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Chapter 26

Biomolecules

Chapter Contents

Introduction

Living systems are made up of various complex biomolecules such as carbohydrates, proteins, enzymes, lipids, vitamins, hormones, nucleic acids and compounds for storage and inchange of energy such as ATP, etc. These biomolecules interact with each other and most of the biochemical reactions take place in dilute solutions (pH ~ 7) at body temperature (37°C) and at 1 atmospheric pressure. The structure and functions of biomolecules inside the living being is studied in biochemistry.

CARBOHYDRATES

Hydrates of carbon having general formula, $C_x(H_2O)_y$, is known as carbohydrates. For example, glucose ($C_6H_{12}O_6$) fits into the general formula, $C_6(H_2O)_6$.

But all the compounds having general formula $C_x(H_2O)_y$ are not considered as carbohydrates. For example, Ethanoic acid (CH_3COOH) fits into this general formula, $C_2(H_2O)_2$, but it is not a carbohydrate. Also, all carbohydrates do not fit into the general formula $C_x(H_2O)_y$. *e.g.*, rhamnose ($C_6H_{12}O_5$). Chemically carbohydrates are defined as optically active polyhydroxy aldehydes or ketones or the compounds which produce such units on hydrolysis. Carbohydrates are also known as saccharides. Some of the carbohydrates which are sweet to taste, are also called sugars.

Classification of Carbohydrates :

On the basis of their behaviour upon hydrolysis, carbohydrates can be divided into three main groups :

(i) **Monosaccharides :** A carbohydrate which cannot be hydrolyzed into simpler unit of polyhydroxy aldehyde or ketone is called monosaccharide. About 20 monosaccharides are known to occur in nature. *e.g.*, glucose, fructose, ribose, etc.

(ii) **Oligosaccharides :** A carbohydrate which upon hydrolysis yields 2–10 unit of monosaccharide is called oligosaccharide. They are further classified as disaccharides, trisaccharides, etc., depending upon the number of monosaccharides, they provide on hydrolysis. For example, sucrose is a disaccharide which on hydrolysis yields two unit of monosaccharides *i.e.*, glucose and fructose whereas raffinose is a trisaccharide which on hydrolysis yields three unit of monosaccharides *i.e.*, glucose, fructose and galactose.

(iii) **Polysaccharides :** A high molecular mass carbohydrate which upon hydrolysis yields a large number of monosaccharide units is called polysaccharide *e.g.,* starch, cellulose, glycogen, gums, etc.

$$\underset{\text{Starch or Cellulose}}{(C_6H_{10}O_5)_n} + nH_2O \xrightarrow{H^{\oplus}} \underset{\text{Glucose}}{nC_6H_{12}O_6}$$

Sugar and non-sugars : In general monosaccharides and oligosaccharides, are crystalline solids, soluble in water and sweet to taste, are collectively known as sugars. The polysaccharides, on the other hand, are amorphous insoluble in water and tasteless, are known as non-sugars.

Reducing and non-reducing carbohydrates : The carbohydrates containing free aldehydic ($-\overset{O}{\overset{\|}{C}}-H$) or ketonic ($>C=O$) group can reduce Fehling's solution and Tollen's reagent are known as reducing carbohydrates. All monosaccharides whether aldose or ketose are reducing in nature.

The carbohydrates in which the reducing parts are not free cannot reduce Fehling's solution and Tollen's reagent are known as non-reducing carbohydrates.

For example, in sucrose reducing part of glucose is bonded with the reducing part of fructose. So this disaccharide is non-reducing. All disaccharides except sucrose are reducing in nature.

All polysaccharides like starch, cellulose, glycogen etc. are non-reducing carbohydrates.

Monosaccharides :

If a monosaccharide contains an aldehyde group, it is known as an aldose and if it contains a keto group, it is known as a ketose.

Different types of Monosaccharides

Sr. No.	Carbon-atoms	General terms	Aldehyde	Ketone
1.	3	Triose	Aldotriose *e.g.,* Glyceraldehyde	Ketotriose *e.g.*, Dihydroxyacetone
2.	4	Tetrose	Aldotetrose *e.g.*, Erythrose	Ketotetrose *e.g.*, Erythrulose
3.	5	Pentose	Aldopentose *e.g.*, Arabinose	Ketopentose *e.g.*, Ribulose
4.	6	Hexose	Aldohexose *e.g.*, Glucose	Ketohexose *e.g.*, Fructose
5.	7	Heptose	Aldoheptose *e.g.*, Sedophetolose	Ketoheptose *e.g.,* Sedoheptulose

Glucose (Dextrose; Grape Sugar) :

Glucose occurs in nature in free as well as in the combined forms. It is present in sweet fruits and honey. Ripe grapes contain ~20% of glucose.

Preparation of Glucose

1. **From Sucrose (Cane Sugar) :** When sucrose is boiled with dilute HCl or H_2SO_4 in alcoholic solution, glucose and fructose are obtained in equimolar proportion.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\Delta]{H^{\oplus}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

2. **From Starch :** When starch is boiled with dilute H_2SO_4 at 393 K under pressure, glucose is obtained. This is the commercial method for the preparation of glucose.

$$\underset{\text{Starch or Cellulose}}{(C_6H_{12}O_5)_n} + nH_2O \xrightarrow[\text{393 K; 2–3 bar}]{H^{\oplus}} \underset{\text{Glucose}}{nC_6H_{12}O_6}$$

Structure of Glucose

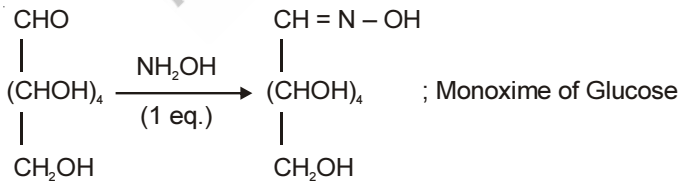
Glucose is an aldohexose and is the monomer of many larger carbohydrates like starch, cellulose etc. It is the most abundant organic compound on the Earth.

Its structure has been determined on the basis of following observations :

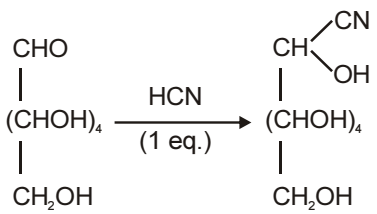
1. **Molecular Formula :** On the basis of elemental analysis and molecular weight determination its molecular formula is found to be $C_6H_{12}O_6$.

2. **Presence of Straight Six Carbon Chain :** Glucose on prolonged heating with HI forms n-hexane, suggesting that all six carbon atoms in glucose are linked linearly.

3. **Presence of Carbonyl Group :** Glucose reacts with hydroxylamine (NH_2OH) to give monoxime and adds a molecule of HCN to give a cyanohydrin.



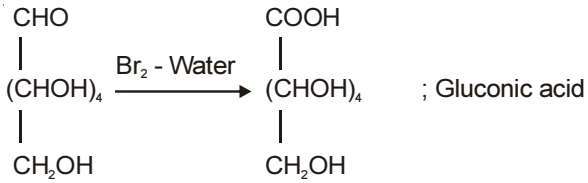
; Monoxime of Glucose



; Cyanohydrin of glucose

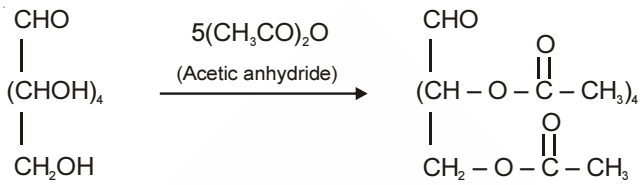
These reactions confirm the presence of a carbonyl group ($\rangle C = O$) in glucose.

4. **Presence of $>C = O$ as an Aldehydic Group :** Glucose gets oxidised to monocarboxylic acid Gluconic acid upon oxidation with mild-oxidising agents like Bromin water, Tollen's reagent, Fehling's solution etc.



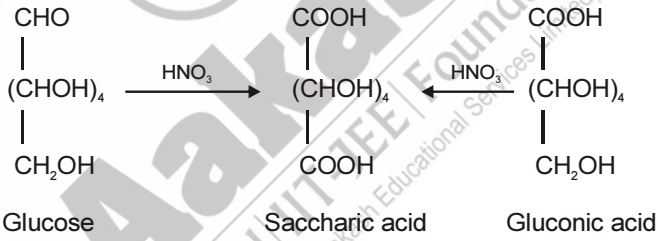
This confirms the presence of an aldehydic group in glucose.

5. **Presence of Five Hydroxyl Group :** Acetylation of glucose with acetic anhydride gives stable pentacetate of glucose.

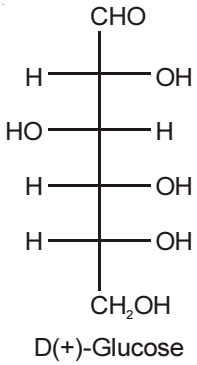


This confirms the presence of five –OH groups attached to different carbon atoms in glucose.

6. **Presence of Primary Alcoholic ($CH_2 - OH$) Group :** On oxidation with nitric acid, glucose as well as gluconic acid both yield the dicarboxylic acid, saccharic acid.



7. **Spatial Arrangement of –OH Groups :** The exact spatial arrangement of 5 – OH groups in glucose was provided by Fischer after studying many other properties of it. The configuration of open chain structure of glucose can be represented by Fischer projection formula as :



D(+)-Glucose

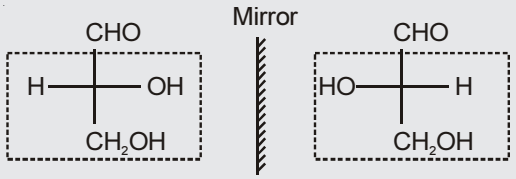
Glucose is correctly named as D(+) - Glucose. 'D' before the name of glucose represents the configuration whereas '+' represents dextrorotatory nature of the molecule. It should be noted that there is no direct relation between D, L configurations with d and l or (+) or (–) notations.

***Note* :**

FISCHER PROJECTION FORMULA

Fischer projection is used for describing the 3D-arrangement of a tetrahedral carbon in 2D-manner.

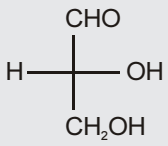
While drawing the Fischer projection of a molecule the main longest carbon chain is drawn vertically with the most highly oxidized carbon at the top.



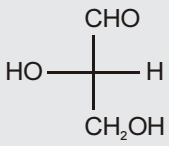
; Fischer projections of D(+)-Glyceraldehyde and L(–)-Glyceraldehyde

The horizontal bonds point towards the observer *i.e.,* above the plane of the paper while vertical bonds point away from the observer *i.e.*, below the plane of the paper. The chiral carbon lies in the plane of the paper and is usually omitted.

The D, L System of Configurational Designation : The letters 'D' & 'L' before the name of any compound indicate the substituents orientation at a centre of chirality to that in D- and L-Glyceraldehydes. Glyceraldehyde contains one asymmetric carbon atom and exists in two enantiomeric forms as :

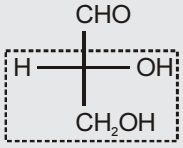


D - (+) - Glyceraldehyde

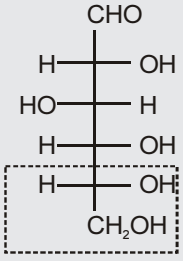


L - (+) - Glyceraldehyde

The D- and L- nomenclature to glyceraldehyde was arbitrarily given by Fischer who introduced this system. D-refers to an arrangement about a centre of chirality that is identical to the three dimensional arrangement in D-(+) glyceraldehyde in which the –OH group on the chiral centre is on right in its Fischer projection. Similarly L-refers to an arrangement about a centre of chirality that is identical to the 3D-assigned in L-(–)-glyceraldehyde. All molecules which could be chemically related to D-glyceraldehyde are arranged the D-configuration and those related to L-glyceraldehyde are assigned L-configuration. For assigning the configuration of monosaccharides, it is the lowest asymmetric carbon atom (in the Fischer projection formula of the compound) is compared.



D - (+) - Glyceraldehyde



D - (+) - Glucose

Limitations of Open Chain Structure of Glucose

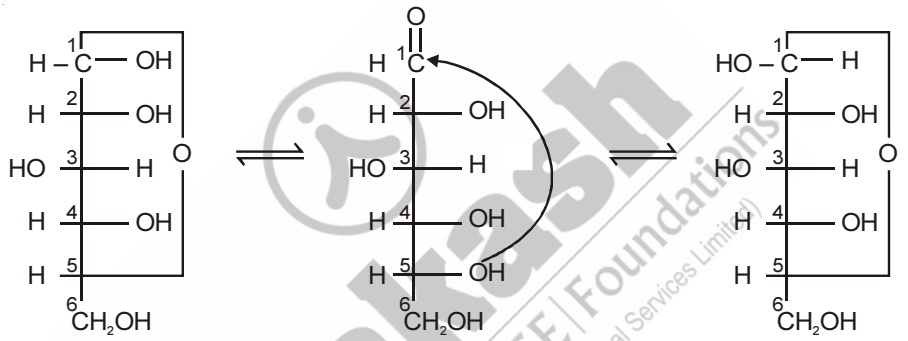
The open chain structure of glucose explains most of the properties of glucose except following ones :

1. Although glucose has an aldehydic group, it does not give, 2, 4-DNP test, Schiff's test and also it does not react with $NaHSO_3$ or NH_3 to form addition product.
2. The pentacetate of glucose formed upon acetylation of glucose, does not react with hydroxylamine. This indicates the absence of aldehydic (–CHO) group.
3. The existence of glucose in α and β– anomeric forms could not be explained by the open chain structure.

   The α-form of glucose having m.p. 419 K is obtained by crystallising form of concentrated solution of glucose at 303 K while the β-form having m.p. 423 K is obtained by crystallising of hot and saturated aqueous solution at 371 K.

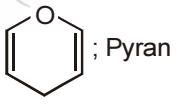
Cyclic Structure of Glucose

The limitations shown by the open chain structure of glucose can be explained by its cyclic structure. It was proposed that glucose can form a six-membered ring in which –OH at C-5 can add to the –CHO group and can form a cyclic hemiacetal structure. This explains the absence of –CHO group and also the existence of glucose in α and β-anomeric forms as :

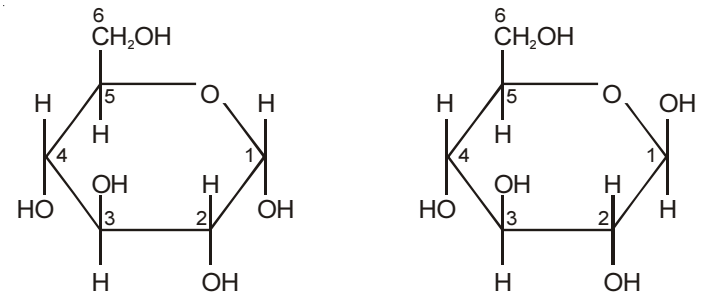


α - D - (+) - Glucose β - D - (+) - Glucose

The two cyclic hemiacetal forms of glucose differ only in the configuration of the hydroxyl group at C-1, called anomeric carbon (the aldehyde carbon before cyclisation) and the corresponding α and β-forms are called anomers. It should be noted that α and β-forms of glucose are not mirror images of each other, hence are not enantiomers. The six membered cyclic structure of glucose is called pyranose structure (α or β), in analogy with pyran.


; Pyran

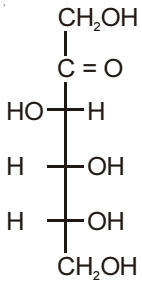
Pyran is a six membered ring with one oxygen and five carbon atoms in the ring. The cyclic structure of glucose is more correctly represented by Haworth structure as given below :



α - D - (+) - Glucopyranose β - D - (+) - Glucopyranose

Fructose and Its Structure

Fructose is an important ketohexose. It is obtained by the hydrolysis of sucrose. On the basis of molecular weight determination, elemental analysis and various reaction its molecular formula is found to be $C_6H_{12}O_6$ and open chain structure of it can be written as :



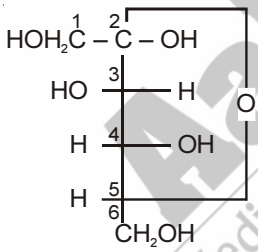
D-(–)-Fructose

It contains a ketonic functional group at C-2 and six-carbon atoms in straight chain. Naturally occurring fructose is lavorotatory and belongs to D-family.

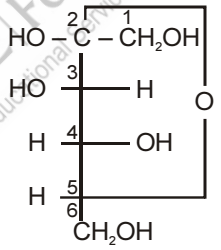
Fructose also exists in two cyclic forms like glucose *i.e.*, α-D-(–) - fructose and β-D- (–) - fructose. The five-membered cyclic structure of fructose is formed by the involvement of –OH at C-5 and carbonyl group. The five-membered ring of fructose is named as furanose with analogy to the compound furan.

; Furan

Furan is a five-membered cyclic compound with one oxygen and four carbon atoms.

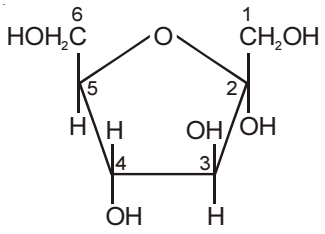


α-D-(–)-Fructofuranose

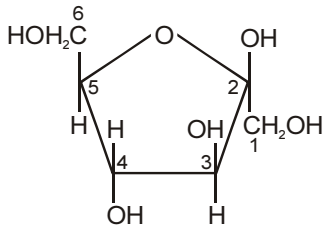


β-D-(–)-Fructofuranose

The cyclic structures of two anomers of fructose can be represented by Haworth structures as :



α-D-(–)-Fructofuranose



β-D-(–)-Fructofuranose

Disaccharides

The disaccharides are composed of two units of monosaccharides On hydrolysis with dilute acids or specific enzymes they give the corresponding monomers.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} \xrightarrow{H_3O^{\oplus}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

$$\underset{\text{Lactose}}{C_{12}H_{22}O_{11}} \xrightarrow{H_3O^{\oplus}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Galactose}}{C_6H_{12}O_6}$$

$$\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} \xrightarrow{H_3O^{\oplus}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Glucose}}{C_6H_{12}O_6}$$

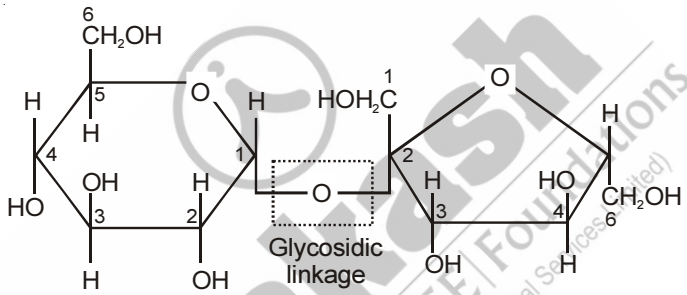
In disaccharides the two monosaccharides units are joined together by an oxide linkage formed by the loss of a water molecule and the linkage is known as glycosidic linkage.

The disaccharides may be reducing or non-reducing depending upon the position of linkage between the two monosaccharide units.

(i) Sucrose :

$$\underset{[\alpha]_D=+66.5^\circ}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^{\oplus}} \underset{\substack{\text{D}-(+)-\text{Glucose}\\ [\alpha]=+52.5^\circ}}{C_6H_{12}O_6} + \underset{\substack{\text{D}-(+)-\text{Fructose}\\ [\alpha]_D=-92.4^\circ}}{C_6H_{12}O_6}$$

Sucrose is formed by the glycosidic linkage between C-1 of α-D-(+)-glucose and C_2 of β-D-(–) fructose :

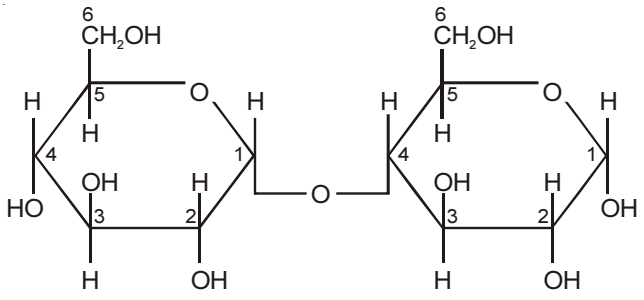


α-D - Glucose β-D - Fructose

As the reducing parts of glucose and fructose are involved in glycosidic linkage, sucrose is a non-reducing sugar.

Sucrose is dextrorotatory in nature but upon hydrolysis it gives the equimolar mixture of D-glucose ($[\alpha]_D$ = + 52.5°) and D-fructose ($[\alpha]_D$ = –92.4°) which is laevorotatory. Thus the hydrolysis of sucrose changes the sign of rotation, from dextro (+) to laevo (–) and the product so formed is known as **invert sugar**.

(ii) Maltose : Maltose is formed by the glycosidic linkage between C-1 of one glucose unit to the C-4 of another glucose unit.



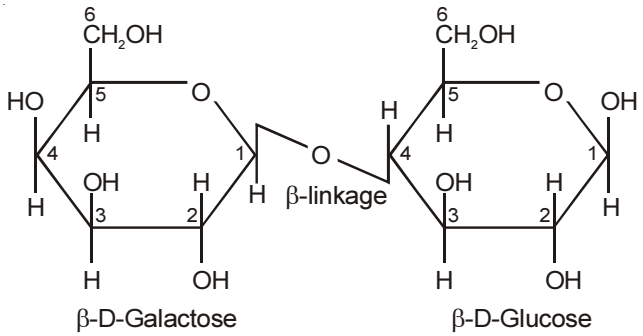
(I) (II)

α-D-Glucose α-D-Glucose

Maltose

Maltose is a reducing sugar because the C-1 of second glucose unit is not involved in glycosidic linkage and in solution it can show reducing properties so it is a reducing sugar.

(iii) Lactose : Lactose is found in milk so it is also known as milk sugar. It is formed by the glycosidic linkage between C-1 of β-D-galactose unit and C-4 of β-D-glucose unit.



Lactose

Lactose is a reducing sugar.

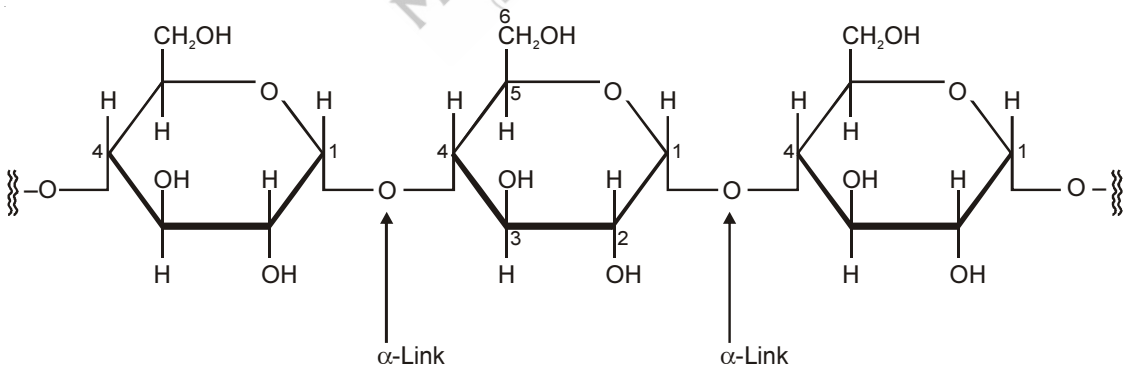
Polysaccharides

Polysaccharides are long chain polymer of monosaccharides joined together by glycosidic linkages. For example, starch, cellulose, glycogen etc. They mainly act as the food storage or structural materials.

Starch $(C_6H_{10}O_5)_n$: Starch is the main storage polysaccharide of plants. High content of starch is found in cereals, roots, tubers and some vegetables.

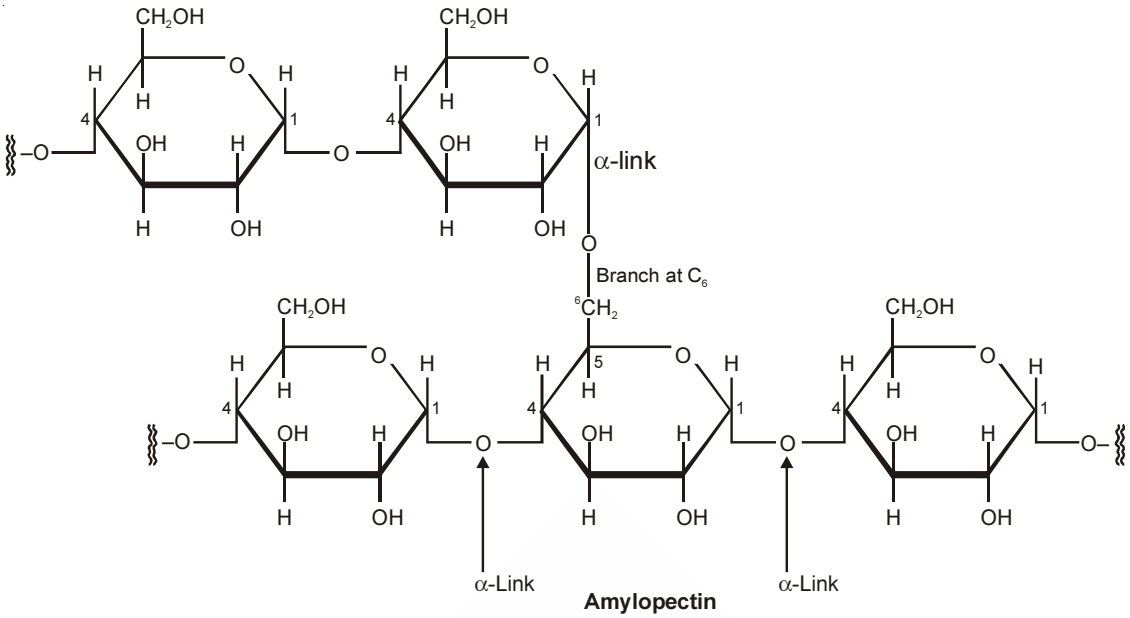
$$\underset{\text{Starch}}{(C_6H_{10}O_5)_n} \xrightarrow{\text{Diastase}} \underset{\text{Maltose}}{C_{12}H_{22}O_{11}} \xrightarrow{H_3O^{\oplus}} C_6H_{12}O_6 ; \text{D – glucose}$$

Starch is a polymer of α-D-(+) Glucose coming of two components namely Amylose and Amylopectin. Amylose is water soluble component, which constitutes about 15 - 20% of starch. It is a straight chain polysaccharide containing α-D-(+)-glucose units joined together by α-glycosidic linkage involving C-1 of one glucose unit and C-4 of the next. It can have 200 - 1000 α-D-(+)-glucose units held by C1 - C4 glycosidic linkage.



Amylose

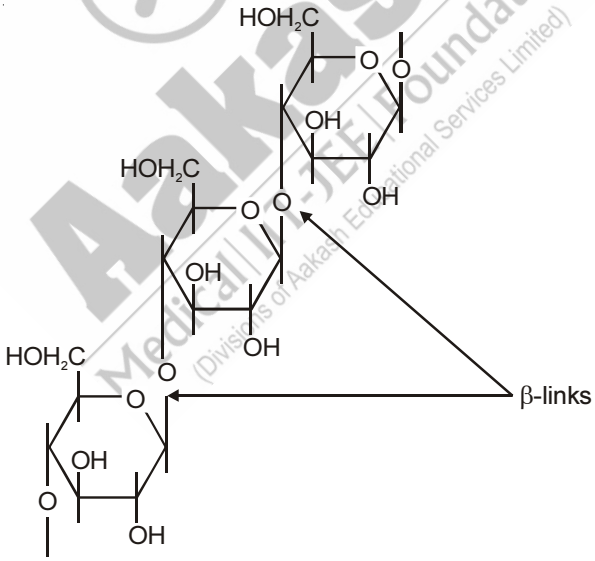
Amylopectin is a branched chain polysaccharide insoluble in water. It constitutes about 80 – 85% starch. It is a branched chain polymer of α-D-glucose units in which chain is formed by C1 - C4 glycosidic linkage whereas branching occurs by C1 – C6 glycosidic linkage.



Amylopectin

Cellulose

Cellulose is a straight chain polysaccharide composed of only β-D-glucose units. In cellulose there is β-glycosidic linkages between C-1 of one glucose unit and C-4 of the next glucose unit. Cellulose occurs mainly in plants and it is the most abundant organic substance in plant kingdom. It is the chief constituent of the cell walls of plants.



Cellulose

Glycogen

Its structure is similar to amylopectin with more branching than in amylopectin. It is also known as animal starch. In body, carbohydrates are stored as glycogen and when the body needs glucose, enzymes break the glycogen down to glucose. Glycogen is present in liver, muscle and brain. It is also found in yeast and fungi.

Importance of Carbohydrates

Carbohydrates are essential for life in both plants and animals. Carbohydrates are stored in plant as starch and in animals as glycogen. Cell wall of bacteria and plant is made up of cellulose. Furniture used in daily life, are made from cellulose in the form of wood, clothe we wear is also made from cellulose in the form of cotton fibre.

Example 1 : *Name a disaccharide which is not reducing sugar.*

Solution : Sucrose.

***Note* :**

- Fructose is ketonic sugar. It behaves like a keto hexose.
- Fructose shows mutarotation *i.e.*, specific rotation of a freshly prepared fructose solution changes with time. It suggests its ring structure.
- Fructose contains three asymmetric carbon atoms and exists in eight stereo isomeric forms.
- Fructose is not oxidized by bromine water but with HNO_3 gives glycolic and tartaric acid.
- Although fructose is a ketonic sugar but yet it reduces Tollen's reagent etc. It is due to the fact that under alkaline conditions it rearranges to give a mixture of glucose, mannose and fructose.
- On reduction with Na–Hg/H_2O fructose gives sorbitol and mannitol.
- Zymase ferments fructose to ethanol and CO_2.
- Osazone of glucose, fructose and mannose are identical.
- Sweetness of sugars :

Sugar	Degree of sweetness
Cane sugar (sucrose)	100
Lactose	16
Maltose	33
Glucose	74
Fructose	175
Invert sugar	130
Galactose	32

- Invert sugar is sweeter than sucrose due to presence of fructose.
- Fructose molecule in sucrose exists as the furanose form but when it is hydrolysed it is pyranose form of fructose which is isolated.
- The cattle and other ruminants have enzyme cellulase which hydrolyses cellulose to glucose. Hence these animals can digest cellulose but human beings can not digest cellulose due to lack of cellulase in digestive system.
- Gun cotton is cellulose trinitrate. It is a powerful explosive.
- Blasting gelatin is a mixture of nitroglycerine and 70% gun cotton.
- Cellulose acetate is used in making non-inflammable photographic and motion picture films.
- Some compounds other than sugar are much sweeter than sucrose. *e.g.*,
  (a) **Saccharin :** (O-Sulphobenzoic imide) : It is about 500 times sweeter than sucrose.
  (b) **Monellin :** It is a protein 2000 times sweeter than sucrose.
  (c) **Aspartame :** It is a peptide which is 160 times sweeter than cane-sugar
- Amylose gives blue colour whereas amylopectin gives brown colour with Iodine.
- Reactions with carbohydrates should be carried out in acidic medium or neutral medium because in basic medium they undergo rearrangement.

EXERCISE

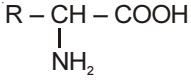
1. Which of the following is a non-reducing sugar?
   (1) Glucose
   (2) Sucrose
   (3) Maltose
   (4) Lactose
2. Which of the following is the monomer of cellulose?
   (1) β-D-glucose
   (2) Amylose
   (3) Amylopectin
   (4) Glycogen
3. Equimolar mixture of α-D(+)-glucose and β-D(+)-glucose has specific rotation ($[\alpha]_D$) is
   (1) –92.4° (2) +112.5°
   (3) +52.5° (4) –19.2°
4. Number of asymmetric carbon in α-D(+)-glucose is
   (1) 4 (2) 6
   (3) 5 (4) 3
5. Presence of carbonyl group in glucose can be shown by its reaction with
   (1) NH_2OH (2) HCN
   (3) Tollen's reagent (4) All of these

PROTEINS

The term protein is derived from the Greek word 'Proteins' which means of prime importance. Proteins are high molecular mass complex biopolymer of α-amino acids present in all living cells. They occur in every part of the body and form the fundamental basis of structure and functions of life.

Proteins are the most abundant biomolecules of the living system. Chief sources of proteins are milk, cheese, pulses, peanuts, fish etc.

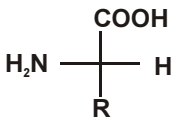
Amino Acids : The compound containing $–NH_2$ and –COOH functional groups are known as amino acid, depending upon the relative position of $–NH_2$ group with respect to –COOH group, amino acids are classified into α, β, γ, δ and so on amino acid. Hydrolysis of proteins gives only α-amino acids represented as :

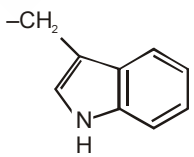
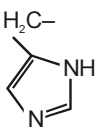
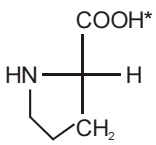


Proteins may contain other functional groups also.

Nomenclature of α-Amino Acids : All α-amino acids have their trival names which generally reflect the property of the amino acids or their sources. For example, glycine is so named since it has sweet taste (in Greek, *Glycos* means cheese) :

Amino acids are generally represented by a three letter symbol, sometimes one letter symbol is also used. The structures of the some commonly occurring amino acids along with their three-letter and one-letter symbols are given in the following table :

Natural Amino Acids 

S. No.	Name of the amino acids	Characteristic feature of side chain, R	Three letter symbol	One letter code
1.	Glycine	H	Gly	G
2.	Alanine	CH_3–	Ala	A
3.	Valine*	$(H_3C)_2CH$–	Val	V
4.	Leucine*	$(H_3C)_2CH - CH_2$–	Leu	L
5.	Isoleucine*	$H_3C - CH_2 - CH(CH_3)$–	Ile	I
6.	Arginine*	$HN = C(NH_2) - NH - (CH_2)_3$–	Arg	R
7.	Lysine*	H_2N–$(CH_2)_4$–	Lys	K
8.	Glutamic acid	$HOOC - CH_2 - CH_2$–	Glu	E
9.	Aspartic acid	$HOOC - CH_2$–	Asp	D
10.	Glutamine	$H_2N - C(=O) - CH_2 - CH_2$–	Gln	Q
11.	Asparagine	$H_2N - C(=O) - CH_2$ –	Asn	N
12.	Threonine*	$H_3C - CHOH$ –	Thr	T
13.	Serine	$HO - CH_2$–	Ser	S
14.	Cysteine	$HS - CH_2$–	Cys	C
15.	Methionine*	$H_3C - S - CH_2 - CH_2$–	Met	M
16.	Phenylalanine*	$C_6H_5 - CH_2$–	Phe	F
17.	Tyrosine	(*p*)$HO - C_6H_4 - CH_2$–	Tyr	Y
18.	Tryptophan*		Trp	W
19.	Histidine*		His	H
20.	Proline		Pro	P

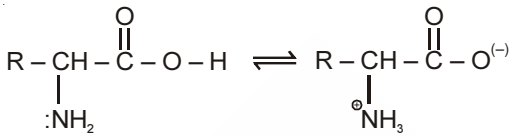
* Essential amino acid, a = entire structure

Classification of Amino Acids : Depending upon the relative number of amino and carboxyl groups in the molecules amino acids are classified as acidic, basic or neutral, depending upon the relative number of amino and carboxyl groups. Equal number of – NH_2 & –COOH groups make the amino acid neutral, more –NH_2 group than –COOH group make the amino acid basic and more –COOH group than –NH_2 group make the amino acid acidic.

Essential and non-essential amino acids : The amino acids which cannot be synthesized in the body are known as essential amino acids which must be taken through diet. The amino acids, which can be synthesized in the body are known as non-essential amino acids.

Physical Properties of α-Amino Acids : Amino acids are generally colourless, crystalline, water-soluble, high melting solids. They behave like salts rather than simple amines or carboxylic acids due to the presence of both –COOH & –NH_2 groups.

