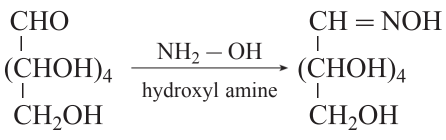
$$\underset{\text{lactose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{lactase}]{H_3O^+} \underset{\text{D-(+)-glucose}}{C_6H_{12}O_6} + \underset{\text{D-(+)-galactose}}{C_6H_{12}O_6}$$

(2) **Sucrose** on hydrolysis in the presence of dil. acid or the enzyme invertase gives one molecule each of glucose and fructose.

$$\underset{\text{sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{invertase}]{H_3O^+\text{ or}} \underset{\text{D-(+)-glucose}}{C_6H_{12}O_6} + \underset{\text{D-(−)-fructose}}{C_6H_{12}O_6}$$

Q. 46. Give two evidences for presence of formyl group in glucose.

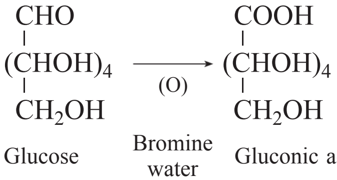
Ans. (1) Glucose reacts with hydroxyl amine in an aqueous solution to form glucose oxime. This indicates the presence of – CHO (formyl group) in glucose.



$$\begin{array}{l} CHO \\ | \\ (CHOH)_4 \\ | \\ CH_2OH \end{array} \xrightarrow[\text{hydroxyl amine}]{NH_2-OH} \begin{array}{l} CH=NOH \\ | \\ (CHOH)_4 \\ | \\ CH_2OH \end{array}$$

glucose　　　　glucose oxime

(2) Glucose on oxidation with mild oxidising agent like bromine water gives gluconic acid which shows carbonyl group in glucose is aldehyde (formyl group).

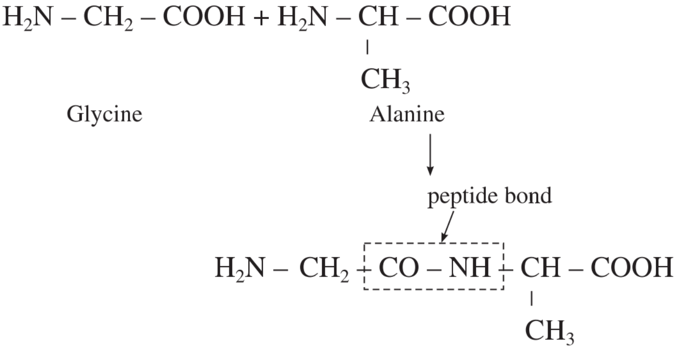


$$\begin{array}{l} CHO \\ | \\ (CHOH)_4 \\ | \\ CH_2OH \end{array} \xrightarrow[\text{Bromine water}]{} \underset{(O)}{} \begin{array}{l} COOH \\ | \\ (CHOH)_4 \\ | \\ CH_2OH \end{array}$$

Glucose　　　　Gluconic acid

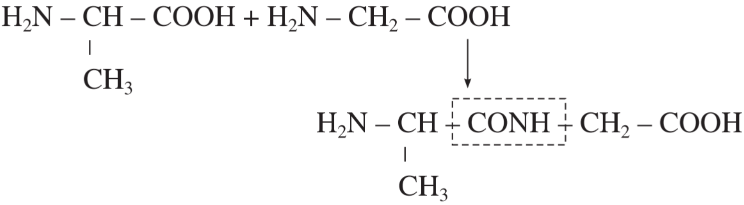
Q. 47. Write the names and schematic representations of all the possible dipeptides formed from alanine, glycine and tyrosine.