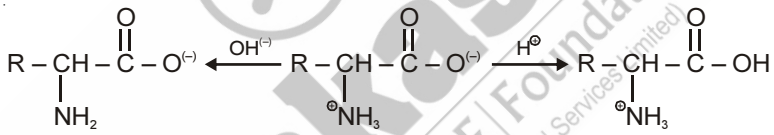
In aqueous solution amino acid can exist as a dipolar ion known as zwitter ion if –COOH group loses $H^{\oplus}$ ion and –NH_2 accepts $H^{\oplus}$ ion



Zwitter ion

In zwitter ionic form, amino acids show amphoteric behaviour.

In acidic solution, the $-\overset{O}{\overset{\|}{C}}-O^{(-)}$ accepts a proton and gets converted to –COOH, while in basic solution the ammonium substituent ($\overset{\oplus}{N}H_3$) loses a proton and gets converted to –NH_2.

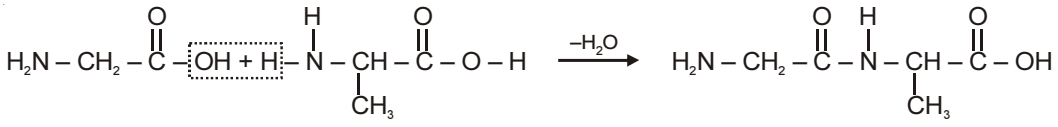


Except glycine, all other naturally occurring α-amino acids are optically active. α-amino acids exist in both D and L-forms. While writing the Fischer projection formula L-amino acids are represented by writing the –NH_2 group on left-hand side. Most of the naturally occurring amino acids have L-configuration.

Structure of Proteins

Peptide-bond or Linkage : The reaction between two molecule of the same or different amino acids, proceeds through the combination of amino group of one molecule with the carbonyl group of the other results in the formation of $(-\overset{O}{\overset{\|}{C}}-\overset{H}{\overset{|}{N}}-)$ bond with the loss of a water molecule.

For example, when carboxyl group of glycine combines with amino group of alanine, we get glycylalanine (dipeptide).



Glycylalanine (Gly-Ala)

Polypeptide : A dipeptide contains two amino acids linked by one peptide linkage, a tripeptide contains three amino acids linked by two peptide linkages and so on. When number of such amino acids is more than ten, then the products are called polypeptides.

Protein : A polypeptide with more than hundred of amino acids having molecular mass higher than 10,000 u is called protein. However, the distinction between a polypeptide and a protein is not very sharp. Polypeptides with fewer amino acids are likely to be called proteins if they ordinarily have a well defined conformation of protein such as insulin which contains 51 amino acids.

Classification of Protein : On the basis of molecular shape, proteins are classified into two types :

(1) Fibrous protein

(2) Globular protein

(1) Fibrous Proteins : When the polypeptide chains sum parallel and are held together by hydrogen and disulphide bonds, then fibre-like structure is formed, known as fibrous proteins. Such proteins are insoluble in water.

For example: Keratin, Myosin etc.

(2) Globular Proteins : When the polypeptide chains coil around to give a spherical shape, the formation of globular protein takes place. Such proteins are usually soluble in water.

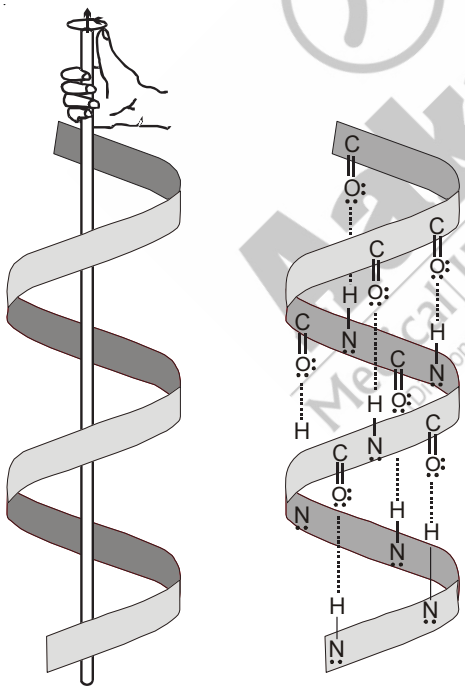
For example : Insulin, Albumins etc.

Primary, Secondary, Tertiary and Quaternary Structures of Proteins

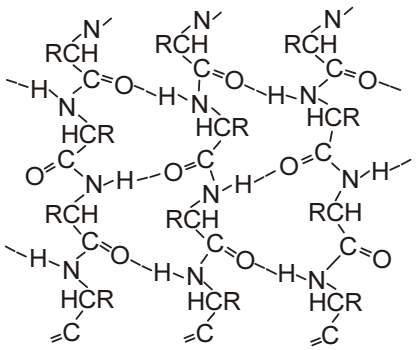
(1) Primary Structure : Proteins may have one or more polypeptide chains. Each polypeptide in a protein has amino acids linked with each in a specific sequence and it is this sequence of amino acids that is said to be the primary structure of that protein. Any charge in this primary structure *i.e.*, the sequence of amino acids creates a different proteins.

(2) Secondary Structure : The secondary structure of protein refers to the shape in which a long polypeptide chain can exist.

They are found to exist in two different types of structure namely α-helix and β-pleated sheet structure. These structures arise due to the regular folding of the backbone of the polypeptide chain due to hydrogen bonding between $-\overset{O}{\overset{\|}{C}}-$ and –NH– groups of the peptide bond.



α-Helix Structure of Proteins

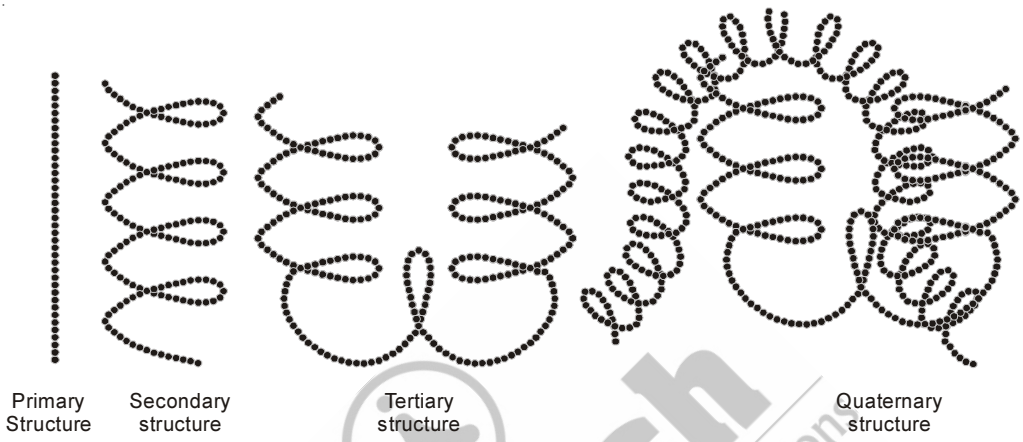


β-Pleated Sheet Structure of Proteins

α-Helix is one of the most common ways in which a polypeptide chain forms all possible hydrogen bonds by twisting into a right-handed screw (Helix) with the –NH group of each amino acid residue hydrogen bonded to $\rangle C = O$ of an adjacent turn of the helix as shown above figure. In β-structure all peptide chains are stretched out to nearly maximum extension and then laid side by side which are held together by intramolecular H-bonds. The structure resembles the pleated folds of drapery and therefore is known as β-pleated sheet.

(3) Tertiary Structure : The tertiary structure of proteins represents overall folding of the polypeptide chains *i.e.*, further folding of secondary structure. It gives rise to two major molecular shapes namely fibrous and globular. The main forces which stabilizes the 2º & 3º structures of proteins are hydrogen bonds, disulphide linkages, van der Waals and electrostatic forces of attraction.

(4) Quaternary Structure : Some of the proteins are composed of two or more polypeptide chains referred to as sub units. The spatial arrangement of these subunits with respect to each other is known as quaternary structure.



Diagrammatic representation of protein structure
(two sub-units of two types in quaternary structure)

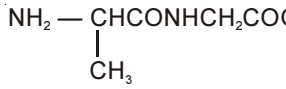
Denaturation of Proteins : The loss in biological activity of a protein due to unfolding of globules and uncoiling of helix is called denaturation of protein. During denaturation secondary and tertiary structures are destroyed but primary structure remains intact. The coagulation of egg white on boiling is a common example of denaturation. Another example is curing of milk which is caused due to the formation of lactic acid by the bacteria present in milk. The reverse of denaturation is called renaturation.

Example 2 : *Which amino acid is optically inactive?*

Solution : Glycine is optically inactive due to lack of chiral C-atom.

EXERCISE

6. The main strucutral feature of proteins is
   (1) Peptide linkage
   (2) Glycoside linkage
   (3) Ether linkage
   (4) All of these
7. Which of the following α-aminoacids is not optically active?
   (1) Alanine
   (2) Glycine
   (3) Phenylalanine
   (4) All are optically active

8. The name of the dipeptide  is

(1) Glycyl glycine (2) Glycyl alanine

(3) Glycine alanine (4) Alanyl glycine

9. Peptidies on hydrolysis give

(1) Ammonia (2) Amines

(3) Amino acids (4) Hydroxy acids

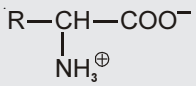
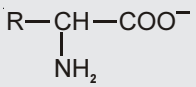
10. Which of the following is a test for proteins?

(1) Molisch's test (2) Beilstein test

(3) Biuret test (4) Benedict's test

***Note* :**

- The word "protein" was first of all given by Mulder.
- All proteins are mixed polymers of amino acids and as such all contain carbon, hydrogen, oxygen, and nitrogen. Most contain sulphur, some contain P and some contain other mineral elements such as Cu^{++}, Zn^{++}, Fe^{++} etc. They have molecular weight higher than 10000 u.
- Like amino acids protein also have amino and carboxylic terminal and are amphoteric in nature. They also have isoelectric point.
- **Conjugated proteins** are those simple proteins which are bonded with a non-proteinic prosthetic group. It acts as a **cofactor**. Carbohydrates, phosphoric acid and iron pigments act as **cofactors.**
- All proteins are optically active due to presence of chiral centre at α-position.
- **Isoelectric point :** At a certain hydrogen ion concentration (pH) : The dipolar ion of amino acid exists as a neutral ion and no net migration towards either electrode this pH is known as isoelectric point of amino acid. The amino acid exist in different ionic forms.

 At pH = 7  At pH > 7

- They are easily characterised by colour reactions : *e.g.*,

  Ninhydrin : Protein when treated with a pyridine solution of ninhydrin give colour ranging from deep blue to violet pink or even red in some cases.

  Biuret Test : When an alkaline solution of protein is treated with a drop of aqueous copper sulphate, a bluish violet colour is obtained.

  Million's Reaction : This test is characteristic of phenol and of only those proteins having this group (*e.g.*, tryosine unit). A white precipitate is obtained when such protein is heated with Million's reagent ($HgNO_3$ in HNO_3 containing little HNO_2).

  Xanthoproteic Test : On treatment with conc. HNO_3 certain proteins give the yellow colour which is the same that is formed on the skin when the skin comes in contact with conc HNO_3 in the laboratory.

ENZYMES

Colloidal solution of protein which works as biological catalyst is known as enzyme.

All enzymes are globular proteins.

Some enzymes are associated with some non-protein component, called the cofactor of their activity. These cofactors are of two types:

(i) Inorganic ions such as Zn^{++}, Mg^{++}, K^{+}, Na^{+}, Fe^{++}, Cu^{++}, Co^{++}, Mo^{++} etc.

(ii) **Organic Molecules :** They are of two types :

(a) **Coenzymes :** They are small organic molecules cofactor is held with protein by very weak bond. In most of the cases these cofactors are derived from vitamins such as, thiamine, riboflavine, niacin etc.

(b) **Prosthetic Groups :** These are also organic molecules (mainly vitamins) and are bonded to protein by covalent bond.

Thus all enzymes are conjugated proteins.

	Name of enzyme	Reaction catalysed
(i)	Zymase	Glucose and Fructose $\rightarrow C_2H_5OH$
(ii)	Invertase	Sucrose $\rightarrow$ Glucose + Fructose
(iii)	Maltase	Maltose $\rightarrow$ Glucose + Glucose
(iv)	Lactase	Lactose $\rightarrow$ Glucose + Galactose
(v)	Emulsin	Cellulose $\rightarrow$ Glucose
(vi)	Urease	Urea $\rightarrow CO_2 + NH_3$
(vii)	Pepsin	Proteins $\rightarrow \alpha$-amino acids
(viii)	Trypsin	Proteins $\rightarrow \alpha$-L-amino acids
(ix)	Diastase	Starch $\rightarrow$ Maltose

Temperature Dependence of Enzyme Activity :

The enzymes work best at an optimum temperature range of 298 K to 313 K. Their activity decreases with decrease or increase in temperature and stops at 273 K.

Efficiency : Even a small amount of enzymes are highly efficient. This is because their molecules are regenerated during their catalytic activity.

- Those chemical substances which tend to reduce activity of a particular enzyme are called enzyme inhibitors.
- Disease albinism is caused by deficiency of tryosinase.
- Phenylketone urea is caused by deficiency of enzyme phenylalanine hydroxylase.
- Streptokinase enzyme is used to dissolve the blood clot.

Example 3 : *Name the molecules which catalyses biological reactions.*

Solution : Enzymes catalyses biological reactions.

EXERCISE

11. Insulin is secreted by
(1) Pancreas (2) Stomach
(3) Thyroid (4) Adrenal medulla

12. The enzyme that converts starch into maltose is called
(1) Zymase (2) Maltase
(3) Diastase (4) Lactase

13. Conversion of urea to CO_2 and ammonia is done by
    (1) Pepsin
    (2) Urease
    (3) Lactase
    (4) Nuclease
14. Enzyme pepsin hydrolyses
    (1) Fats to fatty acids
    (2) Proteins to α-amino acids
    (3) Starch to glucose
    (4) Glucose to ethyl alcohol
15. Which of the following enzymes hydrolyses triglycerides to fatty acids and glycerol?
    (1) Amylase
    (2) Maltase
    (3) Lipase
    (4) Pepsin

***Note* :**

- Most of the enzymes are produced by the cell function within the cell itself and are called endoenzymes or intracellular enzymes. However some of these catalyse the reactions in the cells environment and are called exoenzymes.
- The protein part of a conjugated protein is called apoenzyme and the molecule as a whole is called holoenzyme.

VITAMINS

Vitamins are organic compounds which are essential for normal growth of life for animals, some bacteria and micro organism. Vitamins are not synthesized by animals (except vitamin D). Vitamins are supplied to the organism through food. They are essential dietary factor.

Classification : Vitamins are classified in two categories :

1. Water Soluble Vitamins
2. Fat Soluble Vitamins

(1) Water Soluble Vitamins : Vitamin-B-complex and vitamin-C are water soluble.

Vitamin B_1 : Thiamine

- Its natural sources are green vegetables, soyabeans, dried pea, milk, cheese etc.
- Its deficiency causes Beri-Beri.

(a) Vitamin-B_2 : Riboflavin

Natural Sources : Grains, Cereals, Almonds, Curd, Milk etc.

Deficiency Diseases: Skin swelling around the mouth. Cracking of lips at the edges, bulging of eye cells.

(b) Vitamin-B_3 : Niacin (Nicotinic Acid) and Nicotinamide

Natural Sources : Mushroom, Ground nut, Bread etc.

Deficiency Disease : Pellagra

(c) Vitamin B_5 : Pantothenic

Natural Sources : Ground nut, Soyabean, Liver, Kidney

Deficiency Disease : Swelling in stomach and intestines

(d) Vitamin B_6 : Pyridoxine

Natural Sources : Yeast milk, Egg yolk, Cereals, Grams

Deficiency Disease : Convulsions

(e) Vitamin B_{12} : Cyanocobalamine

Natural Sources : Meat, Fish, Egg, Curd, Milk etc.

Deficiency disease : Pernicious anemia, degradation of nervous system.

(f) Vitamin C : Ascrobic Acid

Natural source : Citrus fruits, Amla and Green leafy vegetables.

Deficiency disease : Scurvy, tooth decrease bleeding of gums.

(2) Fat Soluble Vitamins

Vitamin-A : Retinol

Natural Sources : Fish liver oil, Carrots, Butter and Milk

Deficiency Disease : Blindness (Hardening of cornea of eye)

Vitamin-D : Calciferol

Natural Sources : Milk, Butter, Cheese, Cod liver oil, Egg.

Deficiency Disease : Rickets in children and osteomalacia in adults, brittleness of bones.

Vitamin-E : Tocopherol

Natural Sources : Edible oils, nuts, spinach, potato, milk, egg.

Deficiency Disease : Degeneration of reproduction power, Anaemia.

Vitamin-K : Phylloquinone

Natural Sources : Spinach and other green leafy vegetables, tomato, potato, cabbage, edible oil, liver etc.

Deficiency Disease : Uncontrolled bleeding hamorrhage.

Example 4 : *The disease beri-beri is caused due to deficiency of which vitamin?*

Solution : Vitamin-B_1.

***Note* :**

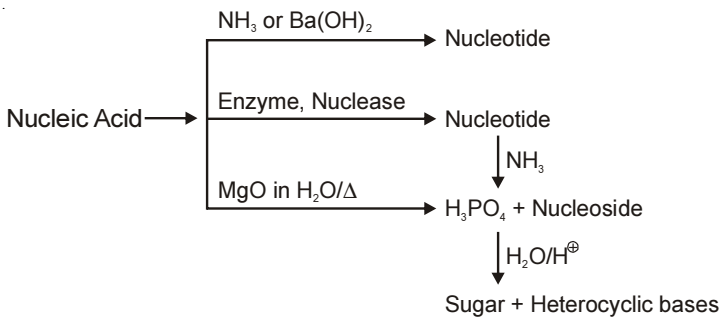
- Some vitamins like C, D and E act as antioxidant.
- Vitamin D_2 is a derivative of steroid *i.e.*, ergosterol and vitamin C is a derivative of glucose.
- Only vitamin B_{12} can be stored in the liver for many months and therefore it is an exception in the water soluble vitamins.
- **Provitamins** are biologically inactive compounds which have almost similar structures as vitamins. These compounds can be easily converted into active vitamins.

NUCLEIC ACID

The particles in nucleus of the cell, responsible for heredity are called chromosomes which are made up of proteins and another type of biomolecules called nucleic acid. These are natural biopolymers made of nucleotide units *i.e.*, polynucleotides. Nucleic acid contain the elements carbon, oxygen, nitrogen and phosphorous.

- Their molecular weight ranges from 10^6 to 10^8.

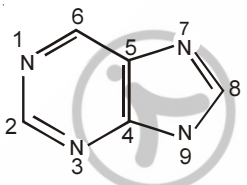
- All nucleic acids can undergo stepwise degradation to three fundamental units : a heterocyclic base, pentose sugar and phosphoric acid.



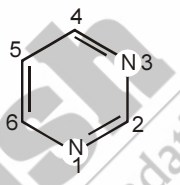
Sugars : Two sugars present in nucleic acid are ribose and deoxyribose.

- Ribose is present in RNA and deoxyribose in DNA.
- These sugars are present in furanose form.

Bases : These are derivatives of purine and pyrimidine.

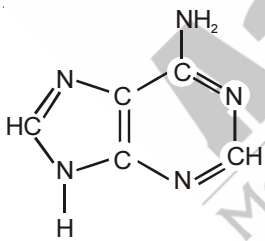


Purine

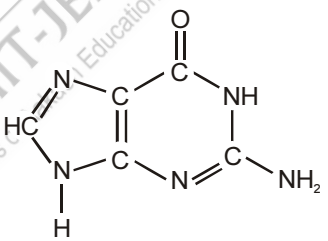


Pyrimidine

Purine Bases :

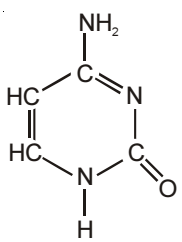


Adenine (A)

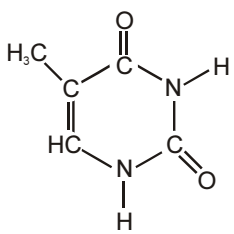


Guanine (G)

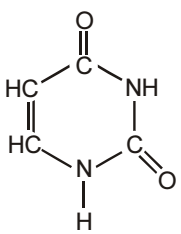
Pyrimidine Bases :



Cytosine (C)



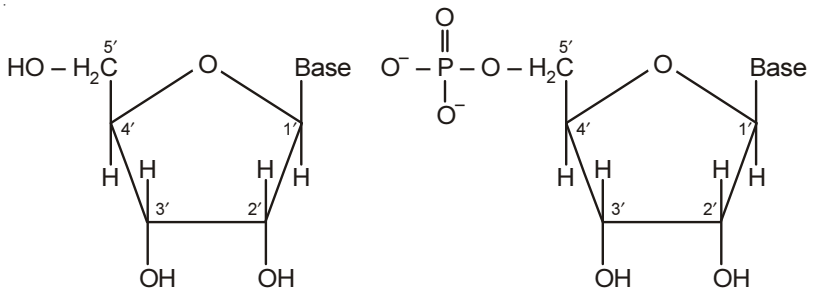
Thymine (T)



Uracil (U)

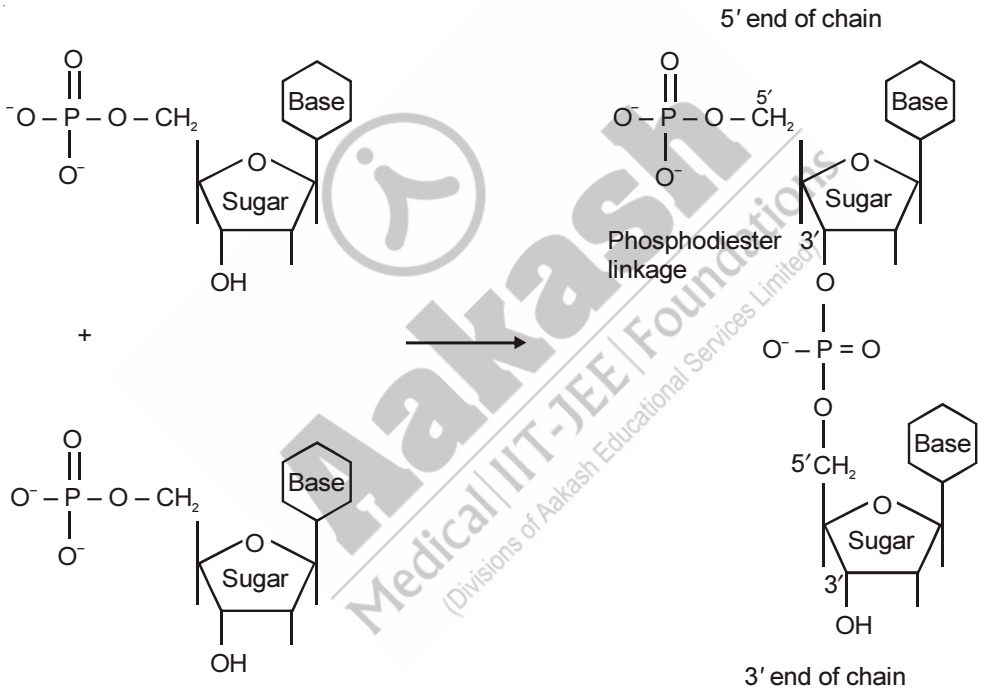
- In RNA the pyrimidine base is uracil and in DNA is replaced by thymine.

Structure of Nucleic Acid : A unit formed by the attachment of a base of 1′ position of sugar is known as nucleoside when nucleoside is linked to phosphoric acid at 5′-position of sugar moiety, we get a nucleotide.

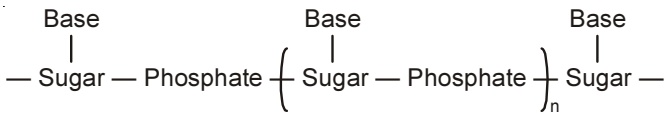


Nucleoside Nucleotide

Nucleotides are joined together by phosphodiester linkage between 5′ and 3′ carbon atoms of the pantose sugar as shown in fig.

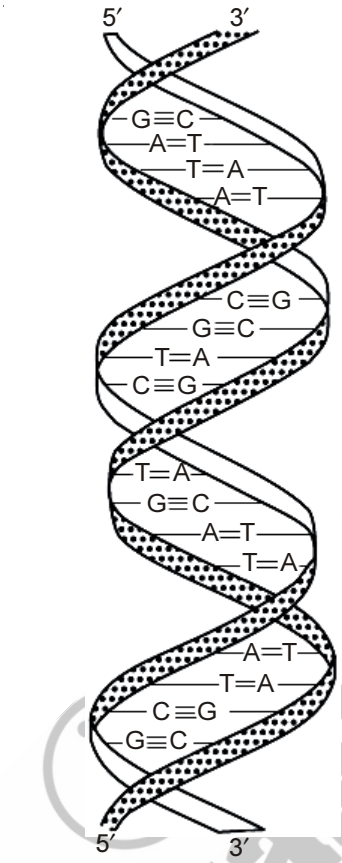


A simplified version of nucleic acid chain is as shown below.



Information regarding the sequence of nucleotides in the chain of a nucleic acid is called its primary structure. Nucleic acids have a secondary structure also. Two nucleic acid chains are held together by hydrogen bonds between pairs of bases. Adenine forms hydrogen bonds with thymine whereas cytosine forms hydrogen bonds with guanine.

In secondary structure of RNA, helices are present which are oly single stranded. Sometimes they fold back on themselves to form a double helix sturcture.



Double strand helix structure for DNA

Example 5 : *The third component present along with deoxyribose and a base in DNA is _____.*

Solution : Phosphoric acid.

EXERCISE

16. Vitamin B_1 is known as
    (1) Ascorbic acid (2) Carotenoids
    (3) Thiamine (4) Pyridoxine
17. Which of the following vitamins is oil soluble?
    (1) A (2) B_6
    (3) B_{12} (4) B_1
18. The deficiency of vitamin K causes
    (1) Haemorrhage (2) Lengthening time of blood clotting
    (3) Inflammation of tung (4) Both (1) & (2)
19. Which of the following if taken excessively can accumulate in body and cause toxicity?
    (1) Vitamin C (2) Vitamin D
    (3) Vitamin B_2 (4) Vitamin B_6
20. Which of the following is a protozoal disease?
    (1) Mumps (2) Measles
    (3) Syphilis (4) Malaria

21. Pyrimidine bases present in RNA are
    (1) Adenine and guanine (2) Thymine and uracil
    (3) Uracil and cytosine (4) Thymine and cytosine
22. Which of the following base is not present in DNA?
    (1) Thymine (2) Uracil
    (3) Adenine (4) Guanine
23. The relation between nucleotide triplets and the amino acids is called
    (1) Transcription (2) Duplication
    (3) Genetic code (4) Gene

HORMONES

Hormones are molecules that act as intercellular messengers. These are produced by endocrine glands in the body and are poured directly in the blood stream which transports them to the site of action. In terms of chemical nature, some of these are steroids, e.g., estrogens and androgens; some are poly peptides for example insulin and endorphins.

Hormones have several functions in the body. They help to maintain the balance of biological activities in the body. The role of insulin in keeping the blood glucose level within the narrow limit is an example of this function. Insulin is released in response to the rapid rise in blood glucose level. On the other hand hormone glucagon tends to increase the glucose level in the blood. The two hormones together regulate the glucose level in the blood.

❑ ❑ ❑

Assignment

SECTION - A

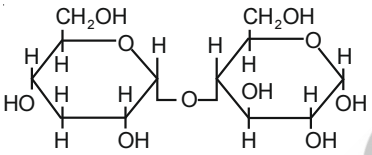
NCERT Based MCQs

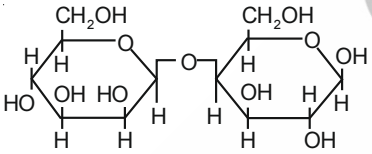
1. Xerophthalmia is caused by the deficiency of **[NCERT Pg. 426]**

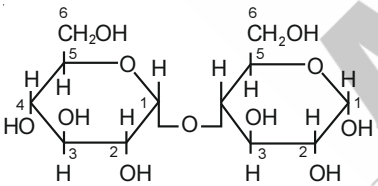
   (1) Vitamin E (2) Vitamin C

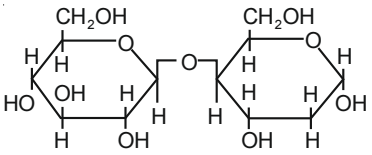
   (3) Vitamin B_6 (4) Vitamin A

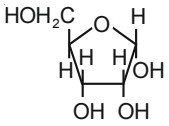
2. Which of the following is the structure of Maltose? **[NCERT Pg. 417]**

   (1) 

   (2) 

   (3) 

   (4) 

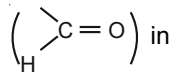
3.  is known as **[NCERT Pg. 427]**

   (1) β – D – 2 – deoxyribose

   (2) α – D – 2 – deoxyribose

   (3) β – D – ribose

   (4) α – D – ribose

4. Which of the following reagents does not confirm the presence of a carbonyl group  in glucose? **[NCERT Pg. 413]**

   (1) NH_2OH

   (2) Br_2, water

   (3) Acetic anhydride

   (4) HCN

5. Which of the following natural amino acids has been classified as essential amino acid? **[NCERT Pg. 421]**

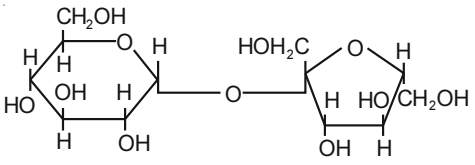
   (1) Histidine (2) Proline

   (3) Tyrosine (4) Serine

6. Find the incorrect match. **[NCERT Pg. 423]**

	Column I		Column II
(1)	Keratin	–	Fibre-like structure
(2)	Insulin	–	Spherical shape
(3)	Albumin	–	Insoluble in water
(4)	Myosin	–	Hydrogen and disulphide bonds

7. Which of the given monosaccharides are contained in the following carbohydrate? **[NCERT Pg. 417]**



   (1) β–D–glucose, α–D–fructose

   (2) α–D–glucose, β–D–fructose

   (3) α–D–glucose, α–D–fructose

   (4) β–D–glucose, β–D–fructose

8. Which of the following bases is **not** present in DNA? **[NCERT Pg. 428]**

   (1) Uracil (2) Thymine

   (3) Guanine (4) Adenine

9. The compound which will not reduce Tollen's reagent is **[NCERT Pg. 417]**
   (1) Glucose (2) Fructose
   (3) Sucrose (4) Mannose

10. Which among the following is a water soluble vitamin? **[NCERT Pg. 426]**
   (1) Vitamin A (2) Vitamin C
   (3) Vitamin D (4) Vitamin K

11. Number of asymmetric carbon atoms present in α-D-glucose is **[NCERT Pg. 416]**
   (1) 4 (2) 3
   (3) 6 (4) 5

12. Which among the following is an **incorrect** statement ? **[NCERT Pg. 418]**
   (1) Cellulose is composed of only β-D-glucose units
   (2) Carbohydrates are stored in animal body as glycogen
   (3) Amylopectin is a polymer of β-D-glucose units
   (4) Amylopectin linear chain is formed by C1-C4 glycosidic linkage

13. Correct statement regarding DNA and RNA is **[NCERT Pg. 428]**
   (1) Sugar component in DNA is α-D-ribose and that in RNA is β-D-2-deoxyribose
   (2) Sugar component in DNA is β-D-2-deoxyribose and that in RNA is β-D-ribose
   (3) Sugar component in DNA is α-D-2-deoxyribose and that in RNA is α-D-2-arabinose
   (4) Sugar component in DNA is β-D-arabinose and that in RNA is α-D-arabinose

14. Which among the following is a cyclic amino acid? **[NCERT Pg. 421]**
   (1) Proline
   (2) Arginine
   (3) Lysine
   (4) Serine

15. Which of the following bases is **not** present in RNA? **[NCERT Pg. 428]**
   (1) Uracil
   (2) Thymine
   (3) Guanine
   (4) Adenine

SECTION - B

Objective Type Questions

1. α - D glucose and β - D glucose are
   (1) Enantiomer (2) Epimer
   (3) Anomer (4) Mesomer

2. Which of the following is not optically active?
   (1) Valine (2) Alanine
   (3) Glycine (4) Phenylalanine

3. The reagent which converts glucose into osazone is
   (1) Tollen's reagent (2) Schiff's reagent
   (3) Phenylhydrazine (4) 2,4-DNP

4. At pH-4 glycine exists as
   (1) NH_2CH_2COOH (2) $H_3\overset{+}{N}CH_2COO^-$
   (3) $H_2NCH_2COO^-$ (4) $H_3\overset{+}{N}CH_2COOH$

5. The number of amino acids required to form four peptide bonds are
   (1) Four (2) Three
   (3) Eight (4) Five

6. Ring structure of glucose results due to hemiacetal formation between
   (1) C_6 and C_1 of same molecule
   (2) C_6 and C_1 of two molecule
   (3) C_5 and C_1 of same molecule
   (4) C_5 and C_1 of two molecule

7. Albumin is a type of
   (1) Fibrous protein (2) Vitamin
   (3) Carbohydrate (4) Globular protein

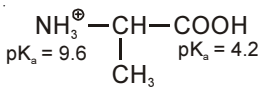
8. Identify **incorrect** statement(s)
   (1) Vitamin B-12 contains Hg^{2+}
   (2) In haemoglobin iron is present as Fe^{+1}
   (3) In photosynthesis CO_2 is reduced to glucose
   (4) Both (1) & (2)

9. Incorrect match is
   (1) $\text{Sucrose} \xrightarrow{\text{hydrolysis}} \underset{D-(+)}{\text{glucose}} + \underset{D-(-)}{\text{fructose}}$
   (2) $\text{Lactose} \xrightarrow{\text{hydrolysis}} \underset{D-(+)}{\text{galactose}} + \underset{D-(+)}{\text{glucose}}$
   (3) $\text{Maltose} \xrightarrow{\text{hydrolysis}} \underset{D-(+)}{\text{glucose}} + \underset{D-(-)}{\text{glucose}}$
   (4) Both (1) & (2)

10. Change in optical rotation of aqueous solution of sugar on acidic hydrolysis is known as
    (1) Mutarotation
    (2) Inversion
    (3) Anomerization
    (4) Racemization

11. α–D–glucose and β–D–glucose are
    (1) Structural isomers
    (2) Non-superimposable mirror images
    (3) Anomers
    (4) Metamers

12. Isoelectric point of following zwitter ion is



    (1) 5.9 (2) 4.9
    (3) 4.3 (4) 6.9

13. Carbohydrates are stored in human body as
    (1) Starch (2) Glucose
    (3) Glycogen (4) Cellulose

14. Which of the following functional group is present at C-1 carbon of α-(D)-glucose in sucrose?
    (1) Aldehyde
    (2) Ketone
    (3) Hemiacetal
    (4) Acetal

15. Total number of optical isomers of glucose are
    (1) 2 (2) 4
    (3) 8 (4) 16

16. **Correct** statements about D-glucose from the following are
    (a) It forms osazone on reaction with excess of phenylhydrazine
    (b) It gives saccharic acid on reaction with Br_2/H_2O
    (c) It shows epimeric relation with galactose
    (d) It is dextrorotatory
    (1) (a), (b) & (c) only
    (2) (b), (c) & (d) only
    (3) (a), (c) & (d) only
    (4) All of these

17. Of the given sugars, reducing ones are
    Fructose, Glucose, Sucrose
    (1) Fructose & Glucose
    (2) Glucose & Sucrose
    (3) Fructose & Sucrose
    (4) All of these

18. Essential amino acids are
    (1) Leucine, lysine, tryptophan
    (2) Leucine, proline, glycine
    (3) Alanine, tryptophan, cystine
    (4) Alanine, glutamine, lysine

19. Identify **correct** statement(s).
    (1) Cellulose is a linear polymer of β-(D)glucose
    (2) Starch is a polymer of α-(D)glucose
    (3) Amylose is water soluble whereas amylopectin is water insoluble
    (4) All of these

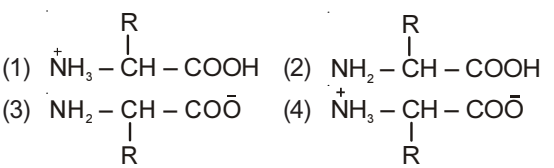
20. The deficiency of which of the following vitamins causes scurvy?
    (1) Vitamin D (2) Ascorbic acid
    (3) Cyanocobalamine (4) Vitamin A

21. Which of the following nitrogenous bases is derived from purine?
    (1) Cytosine (2) Uracil
    (3) Thymine (4) Guanine

22. The enzyme involved in the conversion of cane sugar into glucose and fructose is
    (1) Zymase (2) Maltase
    (3) Invertase (4) Diastase

23. Which of the following does not show mutarotation?
    (1) Sucrose (2) Glucose
    (3) Fructose (4) Lactose

24. In aqueous solutions, the dominant form of an amino acid is



25. Which of the following proteins is insoluble in water?

(1) Keratin (2) Myosin

(3) Both (1) & (2) (4) Insulin

26. If the sequence of bases in one strand of DNA is CTGTCAGTA, then the sequence of bases in its complementary strand is

(1) GUAUTGAUG (2) GACAGTCAT

(3) GUCCUGUTC (4) TAACGCUAC

27. The two forms of D-glucopyranose are related to each other as

(1) Position isomers

(2) Enantiomers

(3) Anomers

(4) All of these

28. Select the incorrect match.

(1) Cellulose : β-D-glucose

(2) Sucrose : Glycosidic linkage

(3) Lactose : α-D-galactose

(4) DNA : Phosphodiester linkage

29. Which of the following is a basic amino acid?

(1) Valine (2) Aspartic acid

(3) Glycine (4) Lysine

30. The change in the optical rotation of a freshly prepared aqueous solution of glucose is called

(1) Racemisation

(2) Mutarotation

(3) Resolution

(4) Specific rotation

SECTION - C

Previous Years Questions

1. Which structure(s) of proteins remain(s) intact during denaturation process? **[NEET-2019 (Odisha)]**

(1) Tertiary structure only

(2) Both secondary and tertiary structures

(3) Primary structure only

(4) Secondary structure only

2. The non-essential amino acid among the following is **[NEET-2019]**

(1) Valine

(2) Leucine

(3) Alanine

(4) Lysine

3. The difference between amylose and amylopectin is **[NEET-2018]**

(1) Amylopectin have $1 \rightarrow 4$ α-linkage and $1 \rightarrow 6$ α-linkage

(2) Amylose have $1 \rightarrow 4$ α-linkage and $1 \rightarrow 6$ β-linkage

(3) Amylose is made up of glucose and galactose

(4) Amylopectin have $1 \rightarrow 4$ α-linkage and $1 \rightarrow 6$ β-linkage

4. Which of the following compounds can form a zwitterion? **[NEET-2018]**

(1) Aniline (2) Acetanilide

(3) Glycine (4) Benzoic acid

5. Which of the following statements is not correct? **[NEET-2017]**

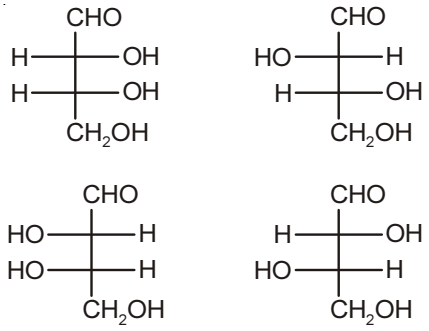
(1) Insulin maintains sugar level in the blood of a human body

(2) Ovalbumin is a simple food reserve in egg-white

(3) Blood proteins thrombin and fibrinogen are involved in blood clotting

(4) Denaturation makes the proteins more active

6. The correct corresponding order of names of four aldoses with configuration given below



respectively, is **[NEET (Phase-2)-2016]**

(1) L-erythrose, L-threose, L-erythrose, D-threose

(2) D-threose, D-erythrose, L-threose, L-erythrose

(3) L-erythrose, L-threose, D-erythrose, D-threose

(4) D-erythrose, D-threose, L-erythrose, L-threose

7. The central dogma of molecular genetics states that the genetic information flows from

[NEET(Phase-2)-2016]

(1) Amino acids → Proteins → DNA

(2) DNA → Carbohydrates → Proteins

(3) DNA → RNA → Proteins

(4) DNA → RNA → Carbohydrates

8. In a protein molecule, various amino acids are linked together by **[NEET-2016]**

(1) Dative bond

(2) α-glycosidic bond

(3) β-glycosidic bond

(4) Peptide bond

9. Which one given below is a non-reducing sugar?

[NEET-2016]

(1) Sucrose

(2) Maltose

(3) Lactose

(4) Glucose

10. The **correct** statement regarding RNA and DNA, respectively is **[NEET-2016]**

(1) The sugar component in RNA is 2′-deoxyribose and the sugar component in DNA is arabinose

(2) The sugar component in RNA is arabinose and the sugar component in DNA is 2′-deoxyribose

(3) The sugar component in RNA is ribose and the sugar component in DNA is 2′-deoxyribose

(4) The sugar component in RNA is arabinose and the sugar component in DNA is ribose

11. Which of the following hormones is produced under the condition of stress which stimulate : glycogenolysis in the liver of human beings ?

[AIPMT-2014]

(1) Thyroxin

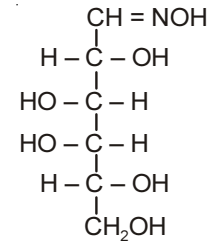
(2) Insulin

(3) Adrenaline

(4) Estradiol

12. D(+) glucose reacts with hydroxyl amine and yield an oxime. The structure of the oxime would be

[AIPMT-2014]

(1)


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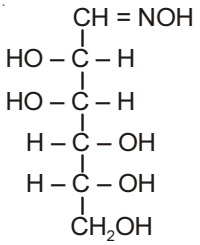
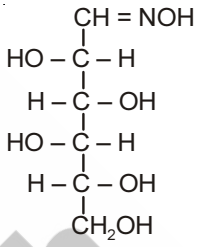
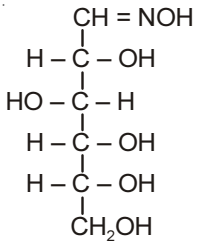


(3)


(4)


13. Deficiency of vitamin B_1 causes the disease

[AIPMT (Prelims)-2012]

(1) Cheilosis

(2) Sterility

(3) Convulsions

(4) Beri-Beri

14. Which one of the following sets of monosaccharides forms sucrose ? **[AIPMT (Prelims)-2012]**

(1) β–D–Glucopyranose and α–D–fructofuranose

(2) α–D–Glucopyranose and β–D–fructopyranose

(3) α–D–Galactopyranose and α–D–Glucopyranose

(4) α–D–Glucopyranose and β–D– fructofuranose

15. Which one of the following statements is not true regarding (+) Lactose? **[AIPMT (Prelims)-2011]**

(1) (+) Lactose, $C_{12}H_{22}O_{11}$ contains 8-OH groups

(2) On hydrolysis (+) Lactose gives equal amount of D(+) glucose and D(+) galactose

(3) (+) Lactose is a β-glycoside formed by the union of a molecule of D(+) glucose and a molecule of D(+) galactose

(4) (+) Lactose is a reducing sugar and does not exhibit mutarotation

16. Which of the statements about "Denaturation" given below are correct?

(a) Denaturation of proteins causes loss of secondary and tertiary structures of the protein.

(b) Denaturation leads to the conversion of double strand of DNA into single strand.

(c) Denaturation affects primary structure which gets distorted. **[AIPMT (Mains)-2011]**

(1) (a) & (b) (2) (a), (b) & (c)

(3) (b) & (c) (4) (a) & (c)

17. Which of the following is not a fat soluble vitamin ? **[AIPMT (Mains)-2011]**

(1) Vitamin E (2) Vitamin A

(3) Vitamin B complex (4) Vitamin D

18. Which one of the following does not exhibit the phenomemon of mutarotation? **[AIPMT (Prelims)-2010]**

(1) (+) Sucrose (2) (+) Lactose

(3) (+) Maltose (4) (–) Fructose

19. Fructose reduces Tollen's reagent due to **[AIPMT (Mains)-2010]**

(1) Asymmetric carbons

(2) Primary alcoholic group

(3) Secondary alcoholic group

(4) Enolisation of fructose followed by conversion to aldehyde by base

20. The segment of DNA which acts as the instrumental manual for the synthesis of the protein is **[AIPMT (Prelims)-2009]**

(1) Ribose (2) Gene

(3) Nucleoside (4) Nucleotide

21. Which of the following hormones contains iodine ? **[AIPMT (Prelims)-2009]**

(1) Testosterone (2) Adrenaline

(3) Thyroxine (4) Insulin

22. In DNA, the complimentary bases are **[AIPMT (Prelims)-2008]**

(1) Uracil and adenine; cytosine and guanine

(2) Adenine and thymine; guanine and cytosine

(3) Adenine and thymine; guanine and uracil

(4) Adenine and guanine; thymine and cytosine

23. Which one of the following is an amine hormone ? **[AIPMT (Prelims)-2008]**

(1) Progesterone (2) Thyroxine

(3) Oxypurin (4) Insulin

24. Which one of the following vitamins is water-soluble? **[AIPMT (Prelims)-2007]**

(1) Vitamin A (2) Vitamin B

(3) Vitamin E (4) Vitamin K

25. RNA and DNA are chiral molecules, their chirality is due to **[AIPMT (Prelims)-2007]**

(1) D - sugar component

(2) L - sugar component

(3) Chiral bases

(4) Chiral phosphate ester units

26. During the process of digestion, the proteins present in food materials are hydrolysed to amino acids. The two enzymes involved in the process

$$\text{Proteins} \xrightarrow{\text{Enzyme (A)}} \text{Polypeptides} \xrightarrow{\text{Enzyme (B)}} \text{Amino acids,}$$

are respectively **[AIPMT (Prelims)-2006]**

(1) Amylase and maltase

(2) Diastase and lipase

(3) Pepsin and trypsin

(4) Invertase and zymase

27. The human body does not produce **[AIPMT (Prelims)-2006]**

(1) DNA (2) Vitamins

(3) Hormones (4) Enzymes

28. Which one of the following is a peptide hormone ? **[AIPMT (Prelims)-2006]**

(1) Glucagon (2) Testosterone

(3) Thyroxine (4) Adrenaline

29. The cell membranes are mainly composed of **[AIPMT (Prelims)-2005]**

(1) Carbohydrates

(2) Proteins

(3) Phospholipids

(4) Fats

30. Which functional group participates in disulphide bond formation in proteins ?

[AIPMT (Prelims)-2005]

(1) Thiolactone (2) Thiol

(3) Thioether (4) Thioester

Questions asked Prior to Medical Ent. Exams. 2005

31. Which is **not** the correct statement about RNA and DNA?

(1) DNA is active in virus while RNA never appears in virus

(2) DNA exists as dimer while RNA is usually single stranded

(3) DNA contains deoxyribose as its sugar and RNA contains ribose

(4) RNA contains uracil in place of thymine (found in DNA) as a base

32. What is the nature of glucose-glucose linkage in starch that makes its so susceptible to acid hydrolysis?

(1) Starch is hemiacetal

(2) Starch is acetal

(3) Starch is polymer

(4) Starch contains only few molecules of glucose

33. α-(D) glucose $\rightleftharpoons$ β(D) glucose, equilibrium constant for this is 1.8. The percentage of α-(D) glucose at equilibrium is

(1) 35.7 (2) 55.6

(3) 44.4 (4) 64.3

34. By the action of enzymes, the rate of biochemical reaction

(1) Does not change (2) Increases

(3) Decreases (4) Either (1) or (3)

35. The secondary structure of a protein refers to

(1) Regular folding patterns of contiguous portions of the polypeptide chain

(2) Three-dimensional structure, specially the bond between amino acid residues that are distant from each other in the polypeptide chain

(3) Mainly denatured proteins and structures of prosthetic groups

(4) Linear sequence of amino acid residues in the polypeptide chain

36. The oxidation of glucose is one of the most important reactions in a living cell. What is the number of ATP molecules generated in cells from one molecule of glucose?

(1) 28 (2) 38

(3) 12 (4) 18

37. Which of the following statements about enzymes are true?

(1) Enzyme catalyse chemical reactions by lowering the activation energy

(2) Enzymes are highly specific both in binding chiral substrates and in catalysing their reactions

(3) Enzymes lack in nucleophilic groups

(4) Pepsin is proteolytic enzyme

38. The α–D glucose and β–D glucose differ from each other due to difference in carbon atom with respect to its

(1) Number of OH groups

(2) Size of hemiacetal ring

(3) Conformation

(4) Configuration

39. Haemoglobin is

(1) A vitamin (2) A carbohydrate

(3) An enzyme (4) A globular protein

40. The function of enzymes in the living system is to

(1) Catalyse biochemical reactions

(2) Provide energy

(3) Transport oxygen

(4) Provide immunity

41. Glucose molecule reacts with X number of molecules of phenyl-hydrazine to yield osazone. The value of X is

(1) Two (2) One

(3) Four (4) Three

42. Which of the following is the sweetest sugar?

(1) Fructose (2) Glucose

(3) Sucrose (4) Maltose

43. α-D-glucose and β-D glucose are

(1) Epimers (2) Anomer

(3) Enantiomers (4) Diastereomers

44. Which one is responsible for production of energy in bio reaction?
(1) Thyroxine (2) Adrenaline
(3) Oestrogen (4) Progesterone

45. Mg is present in
(1) Chlorophyll (2) Haemoglobin
(3) Vitamin-D (4) Vitamin-B

46. Which of the following give positive Fehling solution test?
(1) Sucrose (2) Glucose
(3) Fats (4) Protein

47. Which of the following is correct about H-bonding in nucleotide?
(1) A – T G – C (2) A – G T – C
(3) G – T A – C (4) A – A T – T

48. $-\overset{\overset{O}{\|}}{C}-\dot{N}H-$ (peptide bond). Which statement is incorrect about peptide bond?
(1) C – N bond length in proteins is longer than usual bond length of N – C bond
(2) Spectroscopic analysis show planar structure of $-\overset{\overset{O}{\|}}{C}-NH-$ group
(3) C – N bond length in proteins is smaller than usual bond length of C – N bond
(4) None of these

49. Enzymes are made up of
(1) Monosaccharides
(2) Proteins with specific structure
(3) Nitrogen containing carbohydrates
(4) Carbohydrates

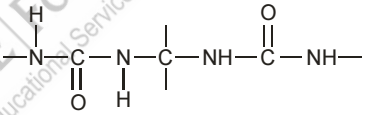
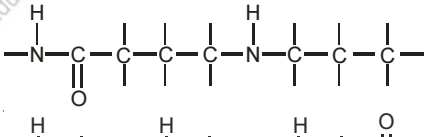
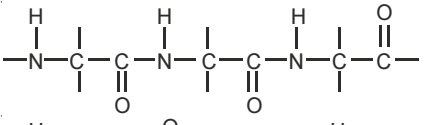
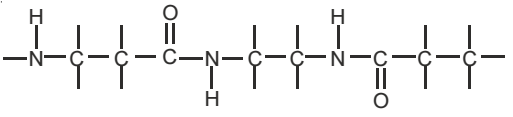
50. Which is not true statement?
(1) α-carbon of α-amino acid is asymmetric
(2) All amino acids are found in *L*-form
(3) Human body can synthesize all amino acids they need
(4) At pH = 7 both amino and carboxylic groups exist in ionised form

51. Vitamin B_{12} contains
(1) Fe (II) (2) Co (III)
(3) Zn (II) (4) Ca (II)

52. Glycolysis is
(1) Oxidation of glucose to glutamate
(2) Conversion of pyruvate to citrate
(3) Oxidation of glucose to pyruvate
(4) Conversion of glucose to haem

53. Phospholipids are esters of glycerol with
(1) Three carboxylic acid residues
(2) Two carboxylic acid residues and one phosphate group
(3) One carboxylic acid residue and two phosphate groups
(4) Three phosphate groups

54. Chargaff's rule states that in an organism
(1) Amount of adenine (A) is equal to that of thymine (T) and the amount of guanine (G) is equal to that of cytosine (C)
(2) Amount of adenine (A) is equal to that of guanine (G) and the amount of thymine (T) is equal to that of cytosine (C)
(3) Amount of adenine (A) is equal to that of cytosine (C) and the amount of thymine (T) is equal to that of guanine (G)
(4) Amounts of all bases are equal

55. Which of the following structure represents the peptide chain?
(1) 
(2) 
(3) 
(4) 

56. A sequence of how many nucleotides in messenger RNA makes a codon for an amino acid?
(1) Three (2) Four
(3) One (4) Two

57. The hormone that helps in the conversion of glucose to glycogen is
(1) Cortisone (2) Bile acids
(3) Adrenaline (4) Insulin

58. The enzyme which hydrolyses triglycerides to fatty acids and glycerol is called
(1) Maltase (2) Lipase
(3) Zymase (4) Pepsin

59. The correct statement in respect of protein haemoglobin is that it
(1) Functions as a catalyst for biological reactions
(2) Maintains blood sugar level
(3) Acts as an oxygen carrier in the blood
(4) Forms antibodies and offers resistance to diseases

60. Number of chiral carbons in β-D-(+) glucose is
(1) Five
(2) Six
(3) Three
(4) Four

61. The helical structure of protein is stabilized by
(1) Dipeptide bonds
(2) Hydrogen bonds
(3) Ether bonds
(4) Peptide bonds

62. During the process of digestion, the proteins present in food materials are hydrolysed to amino acids. The enzymes involved in the process Proteins $\longrightarrow$ Amino acids, are respectively
(1) Invertase and zymase
(2) Amylase and maltase
(3) Diastase and lipase
(4) Pepsin and trypsin

SECTION - D

NEET Booster Questions

1. α-D-glucose and β-D-glucose are
(1) Anomers (2) C_2 Epimers
(3) C_4-Epimers (4) Enantiomers

2. The sweetest carbohydrate is
(1) Sucrose (2) Glucose
(3) Fructose (4) Lactose

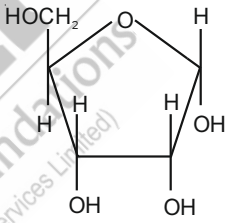
3. Which of the following is true about sucrose?
(1) It gives fructose and glucose on hydrolysis
(2) It is a reducing sugar
(3) It is a monosaccharide
(4) All of these

4. Which one of the following is reducing sugar?
(1) Starch (2) Cellulose
(3) Glycogen (4) Fructose

5. The number of moles of phenylhydrazine required to form glucosazone when react with glucose is
(1) 1 (2) 2
(3) 3 (4) 4

6. The disaccharide that is constituted of two glucose unit is
(1) Lactose (2) Maltose
(3) Sucrose (4) Ribose

7. Which of the following represents the anomer of compound shown?



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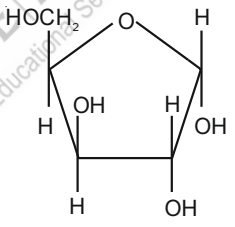

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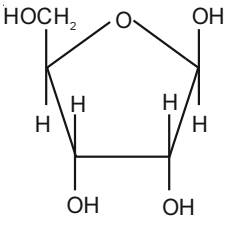

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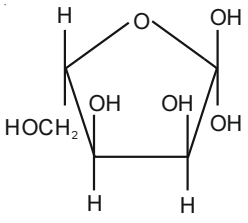


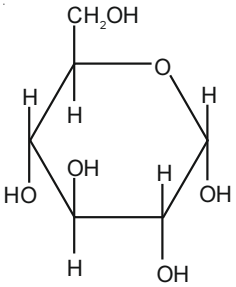
(4) All of these

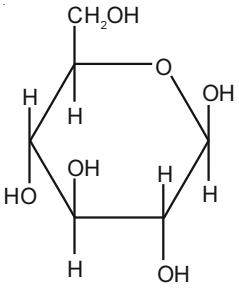
8. Select the wrong pair
(1) Cellulose : Polymer of β - D - Glucose
(2) Lactose : β - D - Galactose and β - D - Glucose
(3) Sucrose : β - D - Glucose and α - D - Fructose
(4) Starch : α - D - Glucose

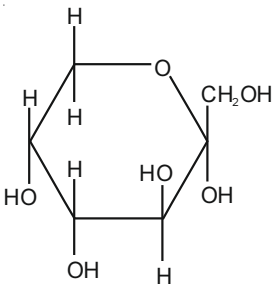
9. C_4-epimer of glucose is
   (1) Allose
   (2) Mannose
   (3) Galactose
   (4) Fructose

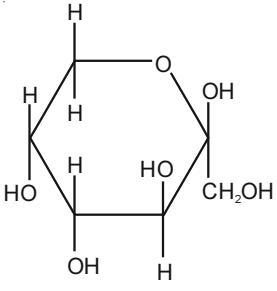
10. Glucose gives positive test with
   (1) Tollen reagent
   (2) Fehling solution
   (3) Benedict solution
   (4) All of these

11. Which of the following structures represents α-D-glucose?

(1) 

(2) 

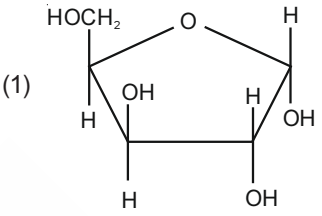
(3) 

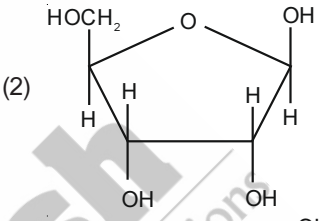
(4) 

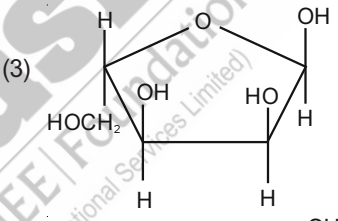
12. Which amino acid does not contain chiral centre?
   (1) Valine (2) Leucine
   (3) Glycine (4) Isoleucin

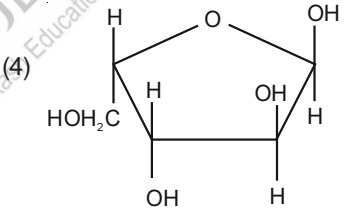
13. D-glucose and D-fructose can be differentiated by:
   (1) Fehling solution (2) Tollens reagent
   (3) Benedict test (4) Br_2/H_2O

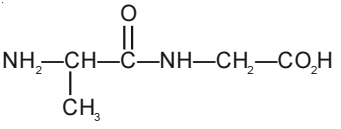
14. Which of the following represents β-D-Ribofuranose of the compound shown?

(1) 

(2) 

(3) 

(4) 

15. 

Identify the amino acid obtained by hydrolysis of the above compound
   (1) Glycine (2) Alanine
   (3) Both (1) and (2) (4) Proline

16. Which of the following is non-reducing sugar?
   (1) Glucose (2) Sucrose
   (3) Maltose (4) Lactose

17. Which of the following is non reducing sugar?
   (1) Sucrose (2) Starch
   (3) Cellulose (4) All of these

18. Which is reducing sugar?
(1) Glucose
(2) Mannose
(3) Fructose
(4) All of these

19. Peptide linkage in protein is chemically
(1) Amide bond (2) Ester bond
(3) Ether bond (4) Glycoside bond

20. Which of the following base is present in RNA but not in DNA?
(1) Uracil (2) Cytocine
(3) Adenine (4) Guanine

21. A person has "bleeding gum" problem. Which of the following vitamin deficiency may be reason for it?
(1) Vitamin C (2) Vitamin K
(3) Vitamin E (4) Vitamin D

22. Enzymes are
(1) Proteins (2) Minerals
(3) Oils (4) Fatty acids

23. Biuret test is not given by:
(1) Proteins (2) Carbohydrates
(3) Polypeptides (4) Urea

24. Optically inactive amino acid is:
(1) Lysine (2) Glycine
(3) Arginine (4) Alanine

25. Scurvy is caused due to deficiency of vitamin
(1) B_2 (2) B_{12}
(3) C (4) D

26. The reagent which may be used to distinguish between cane sugar and glucose solution is
(1) Molisch's reagent
(2) Iodine solution
(3) Baeyer's reagent
(4) Fehling's solution

27. Which pair is an example of anomers?
(1) α-D-glucose and β-D-glucose
(2) Glucose and mannose
(3) Glucose and fructose
(4) Fructose and sugar

28. $\underset{\text{Starch}}{2(C_6H_{10}O_5)_n} + H_2O \xrightarrow{\text{Diastase}} n\,(A) \xrightarrow{H_2O} 2n\,(B)$

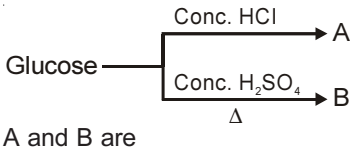
(A) and (B) in given sequence of reactions, respectively is
(1) Maltose, D-Glucose
(2) Lactose, D-Glucose
(3) Sucrose, D-Glucose
(4) Maltose, fructose

29. Glucose when oxidised with conc. HNO_3 then the product formed is
(1) $HOOC(CHOH)_4COOH$
(2) $HOCH_2(CHOH)_4COOH$
(3) $H_3CCH_2CH_2CH_2CH_2CH_3$
(4) $HOCH_2(CHOH)_4CH = NOH$

30. The reagent which forms crystalline osazone derivative when reacted with glucose is
(1) Fehling solution
(2) Phenylhydrazine
(3) Benedicts solution
(4) Hydroxylamine

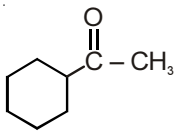
31. Lactic acid on oxidation by alkaline $KMnO_4$ gives
(1) Tartaric acid
(2) Cinnamic acid
(3) Propionic acid
(4) Pyruvic acid

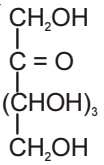
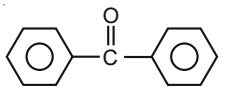
32. Glucose on oxidation with Tollen's reagent and conc. HNO_3 produces respectively
(1) Gluconic acid and saccharic acid
(2) Glucaric acid and saccharic acid
(3) Saccharic acid and glucaric acid
(4) Gluconic acid and Gluconic acid

33. 

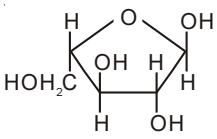
A and B are
(1) Pyruvic acid and black mass
(2) Leavulic acid and ethanol
(3) Pyruvic acid and ethanol
(4) Leavulic acid and black mass

34. Which of the following ketone reduces Tollen's reagent?

(1) CH_3COCH_3 (2) 

(3)  (4) 

35. In the given structure of the carbohydrate, which of the following are used while naming it?



(1) Tetrose (2) Hexose

(3) Aldose (4) Furanose

36. An optically active compound having molecular formula $C_6H_{12}O_6$ is found in two isomeric forms. When isomers dissolved in water, they show the following equilibria

$$\underset{\alpha=111^\circ}{[A]} \rightleftharpoons \underset{52.2^\circ}{\text{equilibrium mixture}} \rightleftharpoons \underset{19.2^\circ}{[B]}$$

Such isomers are called

(1) Anomers (2) Enantiomers

(3) Positional isomers (4) Geometrical isomers

37. Select the correct statement

(1) For exergonic reactions, $\Delta G > 0$

(2) ATP undergoes a two step hydrolysis

(3) Conversion of ATP to ADP is highly endergonic reaction

(4) Dark reaction does not proceed even on being coupled with hydrolysis of ATP

38. Formation of primary and secondary structure of proteins involves linkages

(1) Peptide linkage, H-bond

(2) H-Bond, disulphide bond

(3) Disulphide bond, peptide linkage

(4) H-bond, H-bond

39. Which of the following is not used for testing proteins?

(1) Molisch's test

(2) Biuret test

(3) Ninhydrin test

(4) Millon's test

40. Vitamin A is called

(1) Ascorbic acid (2) Retinol

(3) Calciferol (4) Tocopherol

41. Which of the following is not a pyrimidine base?

(1) Thymine (2) Cytosine

(3) Uracil (4) Guanine

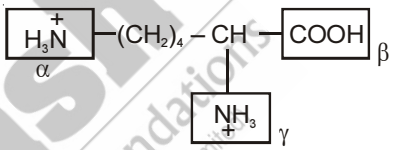
42. Which of the following is not a fat soluble vitamin?

(1) Vitamin A

(2) Vitamin K

(3) Vitamin E

(4) Vitamin C

43. 

pK_a of the sites α, β and γ are 10.79, 2.18 and 8.95. Isoelectric point will be

(1) 9.87 (2) 5.07

(3) 6.5 (4) 2.18

44. A polypeptide on complete hydrolysis gives three amino acids. How many sequences are possible for that polypeptide?

(1) 1 (2) 3

(3) 6 (4) 9

45. $\underset{[1\text{ mole}]}{\text{Amino acid}} \xrightarrow[\Delta]{\text{NaOH + CaO}} \text{gas evolved}$

$\xrightarrow[\text{Lime water}]{\text{Pass in}}$ Salt 0.1999 kg

Amino acid having

(1) Two NH_2 groups

(2) One – COOH group

(3) Two – COOH groups

(4) Three – COOH groups

❑ ❑ ❑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Chapter 27

Polymers

Chapter Contents

Introduction

Monomers and Polymers:

The word polymer is derived from two Greek words: '*poly*' means many and '*mer*' means unit or part. The term polymer is defined as very large molecules having high molecular mass ($10^3 - 10^7$u). These are also called macromolecules, which are formed by joining of repeating structural units on a large scale. The repeating structural units are derived from some simple and reactive molecules known as monomers and are linked to each other by covalent bonds. This process of formation of polymers from respective monomers is called polymerisation. The transformation of ethene to polyethene and interaction of hexamethylene diamine and adipic acid leading to the formation of Nylon-6, 6 are examples of addition and condensation polymerisation.

(i) $\underset{\text{Ethene}}{n CH_2 = CH_2} \xrightarrow{\text{Polymerisation}} \{CH_2 - CH_2\}_n$

Monomer Unit : $CH_2 = CH_2$

Repeating Unit : $n\{CH_2 - CH_2\}$

(ii) $n NH_2(CH_2)_6NH_2 + n HOOC(CH_2)_4COOH$

Hexamethylene diamine — Adipic acid

↓ Polymerises

$$\left\{ \begin{matrix} H \\ | \\ N - (CH_2)_6 - \end{matrix} \begin{matrix} H & O \\ | & \| \\ N - C - \end{matrix} (CH_2)_4 - \begin{matrix} O \\ \| \\ C \end{matrix} \right\}_n$$

Nylon-6, 6

Monomer Unit : $NH_2(CH_2)_6NH_2$ & $HOOC(CH_2)_4COOH$

Repeating Unit : $n\left\{ \begin{matrix} H \\ | \\ N - (CH_2)_6 - \end{matrix} \begin{matrix} H & O \\ | & \| \\ N - C - \end{matrix} (CH_2)_4 - \begin{matrix} O \\ \| \\ C \end{matrix} \right\}$

The polymers are the backbone of four major industries such as plastics, elastomers, fibres and paints.

CLASSIFICATION OF POLYMERS

The polymers may be classified in a number of ways depending upon the following criteria :

1. Classification Based on Source

On the basis of their origin, polymers may be classified as :

(a) **Natural polymers :** These polymers are found in plants and animals. *e.g.,* are proteins, cellulose, starch, some resins and rubber.

(b) **Semi-synthetic polymers :** These are the polymers which are obtained from natural polymers.

e.g., cellulose acetate (rayon), cellulose nitrate and cellulose xanthate

(c) **Synthetic polymers :** They are man-made polymers extensively used in daily life as well as in industry

e.g., are plastic (polythene), synthetic fibres (Nylon-6, 6) and synthetic rubber (Buna-S).

2. Classification Based on Structure of Polymers

There are three different types based on the structure of the polymers.

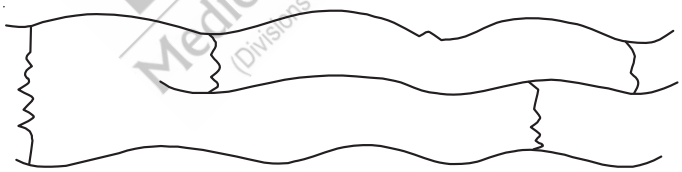
(a) **Linear polymers :** These polymers consist of long and straight chains. The examples are high density polyethene, polyvinyl chloride, and polyesters. These are represented as :

These may be termed as one-dimensional polymers.

(b) **Branched chain polymers :** These polymers contain linear chains having some branches *e.g.*, low density polyethene. These are depicted as follows:

These may be termed as two dimensional polymers

(c) **Cross linked or Network polymers :** These are formed from bi-functional and tri-functional monomers and contain strong covalent bonds between various linear polymer chains *e.g.* bakelite, melamine, etc. These polymers are depicted as follows:



It has three-dimensional network structure.

3. Classification Based on Mode of Polymerisation

Polymers can also be classified on the basis of mode of polymerisation into two subgroups.

(a) **Addition polymers :** The addition polymers are formed by the repeated addition of monomer molecules possessing double or triple bonds.

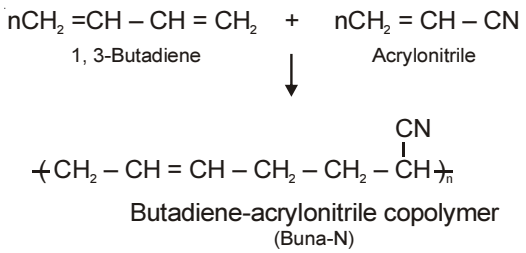
Homopolymer and Copolymers

The addition polymers formed by the polymerisation of a single monomeric species are known as homopolymers, *e.g.*, Polythene

$$n CH_2 = CH_2 \longrightarrow \underset{\text{Polythene (homopolymer)}}{+CH_2 - CH_2+_n}$$

Ethene

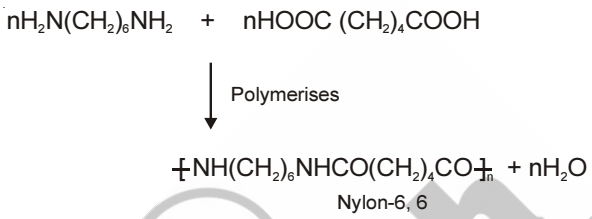
The polymers made by addition polymerisation from two different monomers are called copolymers, *e.g.*, Buna-S, Buna-N, etc.



Butadiene-acrylonitrile copolymer
(Buna-N)

(b) **Condensation polymers :** The condensation polymers are formed by repeated condensation reaction between two different bi-functional or tri-functional monomeric units through elimination of small molecules such as water, alcohol, hydrogen chloride, etc.

Example are terylene (dacron), nylon-6, 6, nylon 6 etc.



Nylon-6, 6

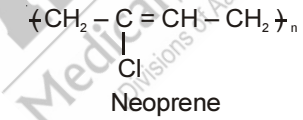
4. Classification Based on Molecular Forces

The application of polymer depends on the mechanical properties like tensile strength, elasticity, toughness in different field. These mechanical properties are governed by van der Waals forces and hydrogen bonds, present in the polymers.

On the basis of intermolecular forces, polymers are classified into four subgroups :

(a) **Elastomers :** These are rubber-like solids with elastic properties and the polymeric chains are held together by the weakest van der Waal interactions.

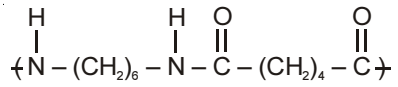
The examples are buna-S, buna-N, neoprene, etc.



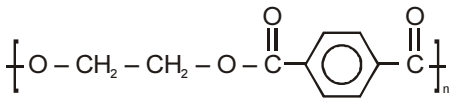
Neoprene

(b) **Fibres :** These are the polymers which have quite strong intermolecular forces such as H-bonding. Due to strong intermolecular forces of attraction, fibres have high tensile strength and least elasticity, close packing of chains which impart crystalline nature.