Ans. (1) Dipeptide formed from alanine and glycine.



$$H_2N-CH_2-COOH + H_2N-\underset{CH_3}{\underset{|}{CH}}-COOH \longrightarrow H_2N-CH_2-\boxed{CO-NH}-\underset{CH_3}{\underset{|}{CH}}-COOH$$

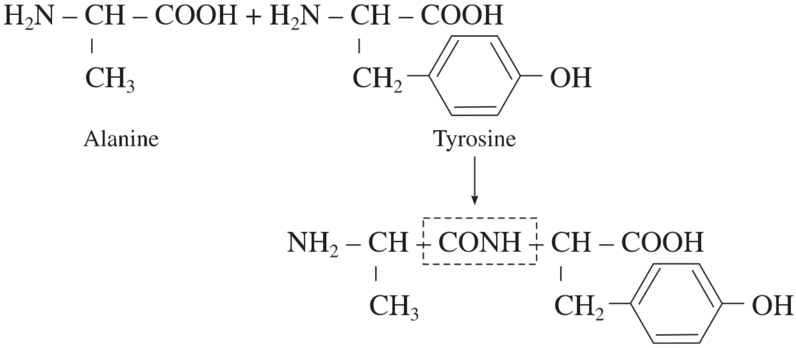
(dipeptide)
glycylalanine (Gly-Ala)



$$H_2N-\underset{CH_3}{\underset{|}{CH}}-COOH + H_2N-CH_2-COOH \longrightarrow H_2N-\underset{CH_3}{\underset{|}{CH}}-\boxed{CONH}-CH_2-COOH$$

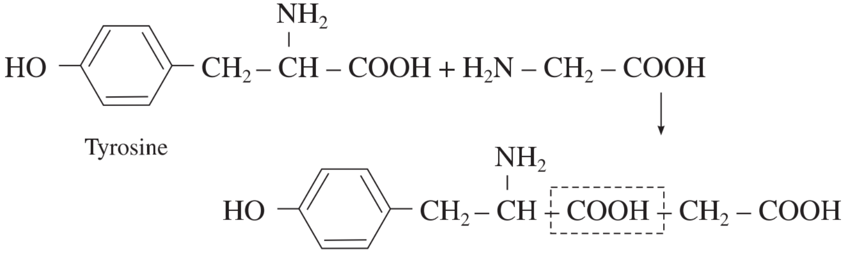
dipeptide

(2) Dipeptide formed from alanine and tyrosine.



Alanyltyrosine (dipeptide)
Ala-tyr

(3) Dipeptide formed from glycine and tyrosine.



Tyrosine

Tyr-Gly
(Glycyl-L-tyrosine)
dipeptide

Q. 48. What is denaturation of proteins? How is denaturation brought about? *OR*

What is the effect of denaturation on the structure of proteins?

Ans. The process by which the molecular shape of protein changes without breaking the amide/peptide bonds that form the primary structure is called denaturation. *OR*

Proteins gets easily precipitated. It is an irreversible change and the process is called denaturation of proteins.

Denaturation uncoils the protein and destroys the shape and thus loses their characteristic biological activity.

Denaturation is brought about by heating the protein with alcohol, concentrated inorganic acids or by salts of heavy metals. During denaturation secondary and tertiary and quaternary structures are destroyed but primary structure remains intact.

Example : Boiling of egg to coagulate egg white, conversion of milk to curd.

Q. 49. What are enzymes? Explain with suitable example.

Ans. All biological or bio-catalysts which catalyse the reactions in living organisms are called enzymes. Chemically all enzymes are proteins. They are required in very small quantities as they are catalyst also they reduce the activation energy for a particular reaction.

Example : Enzyme maltase converts maltose to glucose.

$$\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} \xrightarrow{\text{maltase}} \underset{\text{Glucose}}{C_6H_{12}O_6}$$

Q. 50. Explain vulcanization of rubber. Which vulcanizing agents are used for the following synthetic rubber?

1. Neoprene 2. Buna-N.

Ans. The process by which a network of cross links is introduced into an elastomer is called vulcanization.

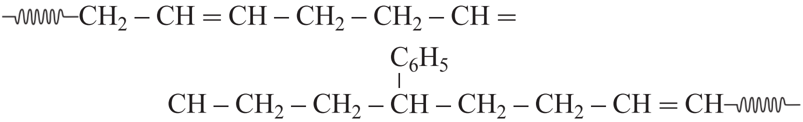
Vulcanization enhances the properties of natural rubber like tensile strength, stiffness, elasticity, toughness, etc. Sulphur forms cross links between polyisoprene chains which results in improved properties of rubber.

(1) For neoprene vulcanizing agent is MgO.