The examples are polyamides, polyesters etc.



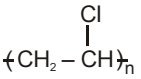
Nylon 6, 6 (polyamide)



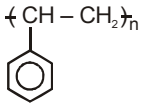
Terylene or Dacron
(Polyester)

(c) **Thermoplastic polymers :** These are the polymers in which intermolecular forces of attraction are in between those of elastomers and fibres. They are neither very strong nor very week and have no cross-links between the chains. These are the linear or slightly branched long chain polymer which is capable of softening on heating and hardening on cooling.

The examples are polythene, polystyrene, polyvinyls etc.

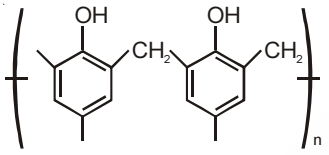


(PVC) Polyvinylchloride

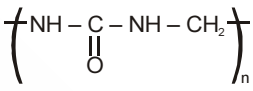


Polystyrene (Styron)

(d) **Thermosetting polymers :** These polymers are cross-linked or heavily branched molecules, which on heating undergo extensive cross-linking between different polymer chains to give a three-dimensional network solid and again become infusible. These cannot be reused. Some common examples are bakelite, urea-formaldehyde resins, etc.



Bakelite



Urea-formaldehyde Resin

5. Classification Based on Growth Polymerisation :

The addition and condensation polymers are also referred as chain growth polymers and step growth polymers depending on the type of polymerisation mechanism.

Example 1 : *$\{CH_2 - CH(CN)\}_n$ is a homopolymer or a copolymer?*

Solution : It is a homopolymer and the monomer unit from which it is obtained is acrylonitrile (vinyl cyanide) :$CH_2 = CH - CN$

Example 2 : *Give the examples of cross-linked polymers.*

Solution : Bakelite, 4 melamine-formaldehyde resin.

Example 3 : *What is artificial silk or rayon? Give an example.*

Solution : Rayon is a semi-synthetic polymer.

e.g., cellulose acetate.

EXERCISE

1. Which among the following is a crossed linked polymer?
   (1) Amylopectin
   (2) Melamine formaldehyde resin
   (3) Glycogens
   (4) Polysters
2. Which among the following is a branched chain polymer?
   (1) Nylons (2) Polyesters
   (3) Glycogens (4) Bakelite

3. Which of the following type of forces are present in Nylon-6 6?
   (1) van der Waal's forces of attraction
   (2) Hydrogen bonding
   (3) Dipole-dipole interactions
   (4) All of these
4. Which of the following is a natural polymer?
   (1) Polythene
   (2) Polysaccharides
   (3) Nylon
   (4) Terylene
5. Which of the following is an elastomer?
   (1) Vulcanized rubber (2) Dacron
   (3) Polystyrene (4) Malamine

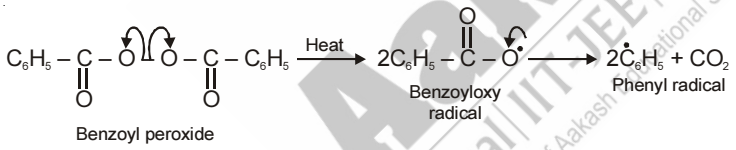
TYPES OF POLYMERISATION REACTIONS

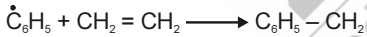
1. Addition Polymerisation or Chain Growth Polymerisation

In addition polymerisation, the molecules of the same monomer or different monomers add together to form polymer. This mode of polymerisation leading to increase in chain length through the formation of either free reactions or ionic species.

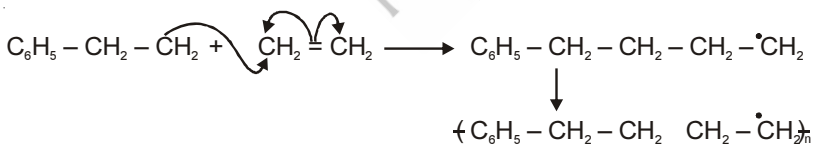
Ex.: Polymerisation of ethene to polyethene consists of heating a mixture of ethene with benzoyl peroxide initiator.

Chain initiation steps

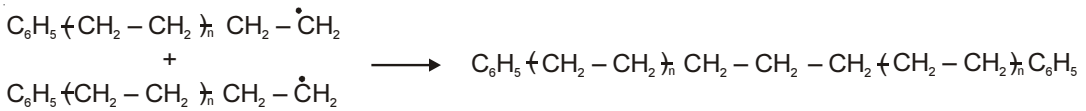




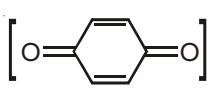
Chain propagating step



Chain terminating step



Example 4 : *Name a substance which inhibits free radical polymerisation.*

Solution : Benzoquinone 

Preparation of Some Important Addition Polymers :

(i) Polythene : There are two types of polythene as given below :

(a) Low density polythene : It is obtained by the polymerisation of ethene under high pressure of 1000 to 2000 atmospheres at temperature of 350 K to 570 K in presence of peroxide initiator. It is chemically inert but flexible and poor conductor of electricity.

(b) High density polythene (HDP) : It is formed when addition polymerisation of ethene takes place in a hydrocarbon solvent in the presence of a catalyst such as Ziegler-Natta catalyst [$(C_2H_5)_2$ Al and $TiCl_4$] at a temperature of 333 K to 343 K and under a pressure of 6 – 7 atmospheres. It is also chemically inert and more tougher and harder.

(ii) Polytetrafluoroethene (Teflon) : Teflon is manufactured by heating tetrafluoroethene with a free radical or persulphate catalyst at high pressures.

$$\underset{\text{Tetrafluoroethane}}{nCF_2 = CF_2} \xrightarrow[\text{High Pressure}]{\text{Catalyst}} \underset{\text{Teflon}}{(CF_2 - CF_2)_n}$$

It is used in making oil seals and gaskets, non-stick surface-coated utensils.

(iii) Polyacrylonitrile (PAN) :

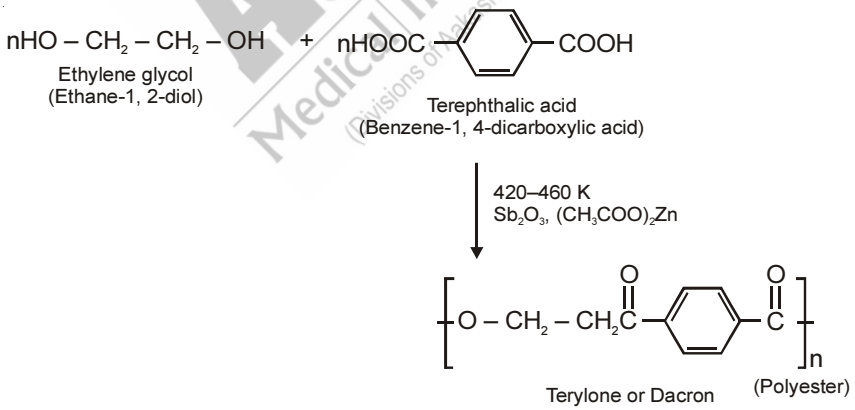
$$\underset{\text{Acrylonitrile}}{nCH_2 = CH - CN} \xrightarrow[\text{Peroxide catalyst}]{\text{Polymerisation}} \underset{\text{Polyacrylonitrile (Orlon)}}{\left(CH_2 - \underset{|}{\overset{CN}{CH}}\right)_n}$$

It is used as a substitute for wool in making commercial fibres as orlon or acrilan.

2. Condensation Polymerisation or Step Growth Polymerisation

This type of polymerisation involves a repetitive condensation reaction between two bi-functional monomers. The product of each step is again a bi-functional species and each step produces a distinct functionalised species which is independent of each other and the sequence of condensation goes on, which is called as step growth polymerisation.

Example : Formation of terylene or dacron



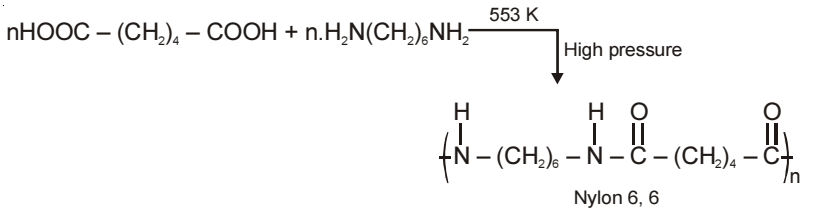
Preparation of some important condensation polymerisation reaction :

(i) Polyamides : These polymers possess amide linkages.

Example : Nylons

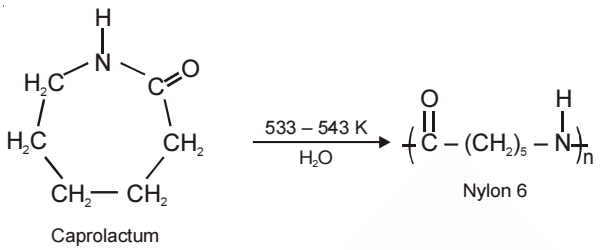
Preparation of nylons :

(a) Nylon-6, 6 : It is prepared by the condensation polymerisation of hexamethylenediamine with adipic acid under high pressure and temperature.



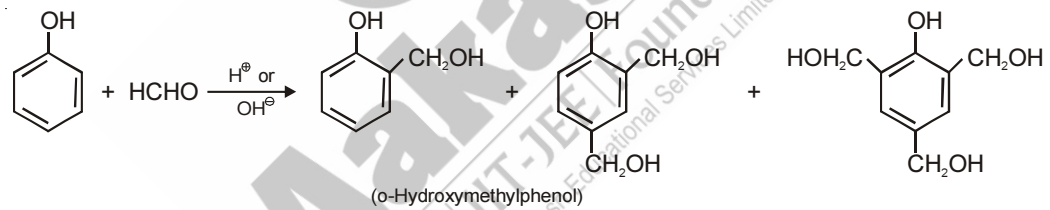
It is used in making sheets, bristles for brushes and in textile industry.

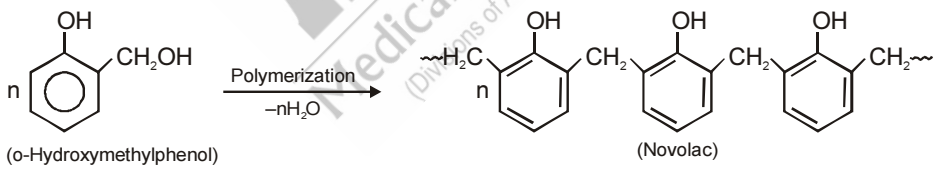
(b) Nylon-6 : It is obtained by heating caprolactum with water at a high temperature.

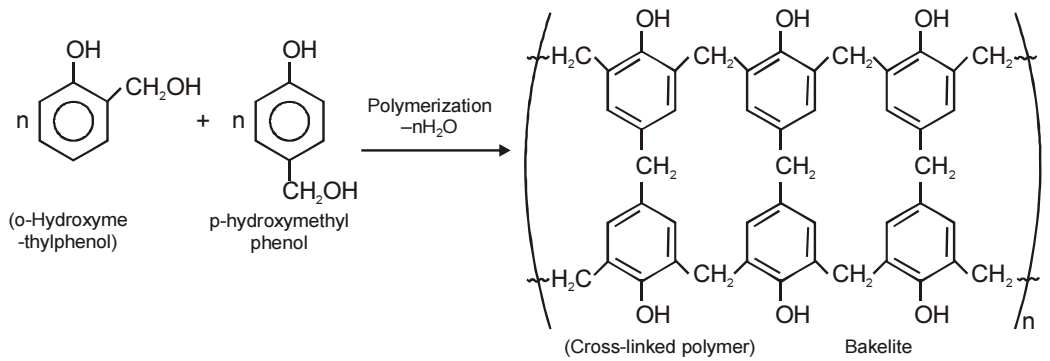


Nylon 6 is used for the manufacture of tyre cords, fabrics and ropes.

(ii) Phenol Formaldehyde Polymer : Phenol formaldehyde resins are obtained by the condensation reaction of phenol and formaldehyde in presence of either an acid or a base catalyst. The reaction starts with the initial formation of ortho and para-hydroxymethyl phenol or its derivatives, which further reacts with phenol to form compounds through methyllene bridges ($-CH_2$ groups) in ortho, para or both ortho and para positions. The initial product could be a linear product (Novolac), used in paints.

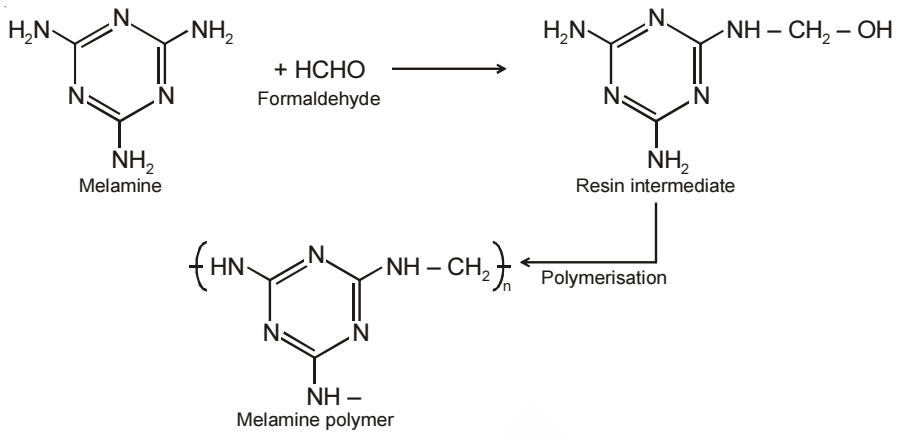






Novolac on heating with formaldehyde forms an infusible solid mass called bakelite. Bakelite is used for making combs, phonograph records, electrical switches and fountain pens.

(iii) Melamine-formaldehyde polymer : It is obtain by the condensation polymerisation of melamine and formaldehyde.

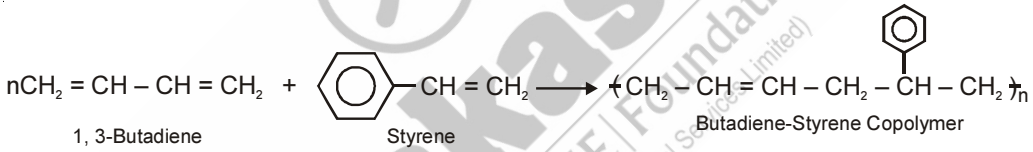


It is used the manufacture of unbreakable crockery.

3. Copolymerisation

When two or more different monomer units joins together to get polymerised it forms a copolymer and the process is termed copolymerisation. The copolymer can be made not only by chain growth polymerisation but by step growth polymerisation also.

For example, formation of styrene butadiene rubber (SBR)



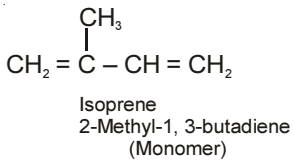
The properties of a copolymer are different from homopolymers. Polystyrene is easily breakable but polybutadiene is flexible. The copolymer, SBR is more flexible than polybutadiene and tougher than polystyrene.

SBR is used for the manufacture of autotyres, floor tiles, footwear components etc.

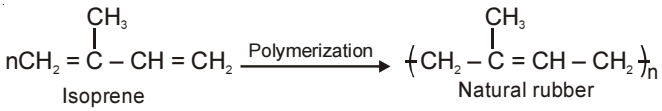
4. Rubber

1. Natural Rubber

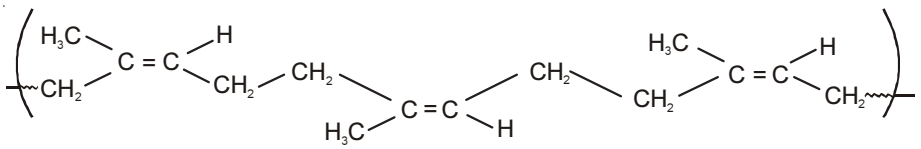
It is a natural polymer and also termed as elastomer. It is manufactured from rubber latex which is a colloidal dispersion of rubber in water. The latex is obtained from bark of rubber tree. Natural rubber may be considered as a linear hydrocarbon polymer of isoprene.



Isoprene is a monomer of natural rubber.



Natural rubber is a linear 1, 4-addition polymer of 2-methyl-1, 3-butadiene. All the double bonds in natural rubber are cis, so natural rubber is also called as cis-1, 4-polyisoprene.



Natural rubber
(cis-1, 4-polyisoprene)

The cis-polyisoprene molecule is held together by weak van der Waal interactions and has a coiled structure. Thus it exhibits elastic properties.

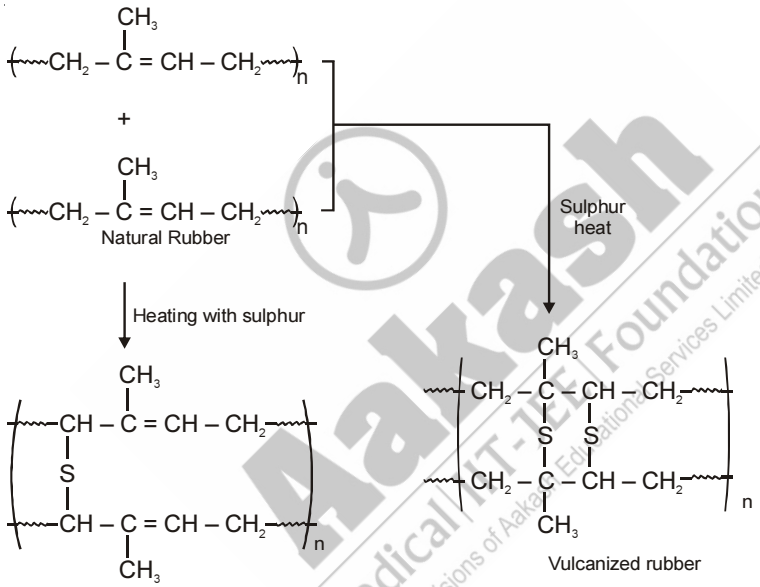
Vulcanisation of rubber :

Natural rubber becomes soft and sticky at high temperature. Its tensile strength is low and elasticity is maintained over a low temperature. It is soluble in non-polar solvent. A process of vulcanisation is carried out to improve these physical properties. Vulcanisation process consists of heating a mixture of natural rubber with sulphur at a temperature range between 373 K to 415 K. After this process, sulphur forms cross links at the reactive sites of double bonds and thus rubber becomes hard and more flexible.

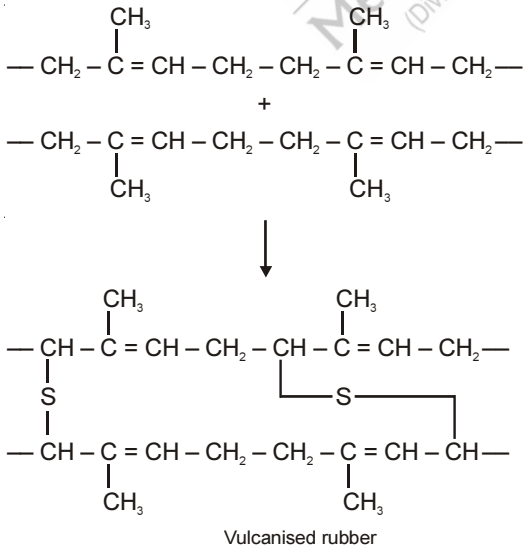
In the manufacture of tyre rubber, 5% of sulphur is used as a cross-linking agent.

The structure of vulcanised rubber molecules are depicted below :

(a)



(b)



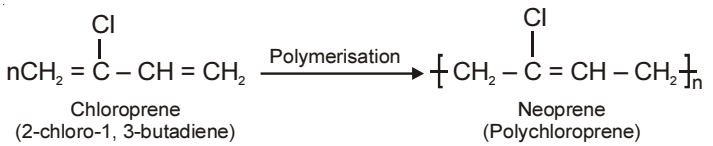
Vulcanised rubber

2. Synthetic Rubber :

Synthetic rubber is vulcanizable rubber which is capable of getting stretched to twice of length. When the external stretching force is released then it returns to its original shape and size.

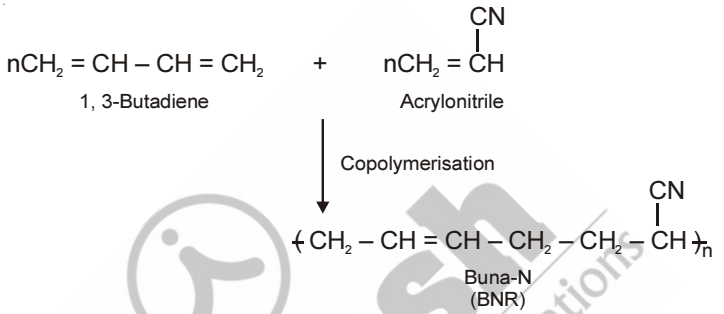
Preparation of Synthetic Rubbers :

(i) Neoprene : It is formed by the free radical polymerisation of chloroprene (monomer).



It is used for manufacturing gasket, hoses for petrol and oil containers, conveyor belts. It has superior resistance to vegetable and mineral oils.

(ii) Buna-N : Buna-N is obtained by the copolymerisation of 1, 3-butadiene and acrylonitrile in presence of a peroxide catalyst.



It is very rigid and is resistant to action of petrol, lubricating oil and many organic solvents. It is mainly used for making fuel tanks.

Example 5 : *Identify the monomer in the following polymeric structures.*

(i) $\left[\overset{O}{\overset{\|}{C}} - (CH_2)_8 - \overset{O}{\overset{\|}{C}} - NH - (CH_2)_6 - NH \right]_n$

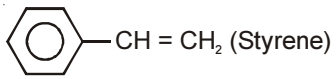
(ii) $\left(CH_2 - \overset{CH_3}{\overset{|}{C}} = CH - CH_2 \right)_n$

(iii) $\left(CH_2 - CH = CH - CH_2 - \underset{\bigcirc}{CH} - CH_2 \right)_n$

(iv) $\left(CF_2 - CF_2 \right)_n$

Solution : (i) $NH_2(CH_2)_6NH_2$ (Hexamethylenediamine) and Sebasic acid $[COOH - (CH_2)_8COOH]$

(ii) $CH_2 = \underset{CH_3}{\overset{|}{C}} - CH = CH_2$ (Isoprene)

(iii)  (Styrene)

& $CH_2 = CH - CH = CH_2$

1, 3-Butadiene

(iv) $(CF_2 = CF_2)$: 1, 1, 2, 2-Tetrafluoroethene

Example 6 : *Arrange the following polymers in increasing order of their intermolecular forces :*

(i) Buna-S, Nylon-6, Polyvinyl chloride *(ii) Polystyrene, Dacron, Buna-N*

Solution : The increasing intermolecular forces of attraction follows the order :

Elastomer < Plastic < Fibre

(i) Buna-S < PVC < Nylon 6 (ii) Buna-N < Polystyrene < Dacron

MOLECULAR MASS OF POLYMERS

Properties of a polymer are closely related to their molecular mass, size and structure. The length of the polymer chain depends upon the availability of the monomer molecules near the growing polymer chain and also the reaction conditions employed. Thus the polymer sample contains chain of varying lengths and hence its molecular mass is always expressed as an average.

But it is not true for natural polymers such as proteins, where the chains are of identical length's and hence their molecular masses are singular and not average in nature.

BIODEGRADABLE POLYMERS

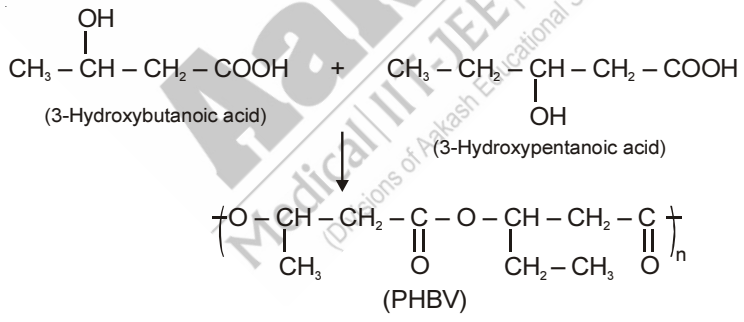
Many polymeric species can be produced by biological systems such as plants and animals. Starch, cellulose, proteins, peptides, RNA and DNA (nucleic acids) which control the various life processes are called biopolymers.

These biopolymers can be broken into their components either by enzyme-catalysed reaction or by themselves during a certain period of time and hence they are biodegradable. They are non-toxic and do not cause pollution. These polymers contain functional groups similar to the functional groups present in biopolymers.

Aliphatic polymers are one of the important classes of biodegradable polymers. Some important examples are :

1. Poly β-hydroxybutyrate - co-p-hydroxy valerate (PHBV) :

It is obtained by the copolymerisation of 3-hydroxybutanoic acid and 3-hydroxypentanoic acid.

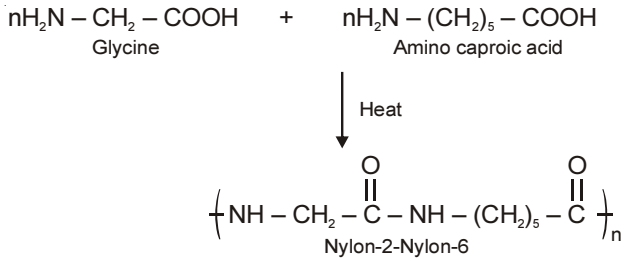


(PHBV)

PHBV is used in speciality packaging, orthopaedic devices and to encapsulate drug. PHBV undergoes bacterial degradation in the environment.

2. Nylon-2-Nylon-6 :

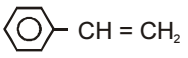
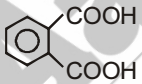
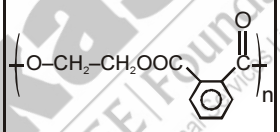
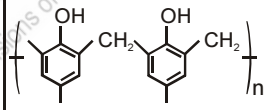
It is an alternating polyamide copolymer of glycine and amino caproic acid and is biodegradable step-growth copolymer.



Nylon-2-Nylon-6

POLYMERS OF COMMERCIAL IMPORTANCE

Some other commercially important polymers along with their structures and uses are given below :

Sr. No.	Name of polymer	Monomer	Structure	Uses
1.	Polypropene	Propene $CH_2 = CH - CH_3$	$+CH_2 - \underset{CH_3}{\underset{\vert}{CH}}+_n$	Manufacture of ropes, toys, pipes, fibres etc.
2.	Polystyrene	 (Styrene)	$+CH_2 - \underset{C_6H_5}{\underset{\vert}{CH}}+_n$	As insulator, wrapping material, manufacture of toys, radio and television cabinets.
3.	Polyvinyl chloride (PVC)	Vinyl chlroride $CH_2 = CH - Cl$	$+CH_2 - \underset{Cl}{\underset{\vert}{CH}}+_n$	Manufacture of rain coats, hand bags, vinyl flooring, water pipes.
4.	Urea-formaldehyde resin	(i) $NH_2 - \overset{\overset{O}{\Vert}}{C} - NH_2$ (Urea) (ii) HCHO (Formaldehyde)	$+NH - \overset{\overset{O}{\Vert}}{C} - NH - CH_2+_n$	For making unbreakable cups and laminated sheets
5.	Glyptal	(i) $\underset{OH}{\underset{\vert}{CH_2}} - \underset{OH}{\underset{\vert}{CH_2}}$ (Ethylene glycol) (ii)  (Phthalic acid)		Manufacture of paints and lacquers.
6.	Bakelite	(i)  (Phenol) (ii) HCHO (Formaldehyde)		For making combs, electrical switches, handles of utensils and computer discs.

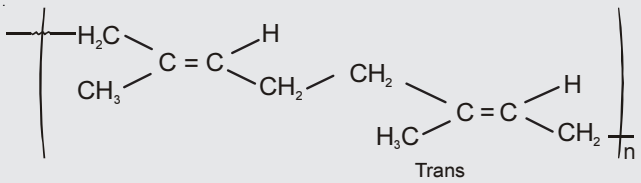
Note : **Some other important polymers**

(1) Gutta-Percha :

It is also known as trans-polyisoprene.

Monomer : $CH_2 = \underset{\text{Isoprene}}{\underset{\vert}{\overset{CH_3}{\overset{\vert}{C}}} - CH = CH_2}$

It is a linear 1, 4-addition of 2-methyl-1, 3-butadiene. All the double bonds in Gutta-Percha are trans.



Trans

It is non-elastic and non-crystalline

(2) Thiokol :

(i) Ethylene chloride (1, 2-dichloroethane) Monomer : $Cl - CH_2 - CH_2 - Cl$

(ii) Na_2S_2 (sodium polysulphide)

$$Cl - CH_2 - CH_2 - Cl + Na - S - S - Na + Cl - CH_2 - CH_2 - Cl$$

$$\downarrow \text{Polymerization}$$

$$- CH_2 - CH_2 - S - S - CH_2 - CH_2 - S - S - CH_2 - CH_2 -$$

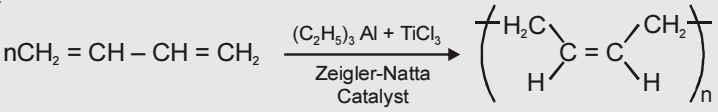
Thiokol

It is used in the manufacture of hoses and engine gaskets.

(3) Cis-Polybuta-1, 3-diene :

Monomer : $CH_2 = CH - CH = CH_2$

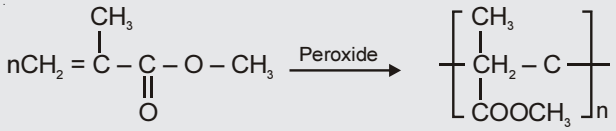
Buta-1, 3-diene



Cis-Polybuta-1, 3-diene
(Synthetic rubber)

(4) (i) Polymethylmethacrylate (PMMA) :

Monomer : Methyl methacrylate

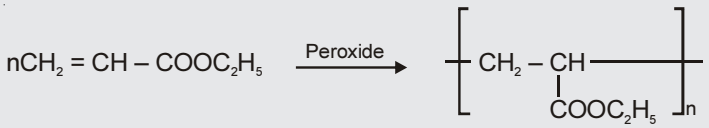


Methyl methacrylate (PMMA)

It is a hard and transparent polymer which is used for making eye lenses, air-craft windows and light shades.

(ii) Polyethylacrylate (PEA) :

Monomer : Ethylacrylate



(Polyethylacrylate)

It is used mainly in preparing blankets and carpets.

(5) Nylon-6, 10 :

Monomers : (i) $HO-\overset{\overset{O}{\|}}{C}-(CH_2)_8-\overset{\overset{O}{\|}}{C}-OH$

Sebacic acid

(ii) $H_2N-(CH_2)_6-NH_2$

Hexamethylenediamine

$$n\,HO-\overset{\overset{O}{\|}}{C}-(CH_2)_8-\overset{\overset{O}{\|}}{C}-OH \;+\; n\,H_2N-(CH_2)_6-NH_2$$

$\downarrow$ Heat, $-nH_2O$

$$\left(\overset{\overset{O}{\|}}{C}-(CH_2)_8-\overset{\overset{O}{\|}}{C}-\overset{\overset{H}{|}}{N}-(CH_2)_6-NH\right)_n$$

(Nylon-6, 10)

It is used in making carpets, fabrics, tyre corels, ropes etc.

(6) Polymonochlorotrifluoromoroethylene (PCTFE) :

$$n\,ClFC=CF_2 \xrightarrow{O_2} \left(ClFC-CF_2\right)_n$$

(Monochlorotrifluoro ethylene)

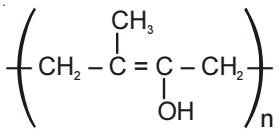
EXERCISE

6. Which of the following is a condensation polymer?
   (1) Teflon (2) Orlon
   (3) Dacron (4) Polyethene
7. Identify the co-polymer
   (1) Buna-N (2) Neoprene
   (3) Natural rubber (4) All of these
8. Which one is biodegradable polymer?
   (1) Nylon-2-Nylon-6 (2) Nylon-6,6
   (3) Nylon-6 (4) All of these
9. The monomer unit of PHBV is
   (1) $CH_3-\underset{\underset{OH}{|}}{CH}-CH_2COOH$
   (2) $CH_3-CH_2-\underset{\underset{OH}{|}}{CH}-CH_2COOH$
   (3) $HO-CH_2-CH_2-COOH$
   (4) Both (1) & (2)

10. Which of the following is true about natural rubber?

(1) Its monomer is 2-methyl-1,3-butadiene

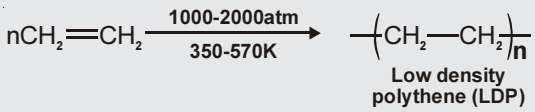
(2) It is also called as trans-1, 4-polyisoprene

(3) Its repeating unit is 

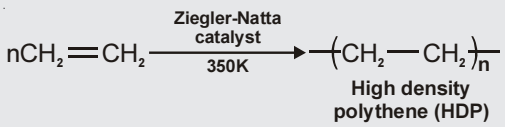
(4) It is a branched polymer

Note :

1. **Vulcanization** of rubber is carried out by heating crude rubber in presence of sulphur or dipping it in a solution of S_2Cl_2 in CS_2. It has extensive cross linking.
2. **Vulcanization** depends upon amount of sulphur used, temperature and duration of heating. The rubber can be hardened by increasing the amount of sulphur.
3. **Butyl rubber** is a copolymer of isobutylene and isoprene.
4. **A high polymer** is one in which the number of repeating units is in excess of about 100. This number is called **degree of polymerization.**
5. The high polymers, known as plastics are mostly synthetic. Hence they are also known as **synthetic resins.** Plastic materials are either thermosetting or thermoplastic.
6. Cellulose nitrate or **pyroxilin** is the first plastic of industrial importance.
7. **Polyvinyl chloride (PVC)**, polyvinyl acetate, vinyl acetals etc are vinyl resins.
8. **Cellulose** is the main constituent of most natural fibres.
9. **Viscose rayon** and **acetate fibres** are semi synthetic fibres.
10. Nylon, dacron, orlon are the examples of **true synthetic fibres.**
11. **Rayon** was originally called **artificial silk,** but now it is the general name given to all artificial fibres derived from cellulose. There are four important types of rayons or artificial silk derived from cellulose. These are **nitrocellulose, pyroxilin (or chardonet silk), cuprammonium rayon, acetate rayon and viscose rayon. Natural silk** contains nitrogen, while artificial silk does not contain nitrogen.
12. **Saran** is a copolymer of vinilidene chloride and vinyl chloride.
13. **Dynel** is a co-polymer of acrylonitrile and vinyl chloride.
14. The LDP has highly branched structure and formed by free radical mechanism. LDP is chemically inert tough but flexible and poor conductor of electricity hence used in insulation of electric wire, manufacturing of squeeze bottles, toys and flexible pipes.

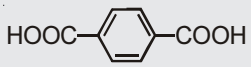
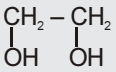
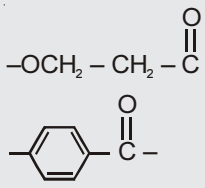
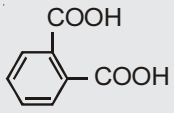
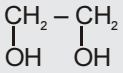
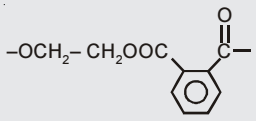
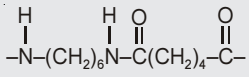
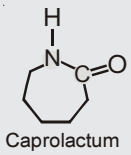
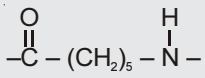
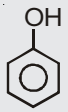
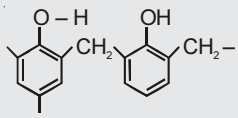


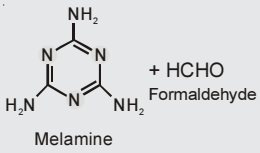
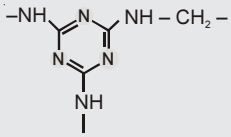
15. The HDP has less branching. It is characterised by relatively high tensile strength, toughness, chemically inert and used in manufacturing of containers, house wares, bottles, pipes etc.



Note :

S.N.	Monomer	Repeating Unit	Polymer Name	Uses
1.	$CH_2 = CH_2$ (Ethylene)	$-CH_2 - CH_2 -$	Polyethylene	Filon toys, bottles, plastic bags, cable covering and shipping containers
2.	$CH_2 = CH - Cl$ (Vinyl chloride)	$-CH_2 - \underset{\displaystyle Cl}{\underset{\vert}{CH}} -$	Polyvinyl chloride (PVC)	Squeeze bottle, pipe, sheets and hand bags
3.	$CH_3 - CH = CH_2$ (Propene)	$-CH_2 - \underset{\displaystyle CH_3}{\underset{\vert}{CH}} -$	Polypropene	Moulded caps and Indoor/outdoor carpeting
4.	$C_6H_5 - CH = CH_2$	$-CH_2 - \underset{\displaystyle C_6H_5}{\underset{\vert}{CH}} -$	Polystyrene	Packing, toys, egg
5.	$CF_2 = CF_2$ (Tetrafluoroethylene)	$-CF_2 - CF_2-$	Polytetrafluoro ethylene (PTFE) (Teflon)	Non-sticking surfaces, cable insulation
6.	$CH_2 = CH - CN$ (Vinyl cyanide)	$-CH_2 - \underset{\displaystyle CN}{\underset{\vert}{CH}} -$	Polyvinylcyanide polyacrylonitrile orlon or acrilan	Blanket, in making commercial fibres
7.	$CH_2 = \underset{\displaystyle CH_3}{\underset{\vert}{C}} - \overset{\displaystyle O}{\overset{\Vert}{C}} - O - CH_3$ Methyl methaerylate	$-CH_2 - \underset{\displaystyle CH_3}{\underset{\vert}{\underset{\displaystyle COOCH_3}{\underset{\vert}{C}}}} -$	Polymethyl methacrylate (PMMA) Plexiglas, lucite	Lighting fixtures, solar panels, skylights
8.	$CH_2 = CH - CH = CH_2$	$-CH_2-CH=CH-CH_2-$	Polybutadiene (Buna rubber)	In manufacture of tyres, hoses etc.
9.	$CH_2 = \underset{\displaystyle CH_3}{\underset{\vert}{C}} - CH = CH_2$ 2-Methyl-1, 3-butadiene	$-CH_2 - \underset{\displaystyle CH_3}{\underset{\vert}{C}} = CH - CH_2-$	Natural rubber	
10.	$CH_2 = \underset{\displaystyle Cl}{\underset{\vert}{C}} - CH = CH_2$ Chloroprene	$-CH_2 - \underset{\displaystyle Cl}{\underset{\vert}{C}} = CH - CH_2 -$	Neoprene	For manufacturing conveyor belts, gaskets and hoses

11.	$CH_2 = CH - CH = CH_2$ (1, 3-Butadiene) & $CH_2 = CH - CN$ (Acrylonitrile)	$-CH_2 - CH = CH -$ $CH_2 - CH_2 - \underset{\displaystyle CN}{\underset{\vert}{CH}} -$	Buna-N (NBR)	Used in making oil seals and tank lining etc.
12.	$CH_2 = CH - CH = CH_2$ (1, 3-Butadiene) & $C_6H_5 - CH = CH_2$	$-CH_2 - CH = CH -$ $CH_2 - CH - CH_2 -$ 	Buna-S (SBR)	For manufacture of auto tyres, floortiles, footwear components and cable insulation etc.
13.	 Terephthalic acid &  Ethane-1, 2-diol		Terylene or dacron or Mylar	
14.	 Phthalic acid &  Ethane-1, 2-diol		Glyptal	Manufacture of paints and lacquers
15.	$HOOC(CH_2)_4COOH$ Adipic acid & $NH_2(CH_2)_6NH_2$ Hexamethylenidiamine		Nylon-6,6	In making sheets, bristles for brushes and in textile industry
16.	 Caprolactum		Nylon-6	Manufacture of tyre cords, fabrics and ropes
17.	 Phenol + HCHO Methanal (formaldehyde)		Bakelite or resol	For making combs, phonograph records, and electrical switches

18.	 Melamine + HCHO Formaldehyde		Melamine polymer	Manufacture of unbreakable crockery
19.	$NH_2 - \underset{\underset{O}{\|\|}}{C} - NH_2$ Urea & HCHO Formaldehyde	$-NH - \underset{\underset{O}{\|\|}}{C} - NH - CH_2$	Urea-formaldehyde resin	For making unbreakable cups and laminated sheets

❑ ❑ ❑

Assignment

SECTION - A

NCERT Based MCQs

1. The monomer of nylon 6 is **[NCERT Pg. 439]**
   (1) Tetrafluoroethene
   (2) 2-Methyl-1,3-butadiene
   (3) 2-Chloro-1,3-butadiene
   (4) Caprolactam

2. Teflon, neoprene and PVC can be classified as **[NCERT Pg. 435]**
   (1) Homopolymers
   (2) Step growth polymers
   (3) Copolymers
   (4) Monomers

3. Identify the incorrect match **[NCERT Pg. 444]**

	Polymer		Use of polymer
(1)	Polypropene	–	in ropes
(2)	Polystyrene	–	as insulator
(3)	Urea-formaldehyde resin	–	in unbreakable cups
(4)	Bakelite	–	in paints

4. Which of the following is/are biodegradable polymer(s)? **[NCERT Pg. 443]**
   (1) PHBV
   (2) Nylon-2-nylon 6
   (3) Nylon 6,6
   (4) Both (1) and (2)

5. Which of the following is a rubber-like solid with elastic properties and involve weakest intermolecular forces? **[NCERT Pg. 443]**
   (1) Terylene
   (2) Polystyrene
   (3) Urea-formaldehyde resin
   (4) Buna-N

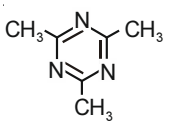
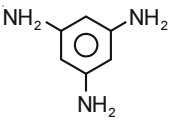
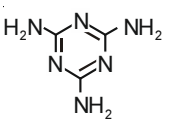
6. Which one of the following statement is correct about low density polythene? **[NCERT Pg. 437,438]**
   (1) It is formed in the presence of Ziegler-Natta catalyst
   (2) For its synthesis, a temperature of 333 K to 343 K is required under a pressure of 6 – 7 atm.
   (3) It is poor conductor of electricity
   (4) Low density polyethene consists of linear molecules.

7. Monomer of Teflon is **[NCERT Pg. 438]**
   (1) $CH_2 = CH–CN$ (2) $CF_2 = CF_2$
   (3) $Ph – CH = CH_2$ (4) $CH_2 = CH – CHO$

8. Which is not an example of condensation polymer? **[NCERT Pg. 438]**
   (1) Nylon-6 (2) Dacron
   (3) Orlon (4) Nylon-6,6

9. Out of the following, which one is an Elastomer? **[NCERT Pg. 436]**
   (1) Neoprene (2) Polyvinyls
   (3) Bakelite (4) Terylene

10. _____ on heating with formaldehyde undergoes cross linking to form an infusible mass called bakelite **[NCERT Pg. 440]**
    (1) Novolac
    (2) Melamine
    (3) Methanol
    (4) Ethanol

11. The correct structure of melamine is **[NCERT Pg. 440]**
    (1) 
    (2) 
    (3) 
    (4) 

12. Bakelite is prepared by the reaction between **[NCERT Pg. 440]**
(1) Phenol and methanol (2) Phenol and methanal
(3) Phenol and glycerol (4) Phenol and glycol

13. Monomer of Natural rubber is **[NCERT Pg. 441]**
(1) Isoprene (2) Acrylonitrile
(3) Caprolactam (4) Styrene

14. Which among the following is a condensation polymer? **[NCERT Pg. 438,439]**
(1) PVC (2) Terylene
(3) Teflon (4) Buna-N

15. The polymer which is used in the manufacture of paints is **[NCERT Pg. 444]**
(1) Glyptal (2) Polypropene
(3) Nylon-2-nylon-6 (4) Polyacrylonitrile

SECTION - B

Objective Type Questions

1. The polymer used for making coating of non-stick cookware is
(1) Teflon (2) Polystyrene
(3) Malamine (4) Nylon

2. Monomer of orlon is
(1) Vinyl cyanide (2) Acrolein
(3) Glycol (4) Isoprene

3. Find the **correct** match.
(1) Terylene : co-polymer of terephthalic acid and ethylene glycol
(2) Buna-N : co-polymer of acrylonitrile and Buta-1,3-diene
(3) Neoprene : polymer of chloroprene
(4) All of these

4. The process done for increasing elasticity and strength of natural rubber is known as
(1) Polymerisation (2) Isomerisation
(3) Vulcanisation (4) Condensation

5. Bakelite is a polymer of formaldehyde and
(1) Chlorobenzene (2) Phenol
(3) Adipic acid (4) Glycine

6. The linear chains in nylon are held together by
(1) Van der Waal's forces
(2) Hydrogen bonds
(3) Covalent bonds
(4) Ionic bonds

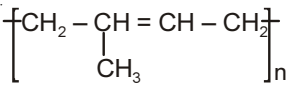
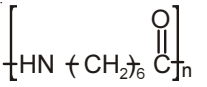
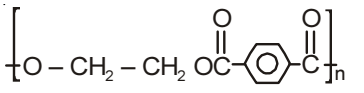
7. Polymer of isoprene
(1) is Neoprene
(2) Can show geometrical isomerism
(3) is Elastomer
(4) Both (2) & (3) are correct

8. Semi synthetic polymer is
(1) Gun cotton (2) Cellulose
(3) Teflon (4) Starch

9. Polymer used in paints is
(1) Neoprene (2) Glyptal
(3) Nylon (4) Teflon

10. Copolymer of buta-1,3-diene and styrene is
(1) Buna-S (2) Buna-N
(3) Neoprane (4) Polystyrene

11. Gutta percha is
(1) A polymer of isoprene
(2) Isomer of natural rubber
(3) Addition polymer
(4) All of these

12. Find the **correct** match:
(1) Neoprene : 
(2) Nylon 6,6 : 
(3) Dacron : 
(4) All of these

13. Which of the following polymer may have cis configuration?
(1) Teflon (2) Polyisoprene
(3) Glyptal (4) PHBV

14. Which of the following polymers is obtained by chain-growth polymerisation?
(1) PHBV
(2) Cis-polyisoprene
(3) Glyptal
(4) Melamine formaldehyde polymer

15. The reductive ozonolysis of natural rubber will finally form
(1) Acetone and Ethanal
(2) 4-Oxopentanal
(3) Acetone and Propanal
(4) All of these

16. Which of the following is a biodegradable polymer?
(1) Nylon–6, 6
(2) Nylon–2–nylon–6
(3) Nylon–6
(4) All of these

17. *p*-xylene $\xrightarrow[\text{(ii) } H_3O^+]{\text{(i) } KMnO_4, \overline{O}H}$ A, (A) is a monomeric unit of
(1) Glyptal
(2) Dacron
(3) Polyacrylonitrile (PAN)
(4) Neoprene

18. Which of the following polymers is formed via chain growth polymerisation mechanism?
(1) Polyvinylchloride (PVC)
(2) Nylon-6
(3) Buna-S
(4) Both (1) & (3)

19. Weakest intermolecular forces are present in
(1) Buna-S
(2) Terylene
(3) Nylon – 6, 6
(4) Polystyrene

20. The number of 1° amino groups ($-NH_2$) present in melamine is
(1) One (2) Three
(3) Zero (4) Two

21. Select the correct statement for the polymer
$-\left(CH_2 - CH = CH - CH_2 - CH_2 - \underset{\displaystyle C_6H_5}{\underset{|}{CH}}\right)_n-$
(1) Addition polymer, homopolymer
(2) Condensation polymer, homopolymer
(3) Addition polymer, copolymer
(4) Condensation polymer, copolymer

22. Select the correct statement in relation to natural rubber.
(1) It is a cross-linked polymer
(2) All double bonds are in cis-configuration
(3) Repeating unit is $-\left(CH = \underset{\displaystyle CH_3}{\underset{|}{C}} - CH = CH\right)-$
(4) Double bonds have both cis – and trans–configurations

23. Strongest intermolecular forces are present in
(1) Terylene
(2) Buna-S
(3) Neoprene
(4) Polythene

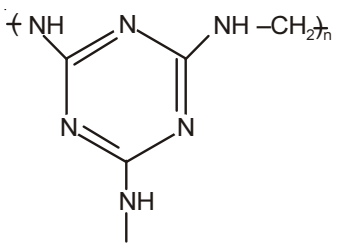
24. Which of the following is a cross-linked polymer?
(1) High density polythene
(2) Low density polythene
(3) Melamine - formaldehyde resin
(4) PVC

25. Which of the following is not a condensation polymer?
(1) Nylon–6 (2) Bakelite
(3) Polyesters (4) Teflon

26. o – Xylene $\xrightarrow[\text{(ii) } H_3O^+]{\text{(i) } KMnO_4, \overline{O}H}$ P. (P) is a monomeric unit of
(1) Bakelite (2) Glyptal
(3) PHBV (4) Buna–N

27. The monomer of natural rubber is an example of
(1) Cumulated alkene
(2) Conjugated alkene
(3) Isolated alkene
(4) Alkynes

28. Select the incorrect option for the following polymer



(1) Condensation polymer

(2) Cross-linked polymer

(3) Homopolymer

(4) Copolymer

29. Bakelite is an example of

(1) Semi - synthetic polymer

(2) Cross - linked polymer

(3) Synthetic polymer

(4) Both (2) & (3)

30. The catalyst used in the preparation of high density polythene (HDP) is

(1) $AlCl_3 + Ti(C_2H_5)_4$

(2) $TiCl_4 + Al(C_2H_5)_3$

(3) $[Rh(PPh_3)_3Cl]$

(4) $(CH_3COO)_2Zn$

SECTION - C

Previous Years Questions

1. The polymer that is used as a substitute for wool in making commercial fibres is **[NEET-2019 (Odisha)]**

(1) Buna-N

(2) melamine

(3) nylon-6,6

(4) polyacrylonitrile

2. The biodegradable polymer is **[NEET-2019]**

(1) Nylon-6,6

(2) Nylon-2-Nylon 6

(3) Nylon-6

(4) Buna-S

3. Regarding cross-linked or network polymers, which of the following statements is incorrect? **[NEET-2018]**

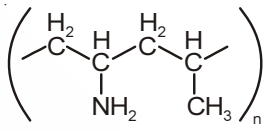
(1) They contain covalent bonds between various linear polymer chains.

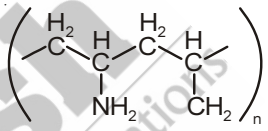
(2) They are formed from bi- and tri-functional monomers.

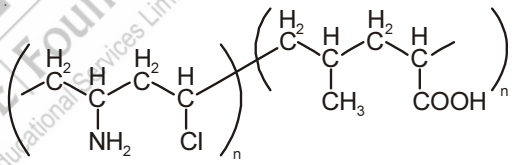
(3) They contain strong covalents bonds in their polymer chains.

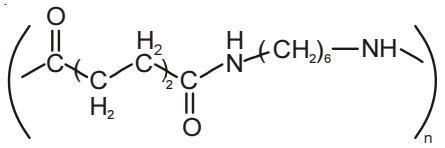
(4) Examples are bakelite and melamine.

4. Which one of the following structures represents nylon 6,6 polymer? **[NEET-(Phase-2)-2016]**

(1) 

(2) 

(3) 

(4) 

5. Natural rubber has **[NEET-2016]**

(1) Random cis - and trans-configuration

(2) All cis-configuration

(3) All trans-configuration

(4) Alternate cis - and trans-configuration

6. Caprolactam is used for the manufacture of **[Re-AIPMT-2015]**

(1) Terylene

(2) Nylon-6, 6

(3) Nylon-6

(4) Teflon

7. Biodegradable polymer which can be produced from glycine and aminocaproic acid is **[AIPMT-2015]**

(1) Nylon 6, 6

(2) Nylon 2 - nylon 6

(3) PHBV

(4) Buna - N

8. Which of the following organic compounds polymerizes to form the polyester Dacron ?

[AIPMT-2014]

(1) Propylene and para HO–(C_6H_4)–OH

(2) Benzoic acid and ethanol

(3) Terephthalic acid and ethylene glycol

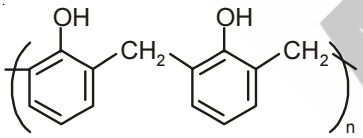
(4) Benzoic acid and para HO–(C_6H_4)–OH

9. Which one of the following is an example of a thermosetting polymer ? **[AIPMT-2014]**

(1) $-(CH_2 - \underset{Cl}{C} = CH - CH_2)_n-$

(2) $-(CH_2 - \underset{Cl}{CH})_n-$

(3) $-(\overset{H}{\underset{|}{N}} - (CH_2)_6 - \overset{H}{\underset{|}{N}} - \overset{O}{\overset{||}{C}} - (CH_2)_4 - \overset{O}{\overset{||}{C}})_n-$

(4) 

10. Which is the monomer of Neoprene in the following ? **[NEET-2013]**

(1) $CH_2=\underset{CH_3}{\underset{|}{C}}-CH=CH_2$

(2) $CH_2=\underset{Cl}{\underset{|}{C}}-CH=CH_2$

(3) $CH_2=CH-C\equiv CH$

(4) $CH_2=CH-CH=CH_2$

11. Nylon is an example of **[NEET-2013]**

(1) Polysaccharide (2) Polyamide

(3) Polythene (4) Polyester

12. Which one of the following is not a condensation polymer? **[AIPMT (Prelims)-2012]**

(1) Dacron (2) Neoprene

(3) Melamine (4) Glyptal

13. Which one of the following sets forms the biodegradable polymer ? **[AIPMT (Mains)-2012]**

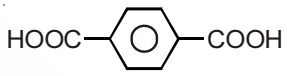
(1) $CH_2 = CH - CN$ and

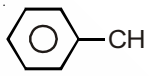
$CH_2 = CH - CH = CH_2$

(2) $H_2N - CH_2 - COOH$ and

$H_2N - (CH_2)_5 - COOH$

(3) $HO - CH_2 - CH_2 - OH$ and



(4)  and

$CH_2 = CH - CH = CH_2$

14. Which of the following statements is false ?

[AIPMT (Prelims)-2012]

(1) The repeating unit in natural rubber is isoprene

(2) Both starch and cellulose are polymers of glucose

(3) Artificial silk is derived from cellulose

(4) Nylon-66 is an example of elastomer

15. Of the following which one is classified as polyester polymer? **[AIPMT (Prelims)-2011]**

(1) Nylon-6, 6

(2) Terylene

(3) Bakelite

(4) Melamine

16. Which of the following structures represents Neoprene polymer ? **[AIPMT (Prelims)-2010]**

(1) $(-CH_2-\underset{Cl}{\underset{|}{C}} = CH-CH_2-)_n$

(2) $\overset{CN}{\underset{|}{(-CH_2-CH-)_n}}$

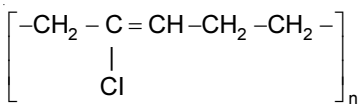
(3) $\overset{Cl}{\underset{|}{(-CH_2-CH-)_n}}$

(4) $\underset{C_6H_5}{\underset{|}{(-CH-CH_2-)_n}}$

17. Structures of some common polymers are given. Which one is not correctly presented?

[AIPMT (Prelims)-2009]

(1) Neoprene



(2) Terylene

(3) Nylon-6, 6
$[NH(CH_2)_6\ NHCO(CH_2)_4–CO–]_n$

(4) Teflon
$(–CF_2–CF_2–)_n$

18. Which of the following statements is not true ?

[AIPMT (Prelims)-2008]

(1) Natural rubber is 1, 4 - polymer of isoprene

(2) In vulcanization, the formation of sulphur bridges between different chains make rubber harder and stronger

(3) Natural rubber has the trans-configuration at every double bond

(4) Buna-S is a copolymer of butadiene and styrene

19. Which one of the following polymers is prepared by condensation polymerization ?

[AIPMT (Prelims)-2007]

(1) Styrene (2) Nylon-6, 6

(3) Teflon (4) Rubber

20. $[NH(CH_2)_6NHCO(CH_2)_4CO–]_n$ is a

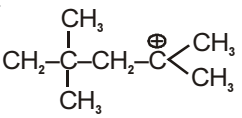
[AIPMT (Prelims)-2006]

(1) Co-polymer

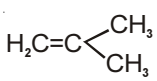
(2) Addition polymer

(3) Thermo-setting polymer

(4) Homopolymer

21. The monomer of the polymer  is

[AIPMT (Prelims)-2005]

(1) 

(2) $(CH_3)_2C=C(CH_3)_2$

(3) $CH_3CH=CHCH_3$

(4) $CH_3CH=CH_2$

Questions asked Prior to Medical Ent. Exams. 2005

22. Correct match in the given two columns is

	Column-I (Polymers)		Column-II (Monomers)
a.	Silk	(i)	Glucose
b.	Insulin	(ii)	Acrylonitrile
c.	Orlon	(iii)	Caproic acid
d.	Nylon-6	(iv)	α-amino acid

(1) a(i), b(iii), c(iv), d(ii)

(2) a(iv), b(i), c(ii), d(iii)

(3) a(i), b(iii), c(ii), d(iv)

(4) a(i), b(iv), c(iii), d(ii)

23. Which of the following set of polymers contains same monomer which is used to prepare urotropine on reaction with NH_3?

(1) Glyptal, urea-formaldehyde resin, Nylon-6, 6

(2) Glyptal, urea-formaldehyde resin, melamine-formaldehyde resin

(3) Nylon-6, urea-formaldehyde resin, melamine-formaldehyde resin

(4) Nylon-6, glyptal, Nylon-6, 6

24. The bakelite is prepared by the reaction between

(1) Phenol and formaldehyde

(2) Tetramethylene glycol

(3) Urea and formaldehyde

(4) Ethylene glycol

25. Which one of the following is used to make 'non-stick' cookware?

(1) Poly-ethylene terephthalate

(2) Polytetrafluoroethylene

(3) PVC

(4) Polystyrene

26. Terylene is a condensation polymer of ethylene glycol and

(1) Salicylic acid

(2) Phthallic acid

(3) Benzoic acid

(4) Terephthallic acid

27. Natural rubber is a polymer of

(1) Styrene

(2) Ethyne

(3) Butadiene

(4) Isoprene

28. $CF_2 = CF_2$ is monomer of

(1) Teflon

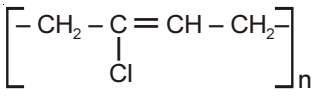
(2) Orlon

(3) Polythene

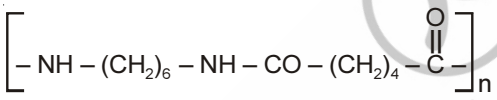
(4) Nylon-6

29. Which of the following is not correctly matched?

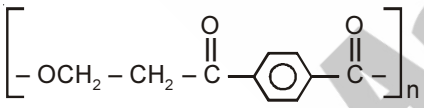
(1) Neoprene :



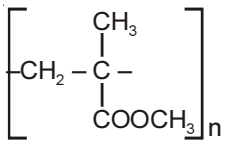
(2) Nylon-6, 6 :

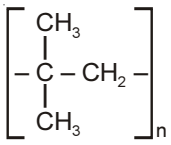


(3) Terylene :



(4) PMMA :



30. Monomer of  is

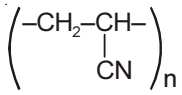
(1) 2-methyl propene

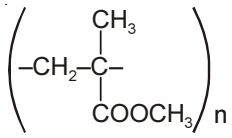
(2) Styrene

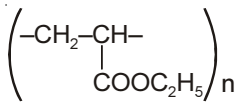
(3) Propylene

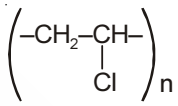
(4) Ethene

31. Acrilan is a hard, horny and a high melting material. Which one of the following represents its structure?

(1) 

(2) 

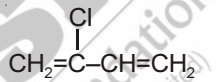
(3) 

(4) 

32. Which one of the following monomers gives the polymer neoprene on polymerization?

(1) $CH_2 = CHCl$

(2) $CCl_2 = CCl_2$

(3) 

(4) $CF_2 = CF_2$

33. Which one of the following is a chain growth polymer?

(1) Starch

(2) Nucleic acid

(3) Polystyrene

(4) Protein

SECTION - D

NEET Booster Questions

Choose the correct answer:

1. Gutta percha is

(1) Cis-polyisoprene (2) Trans-polyisoprene

(3) Polyethylene (4) Polyisobutene

2. Which of the following polymers has ester linkage?

(1) Terylene (2) Nylon-6,6

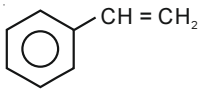
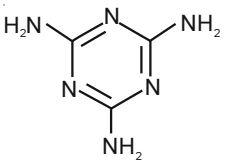
(3) PVC (4) Neoprene

3. Terephthalic acid and ethylene glycol react to form

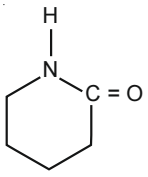
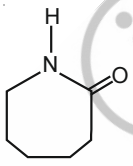
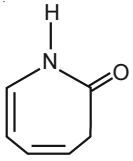
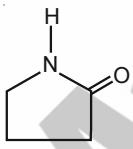
(1) Nylon 6 (2) Nylon–66

(3) Dacron (4) Neoprene

4. In elastomer, intermolecular forces are
(1) Nil (2) Weak
(3) Strong (4) Very strong

5. Which monomer is used for preparing acrilan?
(1) $CF_2 = CF_2$ (2) 
(3)  (4) $CH_2 = CH–CN$

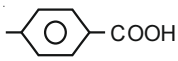
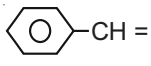
6. Example of polycondensation products of dicarboxylic acids and diols is
(1) Nylon – 6 (2) Dacron
(3) Novolac (4) Neoprene

7. Which of the following is monomer of Nylon-6?
(1)  (2) 
(3)  (4) 

8. The fibre obtained by the condensation of hexamethylene diamine and adipic acid is
(1) Dacron (2) Nylon 6, 6
(3) Rayon (4) Teflon

9. Which of the following polymer contains H-bonding?
(1) Natural Rubber (2) Teflon
(3) Nylon-66 (4) Polystyrene

10. Which is condensation polymer?
(1) Polythene (2) Styrene
(3) Bakelite (4) All of these

11. Which one of the following sets forms the biodegradable polymer?
(1) $HO–CH_2–CH_2–OH$ and HOOC 
(2)  and $CH_2 = CH – CH = CH_2$
(3) $CH_2 = CH – CN$ and $CH_2 = CH – CH = CH_2$
(4) $H_2N – CH_2 – COOH$ and $H_2N – (CH_2)_5 – COOH$

12. The percentage of sulphur used in the vulcanization of rubber is:
(1) 3% (2) 5%
(3) 30% (4) 55%

13. Polymer having amide linkage is
(1) Nylon 6, 6
(2) Terylene
(3) Teflon
(4) Bakelite

14. Monomer of Neoprene rubber is
(1) 1-Chloro-1,3-butadiene
(2) 2-Chloro-1,3-butadiene
(3) 2-Methyl-1,3-butadiene
(4) 2-Chloro-1,3-pentadiene

15. Terylene is a condensation polymer of ethylene glycol and
(1) Benzoic acid
(2) Phthalic acid
(3) Salicylic acid
(4) Terephthalic acid

16. Which of the following is biodegradable polymer?
(1) Terylene (2) Teflon
(3) Cellulose (4) P.V.C

17. Arrange the following in decreasing order of their intermolecular forces:
(a) Nylon 6,6 (b) Buna-S
(c) PVC
(1) b > a > c (2) a > c > b
(3) a > b > c (4) c > a > b

18. Which of the following is not correct regarding terylene?
(1) Step growth polymer
(2) Synthetic fibre
(3) Condensation polymer
(4) Thermosetting plastic

19. Glyptal polymer is obtained from phthalic acid by treating it
(1) Malonic acid (2) Ethylene glycol
(3) Maleic acid (4) Phenol

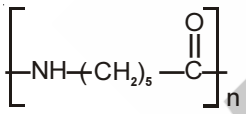
20. Biodegradable polymer which can be produced from glycine and aminocaproic acid
(1) PHBV (2) Buna N
(3) Nylon 6, 6 (4) Nylon-2, Nylon-6

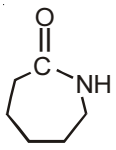
21. Which of the following is a thermosetting polymer?
(1) PVC (2) Neoprene
(3) Bakelite (4) Polythene

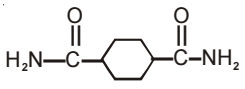
22. Which of the following is a semisynthetic polymer?
(1) Natural rubber
(2) Gun cotton
(3) Cellulose
(4) Nucleic acids

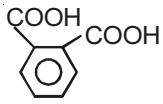
23. Which is not an example of addition polymer?
(1) Neoprene
(2) PMMA
(3) PVC
(4) Dacron

24. Polymerisation of acrylonitrile will best take place by
(1) Cationic polymerisation
(2) Anionic polymerisation
(3) Step growth polymerisation
(4) All of these

25. Monomer of  is

(1) 

(2) 

(3) 

(4) H_2NCONH_2

26. Which of the following is a chain growth polymer?
(1) Starch
(2) Nucleic acid
(3) Polystyrene
(4) Protein

27. Formation of polyethylene from calcium carbide takes place as follows

$CaC_2 + 2H_2O \rightarrow Ca(OH)_2 + C_2H_2$

$C_2H_2 + H_2 \rightarrow C_2H_4$

$nC_2H_4 \rightarrow -(CH_2-CH_2)_n-$

The amount of polyethylene obtained from 64 kg of CaC_2 is
(1) 7 kg (2) 14 kg
(3) 21 kg (4) 28 kg

28. Step growth polymerisation starts by
(1) Condensation reaction between monomers
(2) Coordination reaction between monomers
(3) Conversion of monomer to monomer ion by protons
(4) Hydrolysis of monomers

29. In a polymer sample 30% of molecules have a molecular mass of 20,000, 40% have 30,000 and the rest 60,000. What is the weight average molecular mass of the polymer?
(1) 40,300 (2) 30,600
(3) 43,333 (4) 50,400

30. Which of the following polymers is prepared by condensation polymerization?
(1) Styrene
(2) Nylon-6,6
(3) Teflon
(4) Rubber

31. The monomers of Bakelite are
(1) Ethylene glycol + phthalic acid
(2) Phenol + formaldehyde
(3) Ethylene glycol + terephthalic acid
(4) Phenol + methanoic acid

32. Fibre among the following is
(1) Rubber (2) Buna-S
(3) Nylon-66 (4) Bakelite

33. Polymer of perfluoroethylene is
(1) Polythene (2) PVC
(3) Teflon (4) Buna-N

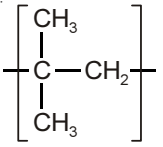
34. Orlon is a polymer of
(1) Styrene (2) Vinyl chloride
(3) Tetrafluoroethylene (4) Acrylonitrile

35. Which of the following is correct statement?
    (1) Low density polyethylene is obtained under high pressure and room temperature
    (2) High density polyethylene has highly branched structure
    (3) High density polyethylene is obtained under a pressure of 6-7 atmospheres
    (4) High density polyethylene is more flexible than low density polyethylene

36. Which is not the biodegradable polymer?
    (1) Nylon-2-Nylon-6
    (2) Poly (Glycolic acid) and Poly (Lactic acid)
    (3) Glyptal
    (4) PHBV

37. Which of the following is a biodegradable polymer?
    (1) Starch
    (2) Polythene
    (3) Polyvinyl chloride
    (4) Nylon-6

38. Which is used for the formation of nylon 66?
    (1) Sulphur hexafluoride
    (2) Adipic acid
    (3) Sulphurous acid
    (4) Phthalic acid

39. Monomer of  is
    (1) 2-methylpropene (2) Styrene
    (3) Propylene (4) Ethene

40. Which one of the following is not a correct match?

	Polymer	Monomer(s)
(1)	Teflon	Tetrafluoroethylene
(2)	Neoprene	Methyl methacrylate
(3)	Buna-S	Styrene and 1,3-butadiene
(4)	Thiokol	Ethylene dichloride and sodium tetrasulphide

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Chapter 28

Chemistry in Everyday Life

Chapter Contents

Introduction

Chemistry has played a vital role for the benefit of the mankind. It has influenced our life so much that since morning to night our activities are directly or indirectly influenced by it.

For **cleanliness**, we use soaps, detergents, toothpastes, bleaches etc, which all are made up of chemical compounds. Similarly **Clothes** (Cotton, Wool, Silk, Terylene), **Food materials** (Carbohydrates, Proteins, Oil, Fats), **Medicines** (Antibiotics, Antimalarials etc.), Explosives, Fuels, Rocket propellants, building materials etc. are all chemical compounds or derived from them.

In this unit we shall chiefly discuss about applications of chemistry in the areas *like* medicines, food materials and cleansing agents.

DRUGS AND THEIR CLASSIFICATION

Drugs are chemicals of low molecular masses (~100-500u). They produce biological response by interacting with macromolecular targets. If the biological response is therapeutic and useful, these chemicals are called medicines. They are used in diagnosis, prevention and treatment of diseases.

Note :

- Most of the drugs used as medicines, can be potential poisons, if taken in higher doses than those recommended.
- Use of chemicals for therapeutic effect is called **chemotherapy**.

Classification of Drugs

Drugs can be classified mainly on the basis of following criteria:

(i) On the basis of pharmacological effect : It is useful for doctors because it provides them whole range of drugs available for treatment of particular type of problem.

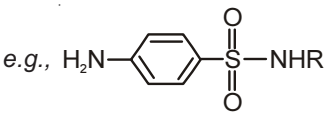
e.g., **Analgesic** - Shows pain killing effect.

Antiseptic - Kill or arrest the growth of microorganisms.

(ii) On the basis of drug action: It is based on action of drug on a particular biochemical process.

Eg.- Histamines causes inflammation in the body and there are various ways in which action of histamines can be blocked. All antihistamines inhibit the action of the histamines.

(iii) On the basis of chemical structure : It is based on chemical structure of the drug. Often drugs with common structural features, have similar pharmacological activity.



Sulphonamides have common structural feature as shown above.

(iv) On the basis of molecular targets : Drug possessing some common structural features, may have same mechanism of action on targets. These **target molecules** or **drug targets** are usually biomolecules such as carbohydrates, lipids, proteins and nucleic acids.

DRUG-TARGET INTERACTION

Macromolecules of biological origin perform various functions in the body.

For example: Proteins which perform the role of biological catalyst in the body are called **enzymes,** those which are crucial to communication system in the body are called **receptors**. Carrier proteins carry polar molecules across the cell membrane. Nucleic acids have coded genetic information for the cell. Lipids and carbohydrates are structural parts of the cell membrane.

Following examples of enzymes and receptors explain the drug-target interaction:

1. Enzymes as Drug Targets

(i) Catalytic action of enzymes: Enzymes perform two major functions:

(a) The first function of enzyme is to hold the substrate for chemical reaction. Enzymes have active sites, which hold the substrate molecule in a suitable position, so that it can be attacked by reagent effectively. The substrate can bind through enzyme by interactions such as ionic bonding, hydrogen bonding, van der Waals interaction or dipole-dipole interaction.

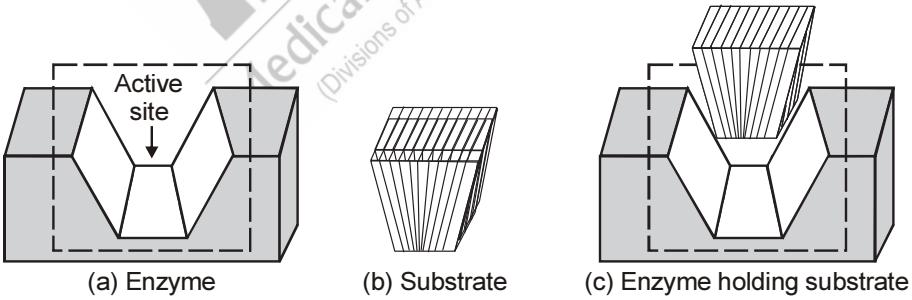


Fig.: (a) Active site of an enzyme; (b) Substrate; (c) Substrate held in active site of the enzyme

(b) The second function of enzyme is to provide functional groups that will attack the substrate and carry out chemical reaction.