(2) For Buna-N vulcanizing agent is sulphur.

Q. 51. Write structural formula of the following synthetic rubbers : (1) SBR rubber (2) Buna-N rubber (3) Neoprene rubber.

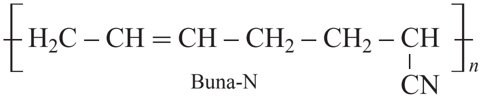
Ans. (1) SBR rubber :



$$\sim\sim CH_2-CH=CH-CH_2-CH_2-CH=CH-CH_2-CH_2-\overset{C_6H_5}{\overset{|}{CH}}-CH_2-CH_2-CH=CH\sim\sim$$

(SBR)

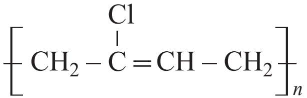
(2) Buna - N rubber :



$$\left[H_2C-CH=CH-CH_2-CH_2-\underset{CN}{\underset{|}{CH}} \right]_n$$

Buna-N

(3) Neoprene rubber :



$$\left[CH_2-\overset{Cl}{\overset{|}{C}}=CH-CH_2 \right]_n$$

Neoprene

Q. 52. What are synthetic resins? Name some natural and synthetic resins.

Ans. Synthetic resins are artificially synthesised high molecular weight polymers. They are the basic raw material of plastic. The main properties of plastic depend on the synthetic resin it is made from.

Examples of natural resins : Rosin, Damar, Copal, Sandarac, Amber, Manila.

Examples of synthetic resins : Polyester resin, Phenolic resin, Alkyl resin, Polycarbonate resin, Polyamide resin, Polyurethane resin, Silicone resin, Epoxy resin, Acrylic resin.

Chapter 16. Green Chemistry and Nanochemistry

Q. 53. Explain atom economy with suitable example.

Ans. (1) Atom economy is a measure of the amount of atoms from the starting material that are present in the final product at the end of a chemical process. Good atom economy means most of the atoms of the reactants are incorporated in the desired products. Only small amount of waste is produced, hence lesser problem of waste disposal.

(2) The atom economy of a process can be calculated using the following formula :

$$\%\ \text{atom economy} = \frac{\text{formula weight of the desired product}}{\begin{array}{c}\text{sum of formula weight of all the}\\ \text{reactants used in the reaction}\end{array}} \times 100$$

Consider the conversion of Butan-1-ol to 1-bromobutane

$$CH_3 - CH_2 - CH_2 - CH_2\ OH + NaBr + H_2SO_4 \longrightarrow$$
$$CH_3 - CH_2 - CH_2 - CH_2 - Br + NaHSO_4 + H_2O$$

% atom economy

$$= \frac{\text{mass of 1-bromo butane}}{\text{sum of mass of 1-butanol + sodium bromide}} \times 100$$

$$= \frac{\text{mass of (4C + 9H + 1Br) atoms}}{\text{mass of (4C + 12H + 5O + 1Br + 1Na + 1S) atoms}} \times 100$$

$$= \frac{137\ \text{u}}{275\ \text{u}} \times 100 = 49.81\%$$

The atom economy of the above reaction is less than 50% and waste produced is higher.

Q. 54. How nanotechnology plays an important role in water purification techniques ?

Ans. (1) Water purification is an important issue as 1.1 billion people do not have access to improved water supply. Water contains water born pathogens like viruses, bacteria.

(2) Silver nanoparticles are highly effective bacterial disinfectant to remove E. coli from water. Hence, filter materials coated with silver nanoparticles is used to clean water. Silver nanoparticles (AgNps) is a cost effective alternative technology (for e.g. water purifier).

Q. 55. State the disadvantages of nanoparticles and nanotechnology.

Ans. Despite the benefits that nanotechnology offers to the world, it is accompanied by certain disadvantages and potential risks.

The standard of living has been raised by nanotechnology but at the same time it has increased the environmental pollution. The kind of pollution caused by nanotechnology is very dangerous for living organism, it is called nano pollution.

Nanoparticles can be potential health hazard depending on the size, chemical composition and shape. They can be inhaled and can be deposited in the human respiratory tract and in the lungs, causing lung damage.