(ii) Drug-enzyme interaction:

Enzyme inhibitors : Drugs can inhibit the activities of enzymes. They can block the binding site of the enzyme, thus prevent the binding of substrate or they can inhibit the catalytic activity of the enzyme.

Drug can inhibit the attachment of substrate on active size of enzymes in following two ways:

(a) Competitive inhibitors: These are drugs which compete with natural substrate for their attachment on the active site of enzymes.

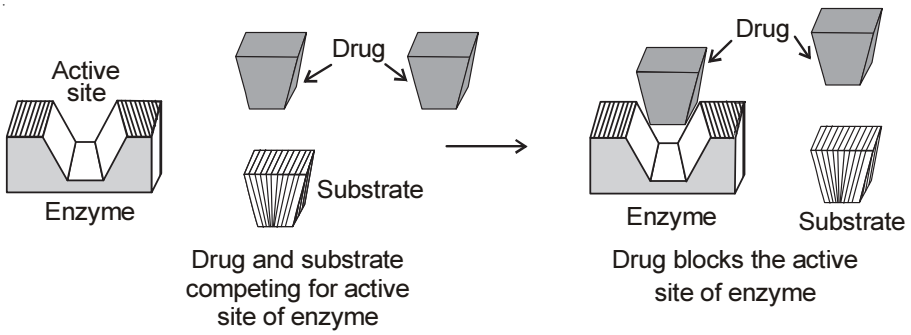


Fig.: Drug and substrate competing for active site

(b) Non-competitive inhibitors: These drugs do not bind to the enzyme's active site, rather bind to a different site of enzyme called **Allosteric site** and changes the shape of active site in such a way that substrate can't recognise it.

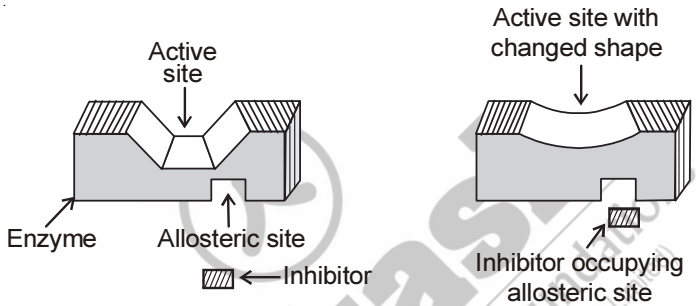


Fig.: Non-competitive inhibitor changes the active site of enzyme after binding at allosteric site.

If the bond formed between enzyme and inhibitor is strong covalent bond and cannot be broken easily, then enzyme is blocked permanently, the body then degrades the enzyme inhibitor complex and synthesize the new enzyme.

2. Receptors as Drug Targets

Receptors are proteins that are crucial to body's communication process. Receptor proteins are embedded in cell membranes in such a way that their small part possessing active site projects out of the surface of the membrane and opens on the outside region of the cell membrane.

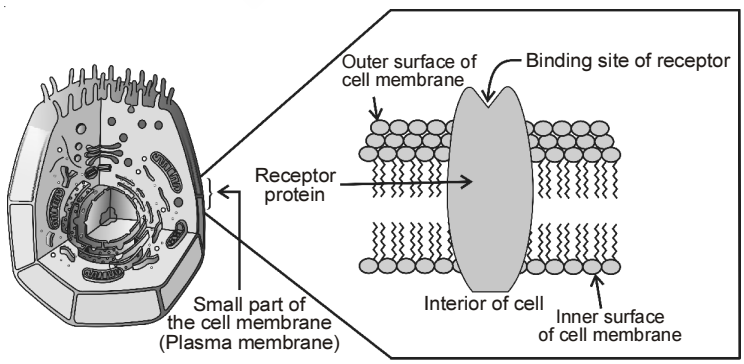


Fig.: Receptor protein embedded in the cell membrane, the active site of the receptors opens on the outside region of the cell.

Chemical Messengers are the chemicals in the body, through which message between two neurons or that between neurons to muscles is communicated. They are received at binding sites of receptor proteins.

To accommodate a messenger, shape of receptor site changes and brings about the transfer of message into the cell. Thus, chemical messenger give message to the cell without entering the cell.

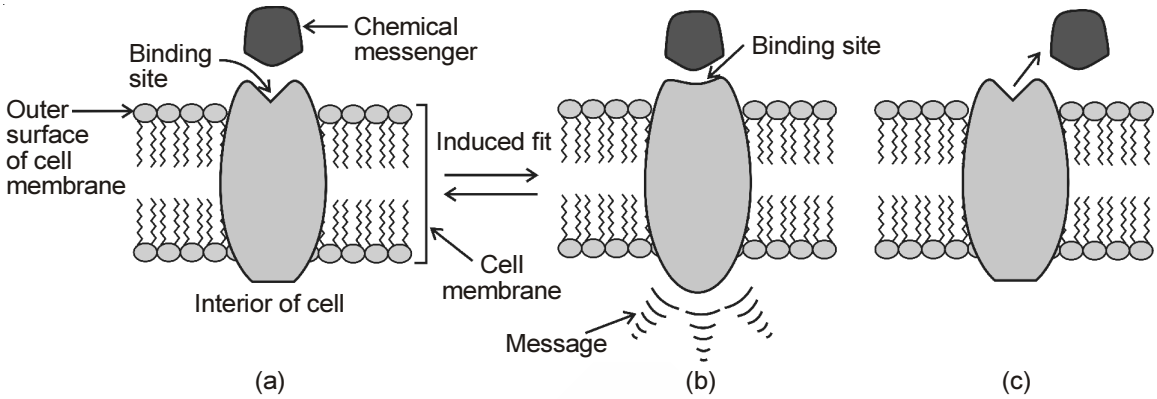


Fig. : (a) Receptor receiving chemical messenger,
(b) Shape of the receptor changed after attachment of messenger,
(c) Receptor regains structure after removal of chemical messenger.

There are large number of different receptors in the body that interact with different chemical messengers. As their binding sites have different shape, structure and amino acid composition, these receptors can show selectivity for one chemical messenger over the other.

Drugs targeting the receptors can be:

Antagonists : Drugs that bind to the receptor site and inhibit its natural function. They are useful when blocking of message is required.

Agonists : These drugs mimic the natural messenger by switching on the receptor and are useful when there is lack of natural chemical messenger.

Example 1 : *Define chemotherapy.*

Solution : Chemotherapy is a branch of chemistry which deals with treatment of diseases using chemicals.

Example 2 : *What are medicines drugs?*

Solution : When biological response is therapeutic and useful, then the drugs are called medicines.

Example 3 : *Distinguish antagonists and agonists.*

Solution : Antagonists- Drugs binding to receptor site and inhibit its natural action.

Agonists- Drugs that mimic the natural messenger by switching on the receptor.

Example 4 : *How drugs are enzyme inhibitor?*

Solution : They can block the binding site of enzyme and prevent the binding of substrate or can inhibit catalytic activity of enzyme.

Example 5 : *What are allosteric sites?*

Solution : Sites other than active sites of the enzyme where drugs bind to enzymes are called allosteric sites.

THERAPEUTIC ACTION OF DIFFERENT CLASSES OF DRUGS

Few important classes of drugs are:

1. Antacids

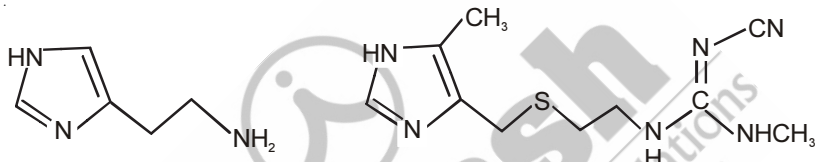
Over production of acid in stomach causes pain and irritation and in severe cases ulcers are developed.

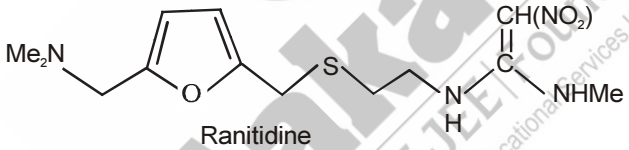
Till 1970, antacids such as **sodium hydrogen carbonate** or mixture of aluminium and magnesium hydroxide was used. But taking excess hydrogen carbonate makes the stomach alkaline and trigger the production of even more acid.

Metal hydroxides are better antacids, as they are insoluble and do not increase the pH above neutrality. These treatment control only symptoms, and not the cause. Therefore, with these metal salts, the patients cannot be treated easily. It was found that the chemical **histamine** stimulates the secretion of pepsin and hydrochloric acid in the stomach. A drug **cimetidine (Tegamet)** was discovered which was used to prevent interaction of histamine with receptors present in the stomach wall that resulted in release of lesser amount of acid (once it became the largest selling drug in world). Other examples - **ranitidine (Zantac)**.

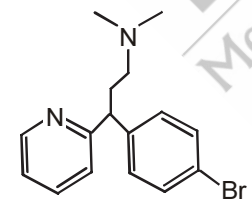
2. Antihistamines

Histamine is a potent vasodilator. It has various functions, like contraction of smooth muscles in the bronchi and gut and relaxing other muscles such as those in walls of fine blood vessels. Histamines are also responsible for nasal conjestion associated with common cold and allergic response to pollen.

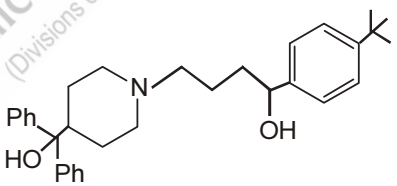




Synthetic drug **brompheniramine (Dimetapp)** and **terfenadine (Seldane)** act as antihistamines. They interfere with natural action of histamine by competing with histamine for binding sites of receptor where histamine exerts its effect.



Brompheniramine
(Dimetapp, Dimetane)



Terfenadine (Seldane)

3. Neurologically Active Drugs

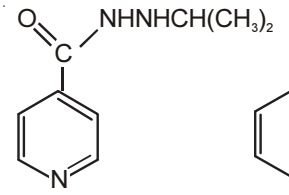
(i) Tranquilizers: They affect the message transfer mechanism from nerve to receptor.

They are class of chemical compounds used for treatment of stress, mild or even severe mental diseases. They form essential component of sleeping pills. They relieve anxiety, stress, irritability or excitement by including sense of well being.

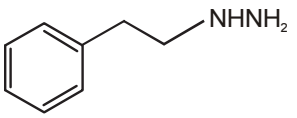
Various type of tranquilizers function by different mechanisms. Example- noradrenaline one of the neurotransmitter that plays a role in mood changes. If the level of noradrenaline is low for some reasons, then the signal sending activity becomes low the and person suffers from depression and in such a situation **antidepressant drugs** are required. They inhibit the enzymes which catalyse the degradation

of noradrenaline, thus neurotransmitter is slowly metabolised and can activate its receptor for longer period of time and counteracting the effect of depression.

Example of antidepressant drugs- Iproniazid and phenelzine



Iproniazid

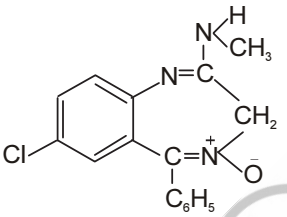


Phenelzine (Nardil)

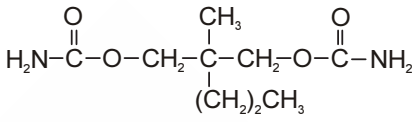
Examples of tranquilizers:

(a) Chlordiazepoxide, meprobamate are mild tranquilizers suitable for relieving tension.

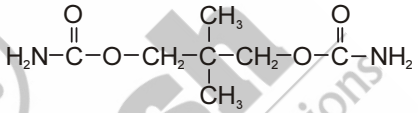
(b) Equanil is used in controlling depression and hypertension.



Chlordiazepoxide



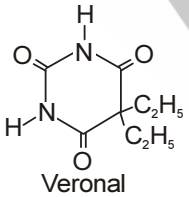
Meprobamate



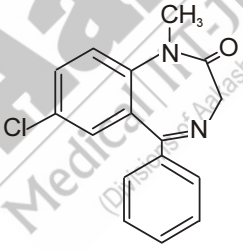
Equanil

(c) Derivatives of barbituric acid *i.e.*, veronal, amytal, nembutal, luminal, seconal constitute an important class of tranquilizers. These derivatives are called **barbiturates**. They are hypnotic *i.e.*, sleep producing agents.

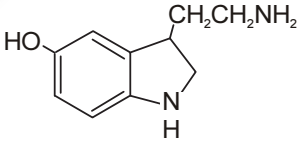
(d) Valium and serotonin are also used as tranquilizers.



Veronal



Valium



Serotonin

(ii) Analgesics: They reduce or abolish pain without causing impairment of consciousness, mental confusion, incoordination or paralysis or some other disturbances of nervous system. They are classified as:

(a) Non-narcotic (non-addictive) analgesics: Example- Aspirin, Paracetamol.

Aspirin inhibits synthesis of chemicals known as prostaglandins which stimulate inflammation in the tissue and cause pain. They are effective in relieving skeletal pain such as that due to arthritis, reducing fever (as antipyretic) and preventing platelet coagulation.

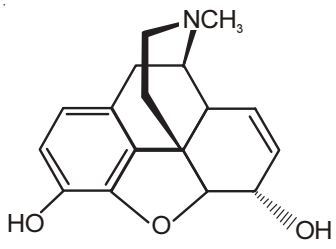
Note :

Due to its anti blood clotting action aspirin finds use in prevention of heart attacks.

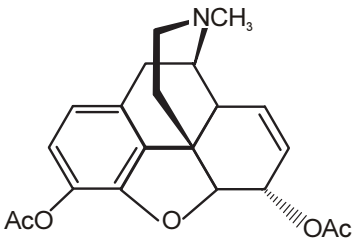
(b) Narcotic analgesics: Example- Morphine and its homologues like Heroin, Codeine etc.

When these drugs are given in medicinal doses, relieve pain and produce sleep. In poisonous, doses produce stupor, coma, convulsions and ultimately death. Morphine narcotics are sometimes referred to as opiates, since they are obtained from opium poppy.

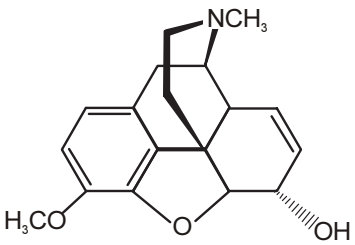
These analgesics, chiefly used for post-operative pain, cardiac pain, pains of terminal cancer and in child birth.



Morphine



Heroin



Codeine

4. Antimicrobials

They destroy or prevent development or inhibit the pathogenic action of microbes such as bacteria (by antibacterial drug), fungi (by antifungal agents), virus (by antiviral agents) or other parasites (antiparasitic drugs) selectively. They include:

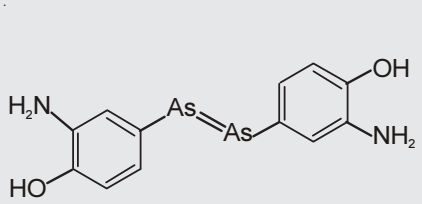
(i) Antibiotics: These are drugs used to cure infections because of low toxicity for humans and animals Initially, they were classified as chemical substances produced by microorganisms, that inhibit the growth or even destroy microorganisms.

According to modified definition of antibiotics, they are substances produced wholy or partly by chemical synthesis, which in low concentrations inhibits the growth or destroys microorganisms by intervening in their metabolic processes.

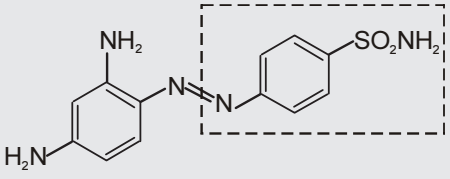
Note :

Paul Ehrlich (German bacteriologist) investigated arsenic based structures in order to produce, less toxic substance for treatment of Syphilis. A medicine named **Arsphenamine** also known as **Salvarsan** was developed, which is effective for treatment of syphilis. Although toxic to human beings but its effect on bacteria, spirochete which causes syphilis is much greater. Also Paul Ehrlich got Nobel Prize in medicine for this discovery.

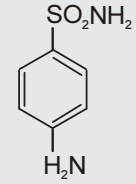
Ehrlich noted similarity in structures of salvarsan and azodyes, as –As=As– linkage present in arsphenamine resembles the –N=N– linkage present in azodyes that may also get the tissues coloured selectively. The first effective antibacterial agent, **prontosil** prepared by Ehrlich which resemble in structure to that of salvarsan. In the body prontosil is converted to compound called **Sulphanil amide**, which is the active compound. Thus sulpha drugs were discovered, the most effective is **Sulphapyridine**.



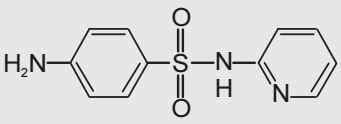
Salvarsan



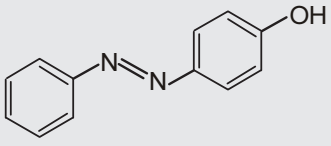
Prontosil



Sulphanilamide



Sulphapyridine



Azodye

The structures of salvarsan, prontosil, azodye and sulphapyridine showing structural similarity.

Alexander Fleming in 1929, discovered the antibacterial properties of **penicillium fungus**.

Antibiotics have either **cidal** (killing) effect or **static** (inhibitory) effect on microbes. Few examples of antibiotics are as follows:

Bactericidal	Bacteriostatic
Penicillin	Erythromycin
Aminoglycosides	Tetracycline
Ofloxacin	Chloramphenicol

The range of microorganisms or bacteria affected by antibiotic is expressed as its spectrum of action.

Two types:

(a) Broad Spectrum antibiotics: Antibiotics which kill or inhibit wide range of Gram-positive and Gram-negative bacteria.

Example:

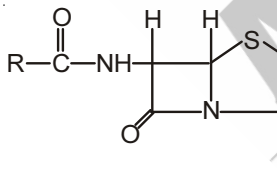
- **Ampicillin**, **Amoxycillin** are synthetic modifications of penicillins, having broad spectrum.
- **Chloramphenicol** was isolated in 1947. It is rapidly absorbed from gastrointestinal tract and can be given orally in case of typhoid, dysentery, acute fever, certain form of urinary infections, meningitis and pneumonia.
- **Vancomycin**, **Ofloxacin** are other examples.

The antibiotic dysidazirine is supposed to be toxic towards certain strains of cancer cells.

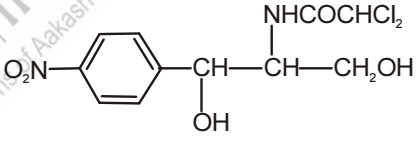
(b) Narrow Spectrum antibiotics: These are effective mainly against Gram-positive or Gram-negative bacteria.

Example: Penicillin G - It is essential to test patients for sensitivity (allergy) to penicillin before administration.

(c) Limited spectrum antibiotics: These are effective against single organism or disease.



General structure of Penicillin



Chloramphenicol

(ii) Antiseptics and Disinfectants

They are chemicals which either kill or prevent growth of microorganisms.

Antiseptics: They are applied to living tissues such as wounds, cuts, ulcers and diseased skin surfaces. They are not ingested like antibiotics.

Examples are:

(i) Furacine, Soframicine.

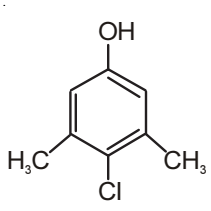
(ii) Dettol, which is a mixture of chloroxylenol and terpineol.

(iii) Bithionol, which is added to soaps to impart antiseptic properties.

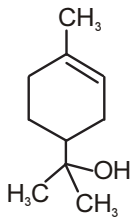
(iv) Iodine, which a powerful antiseptic, is a 2-3% solution in alcohol-water mixture, also known as **tincture of iodine**.

(v) Iodoform, which is also used as antiseptic for wounds.

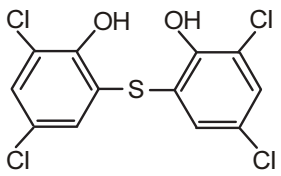
(vi) Boric acid in dilute aqueous solution is a weak antiseptic for eyes.



Chloroxylenol



Terpineol



Bithionol

Disinfectants: They are applied to inanimate objects such as floors, instruments, drainage system etc.

Same substance can act as antiseptic as well as disinfectant by varying its concentration.

For example:

(i) 0.2% solution of phenol is an antiseptic but 1% solution of phenol is disinfectant.

(ii) Chlorine in concentration of 0.2 to 0.4 ppm in aqueous solution and SO_2 in very low concentrations are disinfectants.

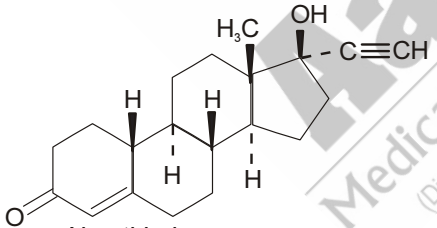
5. Antifertility Drugs

They are used in direction of birth control and in family planning. Birth control pills essentially contains a mixture of synthetic estrogen and progesterone derivatives. Both of these compounds are hormones. Progesterone suppresses ovulation. Synthetic progesterone derivatives are more potent than progesterone.

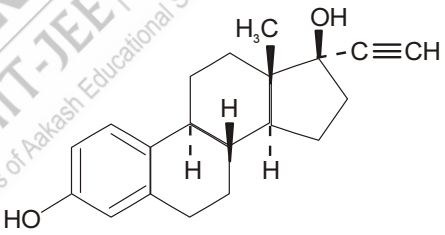
Example:

(i) **Norethindrone** a synthetic progesterone derivative, has antifertility action.

(ii) Estrogen derivative which is used in combination with progesterone derivative is **ethynylestradiol (novestrol)**.



Norethindrone



Ethynylestradiol (novestrol)

Example 6 : *What are tranquilizers?*

Solution : These are the drugs acting on CNS to reduce anxiety, stress, irritability etc.

Example 7 : *Give two examples of broad spectrum antibiotics.*

Solution : Chloramphenicol, Ampicillin.

Example 8 : *Distinguish between antiseptic and disinfectant giving example of each.*

Solution : **Antiseptic-** Applied to living tissues like cuts, wounds etc. These are generally dilute solutions *e.g.*, Dettol, Soframicine etc.

Disinfectants- Applied to inanimate objects. These are generally concentrated solutions *e.g.*, 1% phenol, 0.2—0.4% ppm in aqueous solution of chlorine.

Example 9 : *Why is bithional added to soap?*

Solution : To impart antiseptic properties.

Example 10 : *Sleeping pills are recommended by doctors to the patients suffering from sleeplessness but it is not advisable to take its doses without consultation with doctor. Why?*

Solution : Drugs in higher dosage may produce harmful effects and can act as poison.

Example 11 : *With reference to which classification has the statement, "ranitidine is an antacid", been given?*

Solution : According to pharmacological effect, any drug which is used to neutralize excess of acid present in stomach is called as an antacid.

Example 12 : *What are antipyretic drugs?*

Solution : Chemicals used to lower down body temperature.

Example 13 : *Give example of antifertility drugs.*

Solution : Norethindrone, Novestrol.

EXERCISE

1. Which of the following is not an antihistamine?
   (1) Dimetapp (2) Dimetane
   (3) Seldane (4) Veronal
2. Choose the **incorrect** match
   (1) Tranquilizer – Equanil
   (2) Analgesic – Paracetamol
   (3) Antifertility drug – Bithionol
   (4) Antibiotics – Ofloxacin
3. Which of the following is used to reduce pain without causing impairment of consciousness?
   (1) Tranquilizers (2) Analgesics
   (3) Antihistamines (4) Antiseptics
4. Tincture of iodine is
   (1) 2-3% solution of iodine in alcohol-water mixture
   (2) 12-13% solution of iodine in water
   (3) 0.2-0.3% solution of iodine in alcohol-water mixture
   (4) 5-10% solution of iodine in alcohol
5. Which of the following is broad spectrum antibiotics?
   (1) Ampicillin (2) Amoxycillin
   (3) Ofloxacin (4) All of these

CHEMICALS IN FOOD

Chemicals are added to food for:

(i) Preservation

(ii) Enhancing their appeal

(iii) Adding nutritive value

The main categories of food additives are-

- Food colours
- Flavours and sweeteners
- Fat emulsifiers and stabilising agents
- Flour improvers- antistalling agents and bleaches
- Antioxidants
- Preservatives
- Nutritional supplements like minerals, vitamins and amino acids.

Except for the last one, they do not have nutritive value. They are added to increase shelf life of stored food or for cosmetic purposes.

(a) Artificial Sweetening Agents

They are as sweet as sugar, but have no or less calories, whereas natural sweeteners *e.g.*, sucrose add to calorie intake. It is used by a diabetic person and those who want to control their intake of calories. Ortho-sulphobenzimide, called saccharin is the first popular artificial sweetening agent, which is about 550 times as sweet as cane sugar. It is excreted from the body in urine unchanged. It is harmless and appears to be entirely inert.

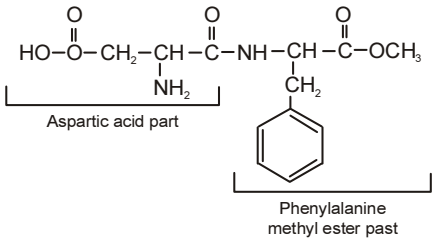
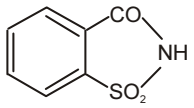
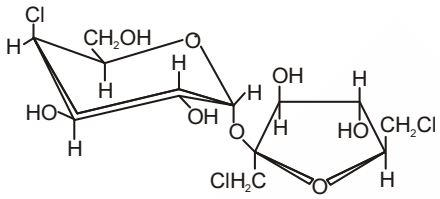
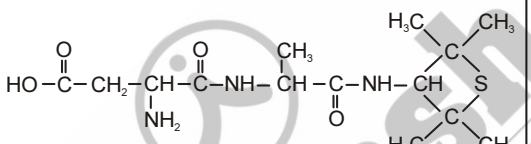
Other examples are:

(i) Aspartame: It is the most successful and widely used sweetener. It is roughly 100 times as sweet as cane sugar. It is methyl ester of dipeptide formed from aspartic acid and phenylalanine. As it is unstable at cooking temperature, its use is limited to cold foods and soft drinks.

(ii) Alitame: It is a high potency sweetener, more stable than aspartame. But control of sweetness of food is difficult while using it.

(iii) Sucralose: It is a trichloro derivative of sucrose. Its appearance and taste are like sugar. It is stable at cooking temperature and does not provide calories.

Artificial Sweeteners

Artificial sweetener	Structural formula	Sweetness value in comparison to cane sugar
Aspartame		100
Saccharin		550
Sucrolose		600
Alitame		2000

(b) Food Preservatives: They prevent spoilage of food due to microbial growth.

Commonly used preservatives are table salt, sugar, vegetable oils, sodium benzoate (C_6H_5COONa), salts of sorbic acid and propanoic acid. Sodium benzoate is used in limited quantities and is metabolised in the body.

(c) Antioxidants in food: These are important and necessary food additives. These help in food preservation by retarding the action of oxygen on food. These are more reactive towards oxygen than the food material which they are protecting. The two most familiar antioxidants are butylated hydroxy toluene (BHT) and butylated hydroxy anisole (BHA). The addition of BHA to butter increases its shelf life from months of years.

Sometimes BHT and BHA along with citirc acid are added to produce more effect. Sulphur dioxide and sulphite are useful anitoxidants for wine and beer, sugar syrups and cut, peeled or dried fuits and vegetables.

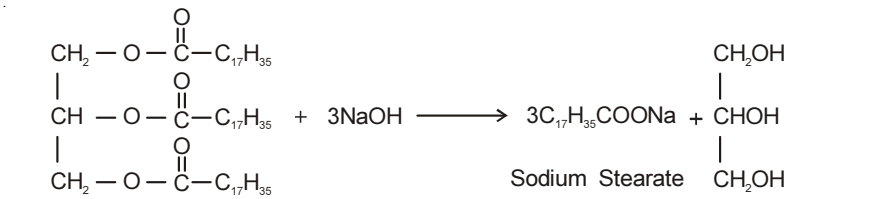
Cleansing Agents

They improve cleansing properties of water and help in removal of fats which bind other materials to the fabric or skin.

(a) Soaps

Soaps used for cleaning purpose are sodium or potassium salts of long chain fatty acids *e.g.,* stearic, oleic and palmitic acids. Soaps containing sodium salts are formed by heating fat (*i.e.*, glyceryl ester of fatty acid) with aqueous sodium hydroxide solution.

This reaction is known as **saponification**.



Glyceryl ester of stearic acid (Fat)

Glycerol (or Glycerine)

In this reaction, esters of fatty acids are hydrolysed and soap obtained remains in colloidal form. It is precipitated from solution by adding sodium chloride. The solution left after removing soap contains glycerol and can be recovered by fractional distillation.

Both sodium and potassium soaps are soluble in water and can be used for cleaning purpose. Generally potassium soaps are soft to the skin than sodium soap.

These can be prepared by taking KOH in place of NaOH in the above reaction.

Types of Soaps: Different types of soaps are made by using different raw materials.

(i) **Toilet Soaps:** They are prepared by using better grades of fats and oils and excess of alkali is removed. Colour and perfumes are added to make these more attractive.

(ii) Soaps that float in water are made by beating tiny air bubbles before their hardening

(iii) **Transparent Soaps:** They are made by dissolving the soap in ethanol and then evaporating the excess solvent.

(iv) **Medicated Soaps:** Substances of medicinal values are added.

(v) **Shaving Soaps:** Contain glycerol to prevent rapid drying. A gum called, rosin is added while making, it forms sodium rosinate which lathers well.

(vi) **Laundry Soaps:** These contains fillers like sodium rosinate, sodium silicate, borax and sodium carbonate.

Soap chips are made by running a thin sheet of melted soap onto a cool cylinder and scraping off the soaps in small broken pieces. Soap granules are dried miniature soap bubbles.

Soap powders and scouring soaps contain some soap, a scouring agent (abrasive) such as powdered pumice or finely divided sand and builders like sodium carbonate and trisodium phosphate. Builders make soaps act more rapidly.

Why soaps do not work in hard water?

As we know that hard water contains calcium and magnesium ions which forms insoluble salts with soaps, that gets separated as scum in water.

$$\underset{\text{Soap}}{2C_{17}H_{35}COONa} + CaCl_2 \longrightarrow 2NaCl + \underset{\text{Insoluble calcium stearate (Soap)}}{(C_{17}H_{35}COO)_2Ca}$$

In fact, the scum so separated offers hinderance to soap action as the precipitate adheres onto the fabric as gummy mass.

Also, the hair washed with hard water looks dull because of this sticky precipitate. Similarly, dyes do not absorb evenly on cloth washed with soap using hard water.

(b) Synthetic Detergents

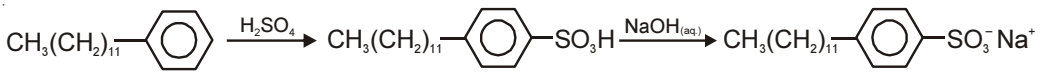
They have all the properties of soaps, but actually do not contain any soap. They can be used in both soft and hard water, some of them can give foam even in ice cold water.

Classification of synthetic detergents: They can be classified into three categories:

(i) **Anionic Detergents :** They are sodium salts of sulphonated long chain alcohols or hydrocarbons. Alkyl hydrogen sulphonates are formed by treating long chain alcohols with conc. H_2SO_4 and neutralised by alkali.

$$\underset{\text{Lauryl alcohol}}{CH_3(CH_2)_{10}CH_2OH} \xrightarrow{H_2SO_4} \underset{\text{Lauryl hydrogen sulphate}}{CH_3(CH_2)_{10}-CH_2OSO_3H} \xrightarrow{NaOH_{(aq.)}} \underset{\text{Sodium Lauryl sulphate (Anionic detergent)}}{CH_3(CH_2)_{10}CH_2OSO_3^-Na^+}$$

Similarly alkyl benzene sulphonate are obtained by neutralising alkyl benzene sulphonic acids with alkali.

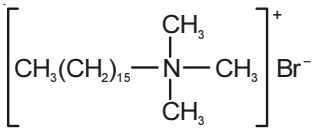


Dodecyl benzene | Dodecyl benzene sulphonic acid | Sodium dodecyl benzene sulphonate

In anionic detergents, anionic part of the molecule is involved in the cleansing action. Sodium salts of alkyl benzenesulphonates are an important class of anionic detergents. They are mostly used for household work, and also in toothpastes.

(ii) Cationic Detergents: They are quarternary ammonium salts of amines with acetates, chlorides or bromides as anions.

Cationic part possess a long hydrocarbon chain with positive charge on nitrogen. Cetyltrimethylammoniumbromide shown below is a cationic detergent.



It is used in hair conditioners and also have germicidal properties. Being expensive they have limited use.

(iii) Non-ionic Detergents: They do not contain any ion in their constitution. It can be formed when stearic acid reacts with polyethyleneglycol.

Stearic acid | Polyethyleneglycol

It is used in liquid diswashing detergents. Their mechanism of cleansing action is same as that of soaps *i.e.*, by micelle formation which removes grease and oil.

Limitations of Detergents: The problem of using detergents is that if their hydrocarbon chain is highly branched, then bacteria cannot degrade this easily and their slow degradation leads to their accumulation. Effluents containing such detergents reach rivers, ponds etc. and persist in water even after sewage treatment. This cause foaming in rivers, ponds and streams which pollutes the water.

Now a days, the branching of hydrocarbon chain is controlled and kept to the minimum. Unbranched chains can be biodegraded more easily and hence pollution is prevented.

Example 14 : *Why do we require sweetening agents?*

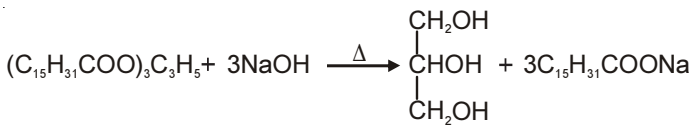
Solution : To reduce calorie intake and to protect teeth decay and are also important for diabetic patient.

Example 15 : *Write chemical equation for preparing sodium soap from glyceryl oleate and glyceryl palmitate. Structural formula of these compounds given below:*

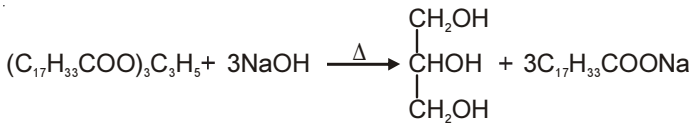
(i) $(C_{15}H_{31}COO)_3C_3H_5$ *– Glyceryl palmitate.*

(ii) $(C_{17}H_{32}COO)_3C_3H_5$ *– Glyceryl oleate.*

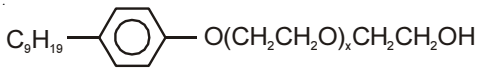
Solution : (i)



(ii)

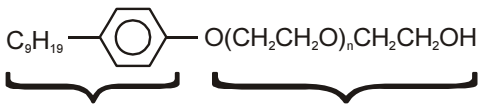


Example 16 : *Following type of non-ionic detergents are present in liquid detergents, emulsifying agents and wetting agents. Label the hydrophilic and hydrophobic parts in the molecule. Identify the functional group(s) present in the molecule.*



(x = 5 to 10)

Solution :



Functional group present — (i) Ether

(ii) 1° Alcoholic group

Example 17 : *Give examples of food preservatives.*

Solution : Table salt, Sugar, Vegetable oils, C_6H_5COONa etc.

Example 18 : *Why are builders added in soap, give their example?*

Solution : Builders make the soaps act more rapidly, *e.g.*, Sodium carbonate, trisodium phosphate.

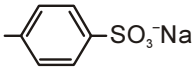
Example 19 : *What type of detergents are used for dish washing?*

Solution : Non-ionic detergents

Example 20 : *Why are detergents preferred over soap?*

Solution : Detergents can be used in hard water as well as in acidic solutions.

EXERCISE

6. Which of the following has maximum sweetness value in comparison to cane sugar?
   (1) Aspartame (2) Alitame
   (3) Sucralose (4) Saccharin
7. Which of the following is not an example of detergent?
   (1) $(CH_3)(CH_2)_{10}CH_2OSO_3^-Na^+$ (2) $[CH_3(CH_2)_5 - N(CH_3)_3]^{\oplus}Br^-$
   (3)  (4) $C_{17}H_{35}COONa$
8. Choose the correct statement
   (1) Aspartame is unstable at cooking temperature
   (2) Sucralose is a trichloroderivative of sucrose
   (3) Saccharin contains benzene ring
   (4) All are correct
9. Identify the food preservative
   (1) Table salt (2) C_6H_5COONa
   (3) Sugar (4) All of these

10. Which of the following is a by-product of soap-industry?

(1) NaCl (2) Glycerol

(3) Soap (4) Fatty acid

Note :

1. Lead aresnate, clcium arsenate, Paris green, fluorine compounds etc are the examples of **inorganic insecticides.** Nicotine, rotenone, allethrin, pyrethrins are the examples of **natural insecticides.**
2. Nitrophenol, DDT, methoxychlor, BHC (Gammexene of Lindane), aldrin, dieldrin, toxaphene, tetraethyl pryophosphate (TEPP), malathion, parathion etc are examples of **organic insecticides.**
3. Diethyl toluamide is an all purpose **repellent.** Thuricide is another **repellent.**
4. Chloropicrin carbondisulphide, methyl bromide, ethylene dibromide, halogenated alkanes etc are well known **fumigants.** Kelthane, tetradifon, morocide etc are the examples of **miticides.**
5. **Fibres** to be dyed are products of **vegetable origin** (e.g. cotton, linen and paper), **animal origin** (e.g. silk, wool, fur etc) and **man made or synthetic origin** (e.g. nylon, dacron, viscose rayon etc.)
6. An **explosive** is a material, which under the influence of thermal and mechanical shock, decomposes rapidly and spontaneously with the evolution of great amount of heat and large volume of gases. **Gun powder** is a mixture of sulphur, charcoal and salt petre and generally contains 15% charcoal, 10% sulphur and 75% salt petre.
7. **Gun cotton** consists of cellulose, a compound of C, H and O. **Nitrocellulose** is prepared by the action of a mixture of conc. HNO_3 and conc H_2SO_4 on cellulose. **Nitroglycerine** was discovered by **Alfred Nobel in 1862.** Mixed with kieselguhr, nitroglycerine is called **dynamite. Cordite** is prepared by mixing a paste of gun cotton (65%) with nitroglycerine, acetone and vaseline. Picric acid, EDNA, TNT, RDX, HMX etc are other powerful explosives in use.
8. **Sedatives. These drugs act as depressant and suppress the activities of the central nervous system.** They are given to patients who are mentally agitated and violent. Sedatives produce a feeling of calmness, relaxation or drowsiness in the body. Their higher doses, however, induce sleep. The most commonly used sedatives are **valium and barbiturates**.
9. **Antidepressants.** These drugs are given to patients with shattered confidence. These produce a feeling of well-being and boost confidence. That is why these are also called **mood booster drugs**. Some common examples are **vitalin cocaine and methadrine** etc.
10. **Hypnotics.** These are also known as tranquilizers and are used to reduce mental tension and anxiety. An important example of hypnotic is chloretone.

    The lower doses of hypnotics or tranquilizers generally do not induce sleep.

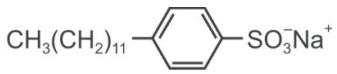
❑ ❑ ❑

Assignment

SECTION - A

NCERT Based MCQs

1. An anionic detergent with formula **[NCERT Pg. 460]**



is known as

(1) Polyethyleneglycol

(2) Lauryl hydrogensulphate

(3) Sodium laurylsulphate

(4) Sodium dodecylbenzenesulphonate

2. Which of the following artificial sweeteners has the highest sweetness value in comparison to cane sugar? **[NCERT Pg. 457]**

(1) Sucralose (2) Alitame

(3) Aspartame (4) Saccharin

3. Which of the following drugs is classified as a Tranquilizer? **[NCERT Pg. 452]**

(1) Equanil (2) Penicillin

(3) Brompheniramine (4) Chloramphenicol

4. Control of sweetness of food is difficult while using **[NCERT Pg. 458]**

(1) Saccharin

(2) Aspartame

(3) Sucralose

(4) Alitame

5. Which among the following is an analgesic? **[NCERT Pg. 453]**

(1) Aspirin (2) Equanil

(3) Ofloxacin (4) Salvarsan

6. Main chemical components of 'Dettol' are **[NCERT Pg. 456]**

(1) Bithionol and terpineol

(2) Bithionol and chloroxylenol

(3) Chloroxylenol and terpineol

(4) Terpineol and ampicillin

7. Which among the following is not a tranquilizers? **[NCERT Pg. 452]**

(1) Chloramphenicol (2) Chlordiazepoxide

(3) Equanil (4) Meprobamate

8. Which of the following is not a barbiturate? **[NCERT Pg. 453]**

(1) Veronal (2) Morphine

(3) Amytal (4) Luminal

9. Which of the following is not a broad spectrum antibiotics? **[NCERT Pg. 455]**

(1) Ampicillin

(2) Chloramphenicol

(3) Vancomycin

(4) Penicillin G

10. Which of the following does not act as a food preservative? **[NCERT Pg. 458]**

(1) Table salt (2) Sugar

(3) Blue vitriol (4) Vegetable oil

11. Which of the following is an antihistamine? **[NCERT Pg. 451]**

(1) Brompheniramine (2) Aspirin

(3) Penicillin (4) Iodoj

12. Which of the following plays a role in mood changes? **[NCERT Pg. 452]**

(1) Paracetamol

(2) Noradrenaline

(3) Alitame

(4) Sodium dodecylbenzene sulphonate

13. Butylated hydroxy toluene is used as **[NCERT Pg. 458]**

(1) Detergent

(2) Food preservative

(3) Soap

(4) Antioxidants in food

14. In order to prevent rapid drying, shaving soaps contains **[NCERT Pg. 459]**
(1) Glycerol (2) Rosin
(3) Sodium carbonate (4) Trisodium phosphate

15. Which of the following is an anti-fertility drug? **[NCERT Pg. 456]**
(1) Norethindrone (2) Chloramphenicol
(3) Soframicine (4) Tetracycline

SECTION - B

Objective Type Questions

1. Barbituric acid is used as
(1) Antipyretic (2) Antiseptic
(3) Antibiotic (4) Tranquilizer

2. Aspirin is a/an
(1) Analgesic (2) Narcotic
(3) Antibiotic (4) Tranquilizer

3. Cetyltrimethylammonium bromide is a common
(1) Non-ionic detergent
(2) Cationic detergent
(3) Anionic detergent
(4) Antioxidant

4. Which of the following is/are use as antacids?
(1) $NaHCO_3$ (2) Na_2CO_3
(3) $Mg(OH)_2$ (4) Both (1) & (3)

5. Which of the following is used in local anaesthesia?
(1) Chloramphenicol (2) Procaine
(3) Diazepam (4) Penicillin

6. Chloramine-T is a/an
(1) Antiseptic (2) Antipyretic
(3) Analgesic (4) Food preservative

7. Identify **incorrect** statement(s).
(1) Tetracycline is a broad spectrum antibiotic
(2) Streptomycin is used in treatment of tuberculosis
(3) Penicillin is a narrow spectrum antibiotic
(4) All antibiotics are chemical substances used to kill microorganisms

8. **Incorrect** match is
(1) P-dichlorometaxylenol : Body deodorant
(2) Bithionol : Medicated soaps
(3) Thymol : Antiseptic
(4) Phenol (0.2%) : Antiseptic

9. Morphine is an
(1) Antiseptic (2) Antibiotic
(3) Analgesic (4) Anaesthetic

10. Identify **correct** statement.
(1) Sodium lauryl sulphate is a biodegradable detergent
(2) Alitame is sweetening agent
(3) Aspartame, a sweetening agent is unstable at cooking temperature
(4) All of these

11. Which of the following is an anti-fertility drug?
(1) Chloramphenicol (2) Norethindrone
(3) Tetracycline (4) Sulphanilamide

12. Which of the following are tranquilizers?
(1) Equanil (2) Barbituric acid
(3) Serotonin (4) All of these

13. Phenacetin is an/a
(1) Analgesic (2) Antipyretic
(3) Antimalarial (4) Antihistamines

14. Identify a food preservative from the following.
(1) Saccharin
(2) $NaHCO_3$
(3) Omeprazole
(4) Sodium benzoate

15. A drug which can be used as antipyretic as well as analgesic is
(1) Chloroquine (2) Penicillin
(3) Paracetamol (4) Dettol

16. Which of the following is not an antibiotic?
(1) Penicillin (2) Ofloxacin
(3) Bithional (4) Amoxycillin

17. Which of the following artificial sweetener has the least sweetening value?
(1) Sucralose (2) Alitame
(3) Aspartame (4) Saccharin

18. Choose the **incorrect** match.
(1) Antipyretics : Phenacetin
(2) Tranquilizers : Valium
(3) Antifertility drug : Mifepristone
(4) Antacid : Terfenadine

19. Which of the following is not a good 'antacid'?
(1) $NaHCO_3$ (2) $Al(OH)_3$
(3) $Mg(OH)_2$ (4) $Al(OH)_3 + Mg(OH)_2$

20. Chlordiazepoxide and meprobamate are examples of
(1) Antihistamines (2) Tranquilizers
(3) Antibiotics (4) Antifertility drugs

21. Which of the following is not an antiseptic?
(1) Tincture of iodine
(2) Aqueous boric acid
(3) 0.2% phenol
(4) Aqueous Cl_2 (0.2 – 0.4 ppm)

22. Norethindrone and ethynylestradiol are
(1) Neurotransmitters
(2) Antifertility drugs
(3) Bactericidal antibiotics
(4) Bacteriostatic antibiotics

23. Which of the following has highest sweetness value?
(1) Aspartame (2) Saccharin
(3) Alitame (4) Sucralose

24. Which of the following detergents forms cationic micelles in aqueous solution?
(1) Sodium lauryl sulphate
(2) Sodium stearate
(3) Sodium dodecylbenzenesulphonate
(4) Cetyltrimethylammonium bromide

25. Branched chain synthetic detergents. (choose the incorrect statement)
(1) Are highly biodegradable
(2) Work even in hard water
(3) Can be cationic, anionic or non ionic
(4) All are incorrect

26. Chloroxylenol is a component of
(1) Antifertility drugs (2) Analgesics
(3) Antiseptics (4) Food preservatives

27. Which of the following does not have antiseptic property?
(1) Barbiturates (2) Boric acid
(3) Bithionol (4) Iodoform

28. Tetracycline and chloramphenicol are examples of
(1) Bactericidal antibiotics
(2) Bacteriostatic antibiotics
(3) Antacids
(4) Analgesics

29. The artificial sweeteners used only in cold foods and soft drinks is
(1) Alitame (2) Sucralose
(3) Aspartame (4) Saccharin

30. Select the incorrect match

	Column I		Column II
(1)	Chloramphenicol	–	Broad spectrum antibiotic
(2)	Morphine	–	Non-narcotic analgesics
(3)	Cationic detergents	–	Hair conditioners
(4)	C_6H_5COONa	–	Food preservative

SECTION - C

Previous Years Questions

1. The artificial sweetener stable at cooking temperature and does not provide calories is **[NEET-2019 (Odisha)]**
(1) Alitame (2) Saccharin
(3) Aspartame (4) Sucralose

2. Among the following, the narrow spectrum antibiotic is **[NEET-2019]**
(1) Penicillin G (2) Ampicillin
(3) Amoxycillin (4) Chloramphenicol

3. Mixture of chloroxylenol and terpineol acts as **[NEET-2017]**
(1) Analgesic (2) Antiseptic
(3) Antipyretic (4) Antibiotic

4. Which of the following is an analgesic? **[NEET-2016]**
(1) Chloromycetin (2) Novalgin
(3) Penicillin (4) Streptomycin

5. Nitrogen dioxide and sulphur dioxide have some properties in common. Which property is shown by one of these compounds, but not by the other? **[AIPMT-2015]**
   (1) Is used as a food-preservative
   (2) Forms 'acid-rain'
   (3) Is a reducing agent
   (4) Is soluble in water

6. Bithional is generally added to the soaps as an additive to function as a/an **[AIPMT-2015]**
   (1) Antiseptic (2) Softener
   (3) Dryer (4) Buffering agent

7. Artificial sweetener which is stable under cold conditions only is **[AIPMT-2014]**
   (1) Saccharine (2) Sucralose
   (3) Aspartame (4) Alitame

8. Antiseptics and disinfectants either kill or prevent growth of microorganisms. Identify which of the following statements is not true ? **[NEET-2013]**
   (1) Chlorine and Iodine are used as strong disinfectants
   (2) Dilute solutions of Boric acid and Hydrogen peroxide are strong antiseptics
   (3) Disinfectants harm the living tissues
   (4) A 0.2% solution of phenol is an antiseptic while 1% solution acts as a disinfectant

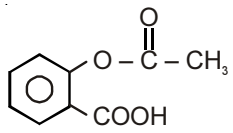
9. Chloroamphenicol is an **[AIPMT (Mains)-2012]**
   (1) Antifertility drug
   (2) Antihistaminic
   (3) Antiseptic and disinfectant
   (4) Antibiotic-broad spectrum

10. Which one of the following is employed as Antihistamine? **[AIPMT (Prelims)-2011]**
   (1) Omeprazole (2) Chloramphenicol
   (3) Diphenyl hydramine (4) Norothindrone

11. Which one of the following is employed as a Tranquilizer drug? **[AIPMT (Prelims)-2010]**
   (1) Promethazine (2) Valium
   (3) Naproxen (4) Mifepristone

12. Which one of the following is employed as a tranquilizer? **[AIPMT (Prelims)-2009]**
   (1) Naproxen (2) Tetracycline
   (3) Chlorpheninamine (4) Equanil

Questions asked Prior to Medical Ent. Exams. 2005

13. 

   The compound is used as
   (1) An anti-inflammatory compound
   (2) Analgesic
   (3) Hypnotic
   (4) Antiseptic

14. Which one of the following statements is not true?
   (1) Ampicillin is a natural antibiotic
   (2) Aspirin is both analgesic and antipyretic
   (3) Sulphadiazine is a synthetic antibacterial drug
   (4) Some disinfectants can be used as antiseptics

15. Which of the following can possibly be used as analgesic without causing addiction and mood modification?
   (1) Drazepom
   (2) Tetrahydrocatinol
   (3) Morphine
   (4) N-acetyl-para-aminophenol

16. Which of the following is an anionic detergent?
   (1) $CH_3(CH_2)_{15}(CH_3)_3N^+Br^-$
   (2) $CH_3(CH_2)_{16}CH_2OSO_3^-Na^+$
   (3) $CH_3(CH_2)_{16}COO(CH_2CH_2O)_nCH_2CH_2OH$
   (4) $CH_3(CH_2)_{16}COO^-Na^+$

17. Non-ionic detergents are
   (1) Salts of sulphonic acid
   (2) Quaternary ammonium salts
   (3) Esters
   (4) All of these

SECTION - D

NEET Booster Questions

1. Morphine is
   (1) Antiseptic (2) Antibiotic
   (3) Analgesic (4) Anaesthetic

2. Which compound commonly is used as food preservative?
   (1) C_6H_5ONa (2) C_6H_5COONa
   (3) NaOH (4) CH_3COONa

3. Which of the following is/are synthetic sweeteners?
(1) Saccharin (2) Aspartame
(3) Alitame (4) All of these

4. Penicillin G is
(1) Antiseptic (2) Antibiotic
(3) Food preservative (4) Tranquilizers

5. Class of chemical compounds which are used for the treatment of mental disease are called
(1) Antacids (2) Antipyretic
(3) Tranquilizers (4) Antiseptic

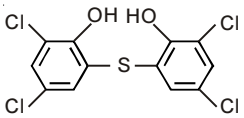
6. Norethindrone is widely used as
(1) Antacid (2) Antihistamine
(3) Antibiotic (4) Antifertility drug

7. Which of the following is not an antiseptic drug?
(1) Iodoform
(2) Dettol
(3) B.H.C
(4) 0.2% solution of phenol

8. Ranitidine is
(1) Tranquilizer (2) Antidepressant
(3) Analgesics (4) Antacid

9. Barbituric acid and its derivatives are well known as
(1) Tranquilizers (2) Antiseptics
(3) Antibiotic (4) Antipyretics

10. Which of the following is an antacid?
(a) Ranitidine (b) Cimetidine
(c) Salvarsan (d) Saccharin
(1) c, d (2) b, c
(3) a, b (4) a, b, c

11. 

The compound is
(1) Antipyretic (2) Antihistamine
(3) Tranquilizers (4) Antiseptic

12. Find the incorrect statement
(1) Barbiturates are hypnotic
(2) 4-Acetamidophenol is antipyretic
(3) All tranquilizers work by same mechanism
(4) The antibiotic which kills microbes is called bactericidal

13. Which group is not an example of chromophores?
(1) NO_2 (2) N = O
(3) NH_2 (4) N = N

14. Which of the following is not correctly match?

	Column-I		Column-II
(1)	Iodoform	–	Antiseptic powder
(2)	Barbiturates	–	Hypnotic drug
(3)	Hydrogen peroxide	–	Antacid
(4)	Boric acid	–	Antimicrobial

15. Major point of difference between antiseptic and disinfectant is
(1) Antiseptic prevents growth of micro organism
(2) Disinfectant kills micro-organism
(3) Disinfectant are not safe to be applied to living tissues
(4) Both (1) & (2)

16. 1% phenol acts as
(1) Disinfectant (2) Antiseptic
(3) Analgesic (4) Both (1) & (2)

17. Chemical compounds used for releasing stress are
(1) Analgesic (2) Tranquilizer
(3) Antiseptic (4) Antimicrobials

18. Which of the following is not a constituent of talcum powder?
(1) Talc (2) Zinc sulphide
(3) Zinc stearate (4) Perfume

19. Which of the following is not a tranquilizer?
(1) Morphine (2) Nembutal
(3) Veronal (4) Amytal

20. Sweetest artificial sweetener is
(1) Saccharin (2) Aspartame
(3) Sucralose (4) Alitame

21. Chemotherapy is
(1) Use of heat for therapeutic effect
(2) Use of chemical for therapeutic effect
(3) Use of natural reagent for therapeutic effect
(4) All of these

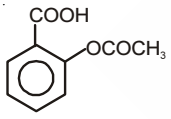
22. How do enzyme catalyse the reaction?
(1) By holding the substrate molecule for chemical reaction
(2) By providing functional groups which will attack the substrate to carry out chemical reaction
(3) Both (1) & (2)
(4) Neither (1) nor (2)

23. Drugs which compete with natural substrate for their attachment on the active sites of enzymes are called
(1) Enzyme Inhibitors
(2) Competitive Inhibitors
(3) Non-competitive Inhibitors
(4) Drug targets

24. Drugs which interfere with natural action of histamine by competing with histamine are called
(1) Antidepressant
(2) Antihistamines
(3) Antimicrobial
(4) Antipyretic

25. Barbituric acid and its derivatives constitutes an important class of
(1) Narcotic analgesic (2) Antiallergic
(3) Tranquilizers (4) Antimicrobial

26. Non-narcotics includes all, except
(1) Ibuprofen (2) Paracetamol
(3) Opiate (4) Diclofenac sodium

27. Important function of the drug with the following structure  is
(1) Reducing fever
(2) Relieving pain
(3) Anti blood clotting action
(4) All of these

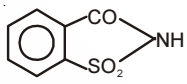
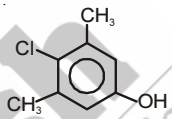
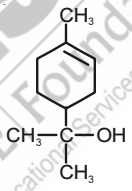
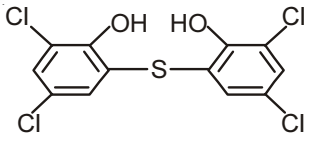
28. The first antibiotic was _____ and was discovered by _____.
(1) Ofloxacin – Ehrlich
(2) Streptomycin – Alexander Fleming
(3) Streptomycin – Ehrlich
(4) Penicillin – Alexander Fleming

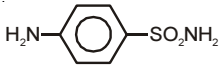
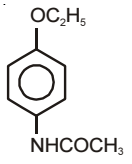
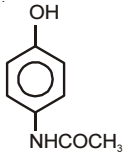
29. Bacteriostatic drugs work by
(1) Arresting the growth of organisms
(2) By increasing immunity and resistance of body to infection
(3) By killing the organism in the body
(4) Both (1) & (3)

30. Antibiotics which do not have bactericidal action among the following is
(1) Penicillin (2) Tetracycline
(3) Ofloxacin (4) Aminoglycosides

31. Antiseptic which is a mixture of chloroxylenol and α-terpineol is
(1) Savlon (2) Dettol
(3) Bithional (4) Salol

32. Drugs which contain mixture of norethindrone and ethynylestradiol are
(1) Antibiotics (2) Antifertility
(3) Antiseptic (4) Antacid

33. The correct structure of Bithional is
(1) 
(2) 
(3) 
(4) 

34. Which is mismatched regarding the structure?
(1)  - Sulphanilamide
(2)  - Aspirin
(3)  - Paracetamol
(4) Both (2) & (3)

35. Salvarsan is an antimicrobial agent which is used for curing
(1) Malaria (2) Allergy
(3) Syphilis (4) Depression

36. Antacids include
(1) Omeprazole (2) Lansoprazole
(3) Sodium bicarbonate (4) All of these

37. Drugs can be classified on the basis of
(1) Pharmocological effect
(2) Drug action
(3) Chemical structure
(4) All of these

38. Drawback of excess of hydrogen carbonate taking as antacid is
(1) It is insoluble
(2) It can trigger the production of even more acid
(3) It causes ulcer
(4) It causes pain and irritation

39. Tranquilizers are prescribed for curing
(1) Anxiety, stress, irritability
(2) The growth of microorganism
(3) Pain, Fever
(4) All of these

40. Tincture of iodine is
(1) Iodoform
(2) 100% Iodine
(3) 2-3% Iodine solution in alcohol-water
(4) Iodobenzene

41. 0.2% of solution of phenol and 0.2–0.4 ppm chlorine in aqueous solution respectively behave as
(1) Antiseptic, Disinfectant
(2) Disinfectant, Antiseptic
(3) Disinfectant, Disinfectant
(4) Antiseptic, Antiseptic

42. Birth control pills essentially contains
(1) Synthetic estrogen
(2) Synthetic progesterone
(3) Both (1) & (2)
(4) Neither (1) nor (2)

43. Which is mismatched, regarding the examples?
(1) Broad spectrum Antibiotic - Chloramphenicol
(2) Narrow spectrum antibiotic - Ampicillin
(3) Antiseptic - Furacine
(4) Antifertility - Novestrol

44. Which of the following is not used as an antidepressant?
(1) Iproniazid (2) Phenelzine
(3) Salvarsan (4) Nardil

45. The groups which are responsible for imparting colour to dyes is/are
(1) $— NO_2$ (2) — NO
(3) $— N \equiv N$ (4) All of these

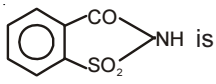
46. Chemicals are added to food for
(1) Preservation
(2) Enhancing the appeal
(3) Adding nutritive value
(4) All of these

47. The first popular artificial sweetening agent is
(1) Saccharin (2) Aspartame
(3) Alitame (4) Both (2) & (3)

48. The main disadvantage associated with use of aspartame is
(1) Its sweetening power is less
(2) It is unstable at cooking temperature
(3) It provide calories
(4) It is difficult to control its sweetness

49. Which of the following can be used as food preservative?
(1) Vegetable oil (2) Table salt
(3) Sodium benzoate (4) All of these

50. Among the following, the maximum high potency sugar is
(1) Saccharin (2) Alitame
(3) Sucrolose (4) Aspartame

51. The compound with structure 

is used as
(1) Food preservative (2) Artificial sweetener
(3) Medicine (4) Edible colour

52. Which is incorrect regarding antioxidants?
(1) They retard the action of oxygen on food
(2) Helps in food preservation for long time
(3) Butylated hydroxy toluene and Butylated hydroxy anisole are important antioxidant
(4) They are flavouring agent

53. Which of the following will not enhance nutritional value of food?
(1) Minerals
(2) Artificial sweetners
(3) Vitamins
(4) Amino acids

54. Soaps are sodium or potassium salt of long chain fatty acids like
(1) Palmitic acid (2) Oleic acid
(3) Stearic acid (4) All of these

55. Glycerylester of Stearic acid + NaOH $\longrightarrow$ Sodium stearate + 'A'
Product 'A' in the above reaction is
(1) Acetone (2) Glycol
(3) Methanol (4) Glycerol

56. Soaps which are made by dissolving the soap in ethanol and then evaporating the excess solvent are called
(1) Transparent soap
(2) Shaving soap
(3) Medicated soap
(4) Toilet soap

57. The fillers that can be present in laundry soap is/are
(1) Sodium rosinate (2) Borax
(3) Sodium silicate (4) All of these

58. Soap powders and scouring soap contains builders like
(1) Trisodium phosphate (2) Finely divided sand
(3) Powdered pumice (4) All of these

59. Soaps on reaction with hard water forms insoluble scum due to the formation of
(1) NaCl (2) $CaCl_2$
(3) $C_{17}H_{35}COONa$ (4) $(C_{17}H_{35}COO)_2Ca$

60. Which type of detergents are preferably used in liquid dishwashing?
(1) Cationic detergent
(2) Anionic detergent
(3) Non-ionic detergent
(4) All of these

61. Which of the following is incorrect?
(1) In anionic detergent, anionic part of the molecule is involved in cleansing action
(2) Alkyl benzene sulphonate can be formed by neutralising alkyl benzene sulphonic acid with alkali
(3) Branched chain detergents are more easily biodegradable
(4) Cetyltrimethylammonium bromide is a cationic detergent

62. Glyceryl oleate can be represented by the formula
(1) $(C_{15}H_{31}COO)_3C_3H_5$
(2) $(C_{17}H_{33}COO)_3C_3H_5$
(3) $(C_{17}H_{35}COO)_3C_3H_5$
(4) Both (2) & (3)

63. Which is correctly matched regarding the use?
(1) Anionic detergent - Hair conditioners
(2) Cationic detergent - Household work and in toothpaste
(3) Non-ionic detergent - Liquid dishwashing
(4) All of these

64. Biodegradable detergent should have
(1) Phenyl side chain
(2) Aromatic side chain
(3) Normal unbranched side chain
(4) Branched side chain

65. Which of the following enhances lathering property of soap?
(1) Sodium carbonate
(2) Sodium rosinate
(3) Sodium stearate
(4) Trisodium phosphate

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Chapter 21

The *d*- and *f*-Block Elements

Chapter Contents

Introduction

Classification of elements in blocks is based on their characteristic properties. During filling of electrons the last electron decides the block of the element. *d*-block contains 3 to 12 group. A number of compounds of this block elements are important catalyst in industry. These elements attract special attention of chemists because of their special chemistry.

In this chapter, we are going to study the usual and unusual properties of these elements which make them **so important**.

POSITION IN THE PERIODIC TABLE

The *d*-block of the periodic table contains the elements of group 3-12 in which the *d* orbitals are progressively filled in each of the four long periods. The name "transition" given to the element of *d*-block is only because of their position between *s* and *p*-block elements. There are four series of the transition metals 3*d* series (Sc to Zn), 4*d* series (Y to Cd) and 5*d* (La, Hf to Hg) and 6*d* series (Ac, unq to Uub).

Definition of Transition Element

A transition element is defined as the one which has incompletely filled *d* orbitals in its ground state or in their most common oxidation state. Zn, Cd and Hg are not typical transition elements because they have full d^{10} configuration in their ground state as well as in their common oxidation state.

However, being the last members of three transition series, their chemistry is studied along with the chemistry of transition metals.

ELECTRONIC CONFIGURATIONS OF THE *d*-BLOCK ELEMENTS

General E.C. of the *d*-block element is as

For 3*d* series	$3d^{1-10}\ 4s^{1-2}$	Overall $(n-1)d^{1-10}ns^{0-2}$
For 4*d* series	$4d^{1-10}\ 5s^{0-2}$	
For 5*d* series	$5d^{1-10}\ 6s^{1-2}$	
For 6*d* series	$6d^{1-10}\ 7s^{1-2}$	

Outer Electronic Configurations of the Transition Elements (ground state)

1st Series										
	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Z	21	22	23	24	25	26	27	28	29	30
4s	2	2	2	1	2	2	2	2	1	2
3d	1	2	3	5	5	6	7	8	10	10

2nd Series										
	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd
Z	39	40	41	42	43	44	45	46	47	48
5s	2	2	1	1	1	1	1	0	1	2
4d	1	2	4	5	6	7	8	10	10	10

3rd Series										
	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg
Z	57	72	73	74	75	76	77	78	79	80
6s	2	2	2	2	2	2	2	1	1	2
5d	1	2	3	4	5	6	7	9	10	10

4th Series										
	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Uub
Z	89	104	105	106	107	108	109	110	111	112
7s	2	2	2	2	2	2	2	2	1	2
6d	1	2	3	4	5	6	7	8	10	10

However, this generalisation has several exceptions because of very little energy difference between (n – 1)*d* and ns orbitals. Furthermore half filled and fully filled sets of orbitals are relatively more stable. Apart from it as Z^* increases energy gap between (n – 1)*d* and ns decreases, which is small enough to prevent electron entering in (n – 1)*d* before completely filling of ns.

The *d* orbitals of the transition element project to the periphery of an atom more than the other orbitals (*s* and *p*). Hence, they are more influenced by the surrounding as well as affecting the atoms or molecules surrounding them.

Example 1 : *On what ground can we say that Sc(Z = 21) is a transition element while Zn(Z = 30) is not?*

Solution : E.C. of $_{21}Sc = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^1\ 4s^2$. In this E.C. 3*d* orbital have one electron in its ground state. That is why it is regarded as a transition element.

E.C. of $Zn = 1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2$

Zn does not have partly filled *d* orbital in its ground state or in its excited state that is why it is not considered as a typical transition element.

Example 2 : *Copper atom has completely filled d orbitals ($4d^{10}$) in its ground state. How can we say that it is a transition element?*

Solution : Transition element is defined as the one which has incompletely filled *d* orbitals in its ground state or in their most common oxidation state. Cu in its +2 oxidation state exhibit $4d^9$ E.C. That is why it is considered as a transition element.

Note :

As per rule (Aufbau Rule) last electron is filled in 3d after filling of 4s in Fe. But during removal last electron is removed from ultimate shell that is (4s) and hence E.C. of Fe^{2+} is $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6$.

Aufbau Rule or (n + l) Rule is only valid for unfilled orbital. After filling of the electron in E.C. higher will be value of n higher will be energy and if value of n is same then higher will be value of l higher will be energy.

For s orbital, l = 0

p, l = 1

d, l = 2

f, l = 3

GENERAL PROPERTIES OF THE TRANSITION ELEMENTS (*d*-BLOCK)

Physical Properties

Nearly all the transition elements display metallic properties such as high tensile strength, ductility, malleability, high thermal and electrical conductivity and metallic lustre.

Note : Except Zn, Cd, Hg and Mn, other metals have one or more typical metallic structure at normal temperature.

Lattice Structures of Transition Metals

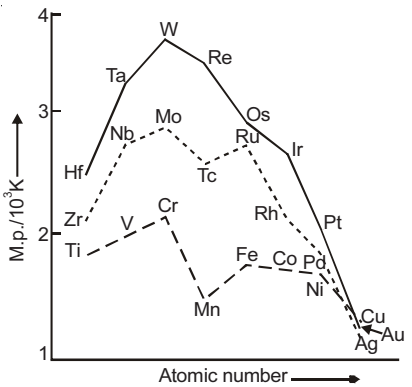
Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
hcp (bcc)	hcp (bcc)	bcc	bcc	X (bcc, ccp)	bcc (hcp)	ccp (hcp)	ccp	ccp	X (hcp)
Y	**Zr**	**Nb**	**Mo**	**Tc**	**Ru**	**Rh**	**Pd**	**Ag**	**Cd**
hcp (bcc)	hcp (bcc)	bcc	bcc	hcp	hcp	ccp	ccp	ccp	X (hcp)
La	**Hf**	**Ta**	**W**	**Re**	**Os**	**Ir**	**Pt**	**Au**	**Hg**
hcp (ccp,bcc)	hcp (bcc)	bcc	bcc	hcp	hcp	ccp	ccp	ccp	X

(bcc = body centred cubic; hcp = hexagonal close packed; ccp = cubic close packed; X = a typical metal structure).

The transition metals (with the exception of Zn, Cd, Hg) are very much harder and have low volatility. Their melting points and boiling points are high.

The high melting points of these metals are attributed to involvement of greater number of electrons from (n – 1)*d* in the addition to ns electrons in the interatomic metallic bonding.

In any row the melting points of these metals rise to maximum at d^5 except for anamolous behaviour of Mn and Tc and fall regularly as the atomic number increases. They have high enthalpies of atomisation which is shown in figure.



Trends in melting points of transition elements

In general **greater the number of valence electrons, stronger is the resultant bonding**. Since the enthalpy of atomisation is an important factor in determining the standard electrode potential of a metal, metals with very high enthalpy of atomisation *i.e.*, very high boiling point tend to be noble in their reactions.

Another generalisation that may be drawn that metals of the 2nd and 3rd series have greater enthalpies of atomisation than the corresponding elements of 1st series. This is an important factor in accounting for the occurrence of much more frequent metal-metal bonding in compounds of heavy transition metals.

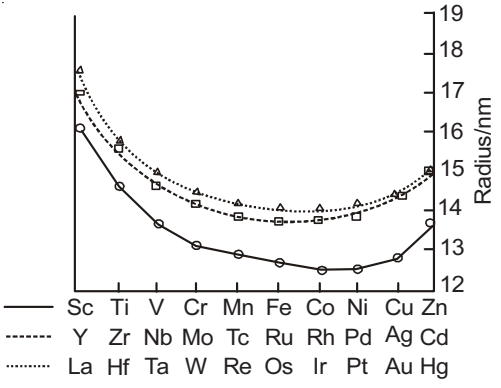
Electronic Configurations and some other Properties of the First Series of Transition Elements

Element		Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Atomic number		21	22	23	24	25	26	27	28	29	30
Electronic configuration											
	M	$3d^1 4s^2$	$3d^2 4s^2$	$3d^3 4s^2$	$3d^5 4s^1$	$3d^5 4s^2$	$3d^6 4s^2$	$3d^7 4s^2$	$3d^8 4s^2$	$3d^{10} 4s^1$	$3d^{10} 4s^2$
	M^+	$3d^1 4s^1$	$3d^2 4s^1$	$3d^3 4s^1$	$3d^5$	$3d^5 4s^1$	$3d^6 4s^1$	$3d^7 4s^1$	$3d^8 4s^1$	$3d^{10}$	$3d^{10} 4s^1$
	M^{2+}	$3d^1$	$3d^2$	$3d^3$	$3d^4$	$3d^5$	$3d^6$	$3d^7$	$3d^8$	$3d^9$	$3d^{10}$
	M^{3+}	[Ar]	$3d^1$	$3d^2$	$3d^3$	$3d^4$	$3d^5$	$3d^6$	$3d^7$	–	–
Enthalpy of atomisation, $\Delta_a H^\ominus$ kJ mol^{-1}											
		326	473	515	397	281	416	425	430	339	126
Ionisation enthalpy/$\Delta_i H^\ominus$ kJ mol^{-1}											
$\Delta_i H^\ominus$	I	631	656	650	653	717	762	758	736	745	906
$\Delta_i H^\ominus$	II	1235	1309	1414	1592	1509	1561	1644	1752	1958	1734
$\Delta_i H^\ominus$	III	2393	2657	2833	2990	3260	2962	3243	3402	3556	3829
Metallic/ionic	M	164	147	135	129	137	126	125	125	128	137
radii/pm	M^{2+}	–	–	79	82	82	77	74	70	73	75
	M^{3+}	73	67	64	62	65	65	61	60	–	–
Standard											
electrode	M^{2+}/M	–	–1.63	–1.18	–0.90	–1.18	–0.44	–0.28	–0.25	+0.34	–0.76
potential $E^\ominus$/V	M^{3+}/M^{2+}	–	–0.37	–0.26	–0.41	+1.57	+0.77	+1.97	–	–	–
Density/g cm^{-3}		3.43	4.1	6.07	7.19	7.21	7.8	8.7	8.9	8.9	7.1

Atomic and Ionic size

In general, ions of the same charge in given series show progressive decrease in radius with increasing atomic number. This is because the new electron enters a *d* orbital each time the nuclear charge increases by unity and shielding effect of *d* electron is not effective hence net electrostatic attraction between the nuclear charge and outer most electron increases and the ionic radius decreases.

This same trend is observed in the atomic radii of a given series. However the variation within a series is quite small. Elements of 4*d* series have larger size than 3*d* but size of 4*d* and 5*d* elements is nearly same in a group. This is due to poor screening of 4*f* electrons.



Trends in atomic radii of transition elements

The filling of 4*f* before 5*d* orbitals results in regular decrease in atomic radii called **Lanthanoid contraction** which essentially compensates for the expected increase in atomic size with increasing atomic number. The net result of the **Lanthanoid contraction** is that the 4*d* and 5*d* series exhibit similar radii and have very similar physical and chemical properties much more than the expected on the usual family relationship.

Density : The decrease in metallic radius coupled with increase in mass results in a general increase in the density of these elements. Thus from Ti to Cu the significant increase in density may be noted.

Note :

Sc, Ti and Y have density less than 5 g/cm^3 while other elements have density greater than 5g/cm^3.

Densities of the 2nd row are high and third row values are even higher.

Density of Os = 22.57 g/cm^3

Density of Ir = 22.61 g/cm^3

Ionisation Enthalpy

There is an increase in ionisation enthalpy along each series of the transition elements from left to right due to an increase in nuclear charge which accompanies the filling of the inner *d* orbitals. The first ionisation enthalpy, in general, increases, but the magnitude of the increase in the second and third ionisation enthalpies for the successive elements, is much higher along a series.

The irregular trend in the first ionisation enthalpy of the metals of 3*d* series, though of little chemical significance, can be accounted for by considering that the removal of one electron alters the relative energies of 4*s* and 3*d* orbitals. When *d*-block elements form ions, *ns* electrons are lost before (n – 1) d electrons. As we move along the period in 3*d* series, we see that nuclear charge increases from scandium to zinc but electrons are added to the orbital of inner subshell, i.e., 3*d* orbitals. These 3*d* electrons shield the 4*s* electrons from the increasing nuclear charge somewhat more effectively than the outer shell electrons can shield one another. Therefore, the atomic radii decrease less rapidly. Thus, ionization energies increase only slightly along the 3*d* series. The doubly or more highly charged ions have d^n configurations with no 4*s* electrons. A general trend of increasing values of second ionisation enthalpy is expected as the effective nuclear charge increases because one *d* electron does not shield another electron from the influence of nuclear charge because *d*-orbitals differ in direction. However, the trend of steady increase in second and third ionisation enthalpy breaks for the formation of Mn^{2+} and Fe^{3+} respectively. In both the cases, ions have d^5 configuration. Similar breaks occur at corresponding elements in the later transition series.

The interpretation of variation in ionisation enthalpy for an electronic configuration d^n is as follows:

The three terms responsible for the value of ionisation enthalpy are attraction of each electron towards nucleus, repulsion between the electrons and the exchange energy. Exchange energy is responsible for the stabilisation of energy state. Exchange energy is approximately proportional to the total number of possible pairs of parallel spins in the degenerate orbitals. When several electrons occupy a set of degenerate orbitals, the lowest energy state corresponds to the maximum possible extent of single occupation of orbital and parallel spins (Hund's rule). The loss of exchange energy increases the stability. As the stability increases, the ionisation becomes more difficult. There is no loss of exchange energy at d^6 configuration. Mn^+ has $3d^5 4s^1$ configuration and configuration of Cr^+ is d^5, therefore, ionisation enthalpy of Mn^+ is lower than Cr^+. In the same way, Fe^{2+} has d^6 configuration and Mn^{2+} has $3d^5$ configuration. Hence, ionisation enthalpy of Fe^{2+} is lower than the Mn^{2+}. In other words, we can say that the third ionisation enthalpy of Fe is lower than that of Mn.

The lowest common oxidation state of these metals is +2. To form the M^{2+} ions from the gaseous atoms, the sum of the first and second ionisation enthalpy is required in addition to the enthalpy of atomisation. The dominant term is the second ionisation enthalpy which shows unusually high values for Cr and Cu where M^+ ions have the d^5 and d^{10} configurations respectively. The value for Zn is correspondingly low as the ionisation causes the removal of 1*s* electron which results in the formation of stable d^{10} configuration. The trend in the third ionisation enthalpies is not complicated by the 4*s* orbital factor and shows the greater difficulty of removing an electron from the d^5 (Mn^{2+}) and d^{10} (Zn^{2+}) ions. In general, the third ionisation enthalpies are quite high. Also the high values for third ionisation enthalpies of copper, nickel and zinc indicate why it is difficult to obtain oxidation state greater than two for these elements.

The lowest common oxidation state of these element is +2 (except Sc and Cu). To form the +2 ion from the gaseous atoms the sum of 1st and 2nd ionisation energy is required in addition to enthalpy of atomisation for each element.

Example 3 : *Why Cr and Cu have abnormally higher 2nd ionisation energy?*

Solution : This is due to half filled and fully filled electronic configuration of Cr^+ and Cu^+ respectively which are considered as very stable.

The trend in the third ionisation enthalpies is not complicated by the 4*s* orbital factor and shows the greater difficulty in removing an electron from the d^5 and d^{10} configurations.

Example 4 : *In 3d series, the enthalpy of atomisation of zinc is the lowest. Why?*

Solution : Enthalpy of atomisation depends on number of unpaired electrons. In Zn there is no unpaired electron. As a result, metallic bonding is weak so that enthalpy of atomisation is low.

Example 5 : *Why Cu, Ni and Zn generally do not show oxidation state greater than 2?*

Solution : IE_3 for Cu, Ni and Zn is generally very high. That is why it does not show oxidation state of +3.

Note :

Out of 4d and 5d series element, element of 5d series have higher IE_1 because of poor screening of 4f orbital called Lanthanoid contraction. Hg have highest IE_1 (1007 kJ/mol) and La have lowest IE_1 (540 kJ/mol).

Oxidation State

One of the notable feature of a transition element is the great variety of oxidation states it may show in its compounds.

Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
	+2	+2	+2	+2	+2	+2	+2	+1	+2
+3	+3	+3	+3	+3	+3	+3	+3	+2	
	+4	+4	+4	+4	+4	+4	+4		
		+5	+5	+5					
			+6	+6	+6				
				+7					

The elements which give the greatest number of oxidation states occur in or near the middle of series. Mn exhibits all oxidation states from +2 to +7.

Note :

1. Sc does not exhibit oxidation state of +2.
2. After middle as we approach from left to right, higher oxidation state becomes less stable. Fe(II, III), Co (II, III), Ni(II), Cu(I, II) are typical species.
3. Titanium (IV) is more stable than Ti(III) or Ti(II).

Example 6 : *How can we show that change in oxidation state is different from variable oxidation state for non transition element?*

Solution : The variability of oxidation states, a characteristic of transition elements, arises out of incomplete filling of *d*-orbitals in such a way that their oxidation states differ from each other by unity *e.g.*, V^{II}, V^{III}, V^{IV}, V^{V}. This is in contrast with the variability of oxidation states of non-transition elements where oxidation states normally differ by a unit of two.

Example 7 : *How would you account for the increasing oxidising power in the series* $VO_2^+ < Cr_2O_7^{2-} < MnO_4$*?*

Solution : This is due to increasing stability of the lower species to which they are reduced.

Formulas of Halides of 3*d* Metals

Oxidation Number									
+6			CrF_6						
+5		VF_5	CrF_5						
+4	TiX_4	VX^{I}_4	CrX_4	MnF_4					
+3	TiX_3	VX_3	CrX_3	MnF_3	FeX^{I}_3	CoF_3			
+2	TiX_2^{III}	VX_2	CrX_2	MnX_2	FeX_2	CoX_2	NiX_2	CuX_2^{II}	ZnX_2
+1								CuX^{III}	

Key : X = F → I; X^{I} = F → Br; X^{II} = F, Cl; X^{III} = Cl → I

Oxides of 3*d* Metals

Oxidation Number	Groups 3	4	5	6	7	8	9	10	11	12
+7					Mn_2O_7					
+6				CrO_3						
+5			V_2O_5							
+4		TiO_2	V_2O_4	CrO_2	MnO_2					
+3	Sc_2O_3	Ti_2O_3	V_2O_3	Cr_2O_3	Mn_2O_3	Fe_2O_3				
					Mn_3O_4*	Fe_3O_4*	Co_3O_4*			
+2		TiO	VO	(CrO)	MnO	FeO	CoO	NiO	CuO	ZnO
+1									Cu_2O	

* Mixed oxides

Example 8 : *Name the transition element which does not exhibit variable oxidation states.*

Solution : Sc (Z = 21) does not exhibit variable oxidation states.

Example 9 : *Name any two transition metals which exhibit oxidation state of +8.*

Solution : Rh and Os exhibit +8 oxidation states.

Example 10 : *Calculate the oxidation state of Fe in* $Fe(CO)_5$.

Solution : Zero.

Example 11 : *In 3d series Mn shows highest oxidation state. Why?*

Solution : The maximum oxidation states of reasonable stability corresponds in value to the sum of *s* and *'d'* electrons up to manganese. Total 7 electrons are present in 3*d* and 4*s* in Mn and hence it can exhibit maximum oxidation state of +7.

Example 12 : *For the first row transition metals the $E^{\ominus}$ values are :*

$E^{\ominus}$	V	Cr	Mn	Fe	Co	Ni	Cu
(M^{2+}/M)	–1.18	–0.91	–1.18	–0.44	–0.28	–0.25	+0.34

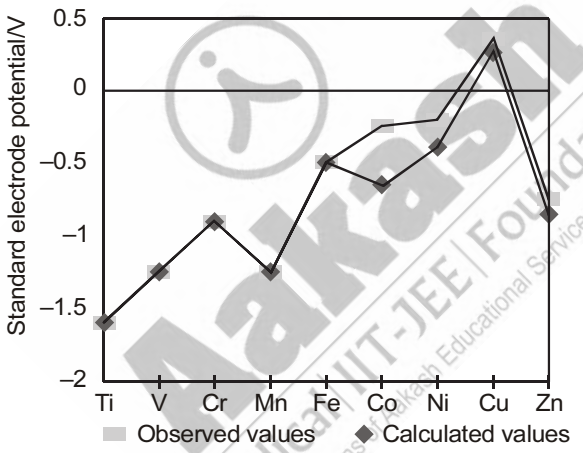
Explain the irregularity in the above values.

Solution : The $E^{\ominus}$ (M^{2+}/M) values are not regular which can be explained from the irregular variation of ionisation enthalpies ($\Delta_i H_1 + \Delta_i H_2$) and also the sublimation enthalpies which are relatively much less for manganese and vanadium.

Example 13 : *Why is the $E^{\ominus}$ value for the Mn^{3+}/Mn^{2+} couple much more positive than that for Cr^{3+}/Cr^{2+} or Fe^{3+}/Fe^{2+}? Explain.*

Solution : Much larger third ionisation energy of Mn (where the required change is d^5 to d^4) is mainly responsible for this. This also explains why the +3 state of Mn is of little importance.

Trends in the M^{2+}/M Standard Electrode Potentials



Observed and calculated values for the standard electrode potentials $M^{2+} \rightarrow {}^{\circ}M$) of the elements Ti to Zn

Thermochemical data (kJ mol^{-1}) for the first row Transition Elements and the Standard Electrode Potentials for the Reduction of M^{II} to M

Element (M)	$\Delta_a H^{\ominus}$ (M)	$\Delta_i H_1^{\ominus}$	$\Delta_i H_2^{\ominus}$	$\Delta_{hyd} H^{\ominus}(M^{2+})$	$E^{\ominus}$/V
Ti	469	661	1310	–1866	–1.63
V	515	648	1370	–1895	–1.18
Cr	398	653	1590	–1925	–0.90
Mn	279	716	1510	–1862	–1.18
Fe	418	762	1560	–1998	–0.44
Co	427	757	1640	–2079	–0.28
Ni	431	736	1750	–2121	–0.25
Cu	339	745	1960	–2121	0.34
Zn	130	908	1730	–2059	–0.76

The stability of the half-filled d sub-shell in Mn^{2+} and the completely filled d^{10} configuration in Zn^{2+} are related to their $E^{\ominus}$ values, whereas $E^{\ominus}$ for Ni is related to the highest negative $\Delta_{hyd}H^{\ominus}$.

Table contains the thermochemical parameters related to the transformation of the solid metal atoms to M^{2+} ion in solution and their standard electrode potential.

The unique behaviour of Cu having a positive E°, accounts for its trend in M^{3+}/M^{2+} standard electrode potential.

An examination of the $E°(M^{3+}/M^{2+})$ values show varying trend. The low value for Sc reflects that Sc in +3 have noble gas E.C. The highest value for Zn is due to the removal of an electron from the stable d^{10} configuration of Zn^{2+}. The comparatively high values for Mn shows that $Mn^{2+}(d^5)$ is especially more stable.

Trend in stability of higher oxidation state

Higher oxidation states are stable with F and O while lower oxidation states are stable with I.

V^V is represented only by VF_5, the other halide however, undergo hydrolysis to give oxohalides VOX_3. Another feature of flourides is their instability in the low oxidation state *e.g.*, VX_2 (X – Cl, Br, I) and same applies to CuX. On the other hand, all Cu^{2+} halides are known except the iodide. In this case Cu^{2+} oxidises I^- to I_2.

$$2Cu^{2+} + 4KI \longrightarrow Cu_2I_2 + I_2 + 4K^+$$

However, many copper (I) compound show disproportionation reaction in aq. medium

$$2Cu^+ \longrightarrow Cu + Cu^{2+}$$

Now, in aq. medium Cu^{2+} is more stable than Cu^+ due to its high hydration energy than Cu^+ which compensate IE_2.

The highest oxidation number in the oxides coincides with the group number and is attained in Sc_2O_3 to Mn_2O_7.

Example 14 : *Why is Cr^{2+} reducing and Mn^{3+} oxidising when both have d^4 configuration?*

Solution : Cr^{2+} is reducing as its configuration changes from d^4 to d^3 having half filled t_2 g level. On the other hand, the change from Mn^{3+} to Mn^{2+} result in the half filled d^5 configuration which has extra stability.

Example 15 : *The $E°(M^{2+}/M)$ value for copper is positive (0.34 volt). What is possible reason for this?*

Solution : Reduction potential will depend on

(i) $Cu(s) \longrightarrow Cu(g)$; ΔH(atomisation)

(ii) $Cu(g) \longrightarrow Cu^{2+}$; $(IE_1 + IE_2)$

(iii) $Cu^{2+} \xrightarrow{H_2O} Cu^{2+}$; (ΔH_{Hyd})

Due to high enthalpy of atomisation and low $\Delta H_{hydration}$ energy $E^{\circ}_{Cu^{+2}/Cu}$ is high.

Example 16 : *Which is stronger reducing agent $Cr^{2(+)}$ or Fe^{2+} and why?*

Solution : By using table Cr^{2+}/Cr (–0.90) and Fe^{2+}/Fe (–0.44) we can say that Cr^{2+}/Cr is stronger reducing agent.

Chemical Reactivity and E° Values

Transition metals vary widely in their chemical reactivity. Many of them are sufficiently electropositive to dissolve in mineral acid although a few are noble, it means these do not react with single acid.

The metal of 3*d* series except Cu are relatively more reactive and are oxidised by 1M H^+ though the actual rate at which these metals react with oxidising agents like hydrogen ion (H^+) is some time slow.

For example Ti and V are passive to dilute non oxidising acids at room temperature. Increase in reduction potential M^{2+}/M from left to right indicate decreasing tendency to form divalent cation along the series.

Note :

1. E° value of Mn^{2+}/Mn, Ni^{2+}/Ni and Zn^{2+}/Zn are more negative then expected. This is due to half filled and full filled E.C. for Mn^{2+} and Zn^{2+} respectively while for Ni^{2+}. This is because of high enthalpy of hydration.
2. Higher will be M^{3+}/M^{2+} stronger will be oxidising agent. That is why Mn^{3+} and Co^{3+} are strongest oxidising agent in aqueous solutions?
3. Ti^{2+}, V^{2+} and Cr^{2+} are strong reducing agents and liberate hydrogen from a dilute acid
   $2Cr^{2+} + 2H^+ \longrightarrow Cr^{3+} + H_2$
4. The trend of reduction potential is not regular because trend of enthalpies of atomisation and $(IE_1 + IE_2)$ is not regular.

Magnetic Properties

When magnetic field is applied to substance. Mainly two types of magnetic behaviour are observed : diamagnetism and paramagnetism. Diamagnetic substance contain no unpaired electron and repelled by magnet while paramagnetic substances are attracted and contain one or more unpaired electron. The substance which are strongly attracted by magnet are said to be ferromagnetic. Paramagnetism arises due to presence of unpaired electrons, each such electron having a magnetic moment associated with its spin angular momentum and orbital angular momentum. For the compounds of the 1st series of transition metals, the contribution of the orbital angular momentum is effectively quenched and hence is of no significance. That is why for these element spin only moment *i.e.*, μ is calculated.

$\mu = \sqrt{n(n+2)}$ BM where n is number of unpaired electron and BM-Bohr magneton.

Calculated and Observed Magnetic Moments (BM)

Ion	Configuration	Unpaired electron(s)	Magnetic moment	
			Calculated	Observed
Sc^{3+}	$3d^0$	0	0	0
Ti^{3+}	$3d^1$	1	1.73	1.75
Tl^{2+}	$3d^2$	2	2.84	2.76
V^{2+}	$3d^3$	3	3.87	3.86
Cr^{2+}	$3d^4$	4	4.90	4.80
Mn^{2+}	$3d^5$	5	5.92	5.96
Fe^{2+}	$3d^6$	4	4.90	5.3 – 5.5
Co^{2+}	$3d^7$	3	3.87	4.4 – 5.2
Ni^{2+}	$3d^8$	2	2.84	2.9 – 3, 4
Cu^{2+}	$3d^9$	1	1.73	1.8 – 2.2
Zn^{2+}	$3d^{10}$	0	0	

Note : The experimental data are mainly for hydrated ions in solution or in solid state.

Example 17 : *Calculate the spin only moment of a divalent ion in aq. solution of atomic number 25.*

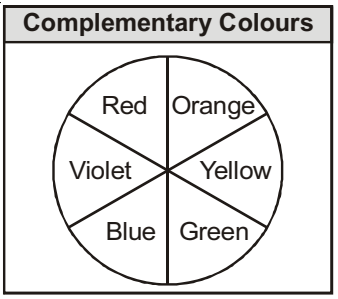
Solution : E.C. of Mn^{2+} = $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5$

Number of unpaired electron = 5.

$\mu = \sqrt{5(5+2)}\ BM = \sqrt{35}\ BM$

Formation of Coloured Ions

When an electron from a lower energy *d* orbital is excited to higher energy *d* orbital, the energy of excitation corresponds to the frequency of light absorbed. This frequency absorbed generally lies in the visible region. The colour observed corresponds to the complementary colour of light absorbed.



The frequency of light that is absorbed is determined by

(i) Nature of ligand

(ii) Size of metal ion

(iii) Oxidation state of metal

Colours of Some of the First Row (aquated) Transition Metal Ions

Configuration	Example	Colour
$3d^0$	Sc^{3+}	colourless
$3d^0$	Ti^{4+}	colourless
$3d^1$	Ti^{3+}	purple
$3d^1$	V^{4+}	blue
$3d^2$	V^{3+}	green
$3d^3$	V^{2+}	violet
$3d^3$	Cr^{3+}	violet
$3d^4$	Mn^{3+}	violet
$3d^4$	Cr^{2+}	blue
$3d^5$	Mn^{2+}	pink
$3d^5$	Fe^{3+}	yellow
$3d^6$	Fe^{2+}	green
$3d^6$, $3d^7$	Co^{3+}, Co^{2+}	bluepink
$3d^8$	Ni^{2+}	green
$3d^9$	Cu^{2+}	blue
$3d^{10}$	Zn^{2+}	colourless

Note :

Along with d–d transition, colour may be due to

1. Charge transfer spectra
2. Polarisation

There are some compounds in which d^0 or d^{10} configuration are present and in these configuration no d–d transition is expected. But still these may be intensely coloured. This colour is due to charge transfer from ligand to metal or from metal to metal.

MnO_4^- is pink coloured due to charge transfer from ligand to metal while $Fe_4[Fe(CN)_6]_3$ is blue coloured due to charge transfer from metal to metal, AgBr and AgI are coloured due to polarisation.

Formation of Complex Compound

Due to smaller size of the metal ions high ionic charges and the availability of *d* orbitals for bond formation, transition elements form a number of complex compounds. Example of some complex compounds/ions are

$[Fe(CN)_6]^{3-}$, $[Cu(NH_3)_4]^{2+}$, $[Mn(H_2O)_4]^{2+}$, $[CuCl_4]^{2-}$

Catalytic Properties

The transition metals and their compounds are known for their catalytic activity. This activity is ascribed to them due to their ability

1. To adopt multiple oxidation states
2. To form complexes

Catalyst at a solid surface involve the formation of bonds between reactant molecules and atoms of the surface of catalyst. This has the effect of increasing the concentration of the reactants at the catalyst surface and also weakening of the bonds in the reacting molecules (the activation energy is lowered). Also because transition metal ions can change their oxidation states, they become more effective as catalyst. For example Fe(III) catalyses the reaction between I^- and $S_2O_8^{2-}$.

$$2I^- + S_2O_8^{2-} \xrightarrow{Fe^{3+}} I_2 + 2SO_4^{2-}$$

Mechanism :

$$2Fe^{3+} + 2I^- \longrightarrow Fe^{2+} + I_2$$

$$2Fe^{2+} + S_2O_8^{2-} \longrightarrow 2Fe^{3+} + 2SO_4^{2-}$$

So actually Fe^{3+} oxidise I^- to I_2.

Note :

	Transition Metal/Compound Catalyst	Process
1.	V_2O_5	Contact process
2.	Fe	Haber process
3.	Ni	Hydrogenation
4.	$TiCl_4 + (C_2H_5)_3Al$	Production of polyethene (Zieglar Natta) catalyst
5.	MnO_2	$KClO_3 \longrightarrow KCl + O_2$
6.	$PdCl_2$	Wacker process
7.	Pt/PtO_2	Adam's catalyst

Formation of Interstitial Compounds

Interstitial compounds are those which are formed when small atoms like H, C or N are trapped inside the crystal lattice of metals. These are usually non stochiometeric and are neither typically ionic nor covalent. For example, TiC, Mn_4N, Fe_3H, $VH_{0.56}$ and $TiH_{1.7}$ etc. The formulas quoted do not of course correspond to any normal oxidation state of metal. Because of the nature of their composition, these compounds are referred to as interstitial compounds.

The principle physical and chemical characteristics of these compounds are :

1. They have high melting point, higher than those of pure metal.
2. These are very hard.
3. They retain metallic conductivity.
4. They are chemically inert.

Alloy Formation

Alloy may be homogeneous solid solution in which the atoms of one metal are distributed randomly among the atoms of the other. Such alloys are formed by atoms with metallic radii that are within about 15 percent of each other. Because of similar radii and other charactertics of transition metals alloys are readily formed by these metals. The alloys so formed are hard and have often high melting point. The best known are ferrous alloys. Cr, V, W, Mo and Mn are used for the production of a variety of steels and stainless steel.

Alloys of transition metals with non transition metals such as brass (Cu – Zn) and bronze (Cu – Sn) are also of considerable industrial importance.

Other examples are:

German Silver: 25-30% Cu, 40-50% Ni, 25-30% Zn

Bell Metal: 80% Cu, 20% Sn

Gun Metal: 80% Cu, 10% Sn, 2% Zn

Brass: 60% Cu, 40% Zn

EXERCISE

1. $(n-1)d^{10}ns^2$ is the general electronic configuration of
   (1) Fe, Co, Ni (2) Cu, Ag, Au
   (3) Zn, Cd, Hg (4) Se, Y, La
2. The lowest melting point metals among *d*-block metals belongs to
   (1) Group 3 (2) Group 11
   (3) Group 6 (4) Group 12
3. Cu^+ ion in aquous medium undergoes
   (1) Oxidation only (2) Reduction only
   (3) Neither oxidation nor reduction (4) Disproportionation
4. Which of the following oxide is least basic?
   (1) CrO (2) Cr_2O_3
   (3) CrO_3 (4) Cr_2O_4
5. Which metal is not present in german silver?
   (1) Cu (2) Ag
   (3) Ni (4) All are present
6. *d*-block elements have tendency for complex formation because of
   (1) Small size of metal ions (2) High ionic charges
   (3) Availability of vacant *d*-orbitals (4) All of these
7. Incorrect order is
   (1) Mn > Fe (IIIrd ionisation energy) (2) Cr > Mn (IInd ionisation energy)
   (3) $Cu^{1+}(aq) > Cu^{2+}(aq)$ (stability order) (4) All of these
8. Hardness of transition metals is due to
   (1) Large atomic size (2) Metallic bonding
   (3) Ionic bond (4) High ionization energy

9. Zn and Hg do not forms coloured ions because
   (1) They are soft
   (2) Their inner d-orbitals are completely filled
   (3) They have only 2- electrons in the outer most shell
   (4) None of these
10. The most abundant transition metal is
   (1) Iron (2) Copper
   (3) Aluminium (4) Zinc

SOME IMPORTANT COMPOUNDS OF TRANSITION ELEMENTS

Oxide and Oxoanions of Metals

These oxides are generally formed by the reaction of metals with oxygen at high temperature. All the metals except Sc form metal oxide which are ionic.

As the oxidation number of metal increases, ionic character decreases. In the case of Mn, Mn_2O_7 is a covalent green oil. Even CrO_3 and V_2O_5 have low melting points. In these higher oxides the acidic character is predominant.

Thus, Mn_2O_7 gives $HMnO_4$ and CrO_3 gives H_2CrO_4 and $H_2Cr_2O_7$. V_2O_5 is however amphoteric though mainly acidic and it gives VO_4^{3-} as well as VO_2^+ salt. V_2O_5 react with alkalies as well as acids to give VO_4^{-3} and VO_4^{+1} respectively. The well characterised CrO is basic but Cr_2O_3 is amphoteric.

$K_2Cr_2O_7$ Potassium dichromate

It is important chemical used in leather industry and an oxidant for preparation of many azo compounds.

It is prepared from chromite ore ($FeCr_2O_4$)

Step 1 : Chromite ore is fused with Na_2CO_3 or K_2CO_3 in excess air.

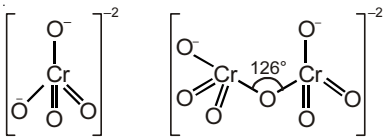
$$4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \longrightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$$

Yellow solution of Na_2CrO_4 is filtered and acidified with sulphuric acid to give a solution from which orange sodium dichromate $Na_2Cr_2O_7 \cdot 2H_2O$ is crystallised.

Note : $Na_2Cr_2O_7$ is more soluble than $K_2Cr_2O_7$

$$Na_2Cr_2O_7 + 2KCl \longrightarrow K_2Cr_2O_7 + 2NaCl$$

Structure of CrO_4^{-2} and $Cr_2O_7^{-2}$



Sodium and potassium dichromate are good oxidising agent. But potassium dichromate is used as primary standard in volumetric analysis.

$$Cr_2O_7^{2-} + 14H^+ \xrightarrow{+6e^-} 2Cr^{3+} + 7H_2O \ (E^\ominus = 1.33\ V)$$

Example of reaction involving oxidation by $Cr_2O_7^{2-}$

$$6I^- \longrightarrow 3I_2 + 6e^-$$

$$3H_2S \longrightarrow 6H^+ + 3S + 6e^-$$

$$3Sn^{2+} \longrightarrow 3Sn^{4+} + 6e^-$$

$$6Fe^{2+} \longrightarrow 6Fe^{3+} + 6e^-$$

Note :

1. $K_2Cr_2O_7 + H_2SO_4 + 4H_2O_2 \longrightarrow \underset{\text{(Blue)}}{2CrO_5} + K_2SO_4 + 5H_2O$

   CrO_5 is stable only in ether or pyridine. In aq. solution it decompose to Cr^{3+} and dioxygen.
2. **Chromyl Chloride Test :** It is the test of chloride ion. As given below :

   $K_2Cr_2O_7 + 6H_2SO_4 + 4NaCl \longrightarrow 2KHSO_4 + NaHSO_4 + \underset{\substack{\text{(Chromyl chloride)}\\\text{(Red vapours)}}}{2CrO_2Cl_2} + 3H_2O$
3. CrO_4^{2-} and $Cr_2O_7^{2-}$ exist in equilibrium at pH = 4

   $\underset{\text{(Yellow)}}{CrO_4^{2-}} \underset{OH^-}{\overset{H^+}{\rightleftharpoons}} \underset{\text{(Orange)}}{Cr_2O_7^{2-}}$

Potassium Permanganate $KMnO_4$

Preparation : $KMnO_4$ is prepared by fusion of MnO_2 with an alkali metal hydroxides and an oxidising agent like KNO_3. This produces dark green K_2MnO_4 which disproportionates in a neutral or acidic solution to give permanganate.

$$2MnO_2 + 4KOH + O_2 \longrightarrow 2K_2MnO_4 + 2H_2O$$

$$3MnO_4^{2-} + 4H^+ \longrightarrow 2MnO_4^- + MnO_2 + 2H_2O$$

Commercially it is prepared by the alkaline oxidative fusion of MnO_2 followed by the electrolytic oxidation of manganate (VI).

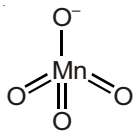
$$\underset{\text{Manganate ion}}{MnO_4^{2-}} \xrightarrow[\text{in alkaline solution}]{\text{Electrolytic oxidation}} \underset{\text{Permanganate ion}}{MnO_4^-}$$

Laboratory preparation : In the laboratory, a manganese (II) ion salt is oxidised by peroxodisulphate to permanganate.

$$2Mn^{2+} + 5S_2O_8^{2-} + 8H_2O \longrightarrow 2MnO_4^- + 10SO_4^{2-} + 16H^+$$

Characteristic properties

1. $KMnO_4$ forms dark purple (almost black) crystals which are isostructural with those of $KClO_4$. The salt is not very soluble in water. (6.4 g/100 g of water at 293 K).
2. It has intense colour and weak temperature dependent paramagnetism.
3. Green manganate ion is paramagnetic while permanganate ion is diamagnetic.
4. π bonding takes place by overlap of *p* orbital of oxygen with *d* orbitals of manganese.
5. Structure :



6. $KMnO_4$ is a good oxidising agent in acidic, basic, or neutral medium.
7. Half cell reaction of $KMnO_4$ in different medium

   $MnO_4^- + e^- \longrightarrow MnO_4^{2-}$ ($E° = 0.56$ V)

   $MnO_4^- + 2H_2O + 3e^- \longrightarrow MnO_2 + 4OH^-$ ($E° = 1.69$ V)

   $MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$ ($E° = 1.52$ V)

We can very well see that the hydrogen ion concentration of the solution play an important part in influencing the reaction. Although reactions can be understood by consideration of redox potential, kinetics of the reaction is also an important factor.

Important oxidising reactions of $KMnO_4$

1. In acidic medium
   (i) $10I^- + 2MnO_4^- + 16H^+ \longrightarrow 2Mn^{2+} + 8H_2O + 5I_2$
   (ii) $\underset{\text{(Green)}}{5Fe^{2+}} + MnO_4^- + 8H^+ \longrightarrow Mn^{2+} + \underset{\text{(Yellow)}}{5Fe^{3+}} + 4H_2O$
   (iii) $5C_2O_4^{2-} + 2MnO_4^- + 16H^+ \longrightarrow 2Mn^{2+} + 8H_2O + 10CO_2$
   (iv) $5S^{2-} + 2MnO_4^- + 16H^+ \longrightarrow 2Mn^{2+} + 8H_2O + 5S$
   (v) $5SO_3^{2-} + 2MnO_4^- + 6H^+ \longrightarrow 2Mn^{2+} + 3H_2O + 5SO_4^{2-}$
   (vi) $5NO_2^- + 2MnO_4^- + 6H^+ \longrightarrow 2Mn^{2+} + 3H_2O + 5NO_3^-$
2. In neutral or faintly alkaline solutions
   (i) $2MnO_4^- + H_2O + I^- \longrightarrow 2MnO_2 + 2OH^- + IO_3^-$
   (ii) $8MnO_4^- + S_2O_3^{2-} + H_2O \longrightarrow 8MnO_2 + 6SO_4^{2-} + 2OH^-$
   (iii) $2MnO_4^- + 3Mn^{2+} + 2H_2O \xrightarrow{Zn} 5MnO_2 + 4H^+$

Example 18 : *Why permanganate titrations in presence of hydrochloric acid are unsatisfactory?*

Solution : Because hydrochloric acid is oxidised to chlorine (Cl_2).

EXERCISE

11. Acidified $K_2Cr_2O_7$ on reaction with hydrogen peroxide give deep blue solution due to formation of
   (1) $Cr_2(SO_4)_3$ (2) CrO_5
   (3) CrO_4^{2-} (4) Cr_2O_3
12. Hybridisation of chromium ions in chromate and dichromate ions is respectively
   (1) sp^2 and sp^2 (2) sp^2 and sp^3
   (3) sp^3 and sp^2 (4) sp^3 and sp^3
13. Equivalent weight of Baeyer's reagent is
   (1) 158 (2) 31.6
   (3) 52.6 (4) All of these
14. On oxidation with $KMnO_4$ in acidic medium, SO_2 is oxidised to
   (1) SO_2 (2) H_2SO_4
   (3) SO_3^{2-} (4) H_2S
15. $MnO_4^{2-} + H^+ \rightarrow$ Product
   Product formed is
   (1) MnO_4^- (2) MnO_2
   (3) Mn (4) Both (1) & (2)
16. Which is coloured because of *d*-*d* transition?
   (1) $KMnO_4$ (2) K_2CrO_4
   (3) $CoCl_3$ (4) All of these
17. When ferric chloride is added to potassium ferrocyanide there is formation of
   (1) Prussian blue (2) Nitroprusside ion
   (3) Coloured ring (4) Ferrous nitrate

18. $FeO \cdot Cr_2O_3 \xrightarrow[O_2]{Na_2CO_3} A \xrightarrow{H_2SO_4} B \xrightarrow{KCl} C$

The hybridisation of compound C and colour of its crystal is

(1) sp^3, orange red (2) sp^3, yellow

(3) sp^2, orange red (4) sp^2, yellow

19. Number of moles of ferrous sulphate oxidised by 1 mole of potassium permanganate in acidic medium is

(1) $\frac{2}{5}$ (2) $\frac{5}{2}$

(3) $\frac{1}{5}$ (4) 5

20. When NaCl is heated with $K_2Cr_2O_7$ in sulphuric acid, the red vapours formed is because of

(1) CrO_5 (2) CrO_4^{2-}

(3) CrO_2Cl_2 (4) Cr_2O_3

THE INNER TRANSITION ELEMENTS

The *f* block consists of two series lanthanoids and actinoids. Lanthanum closely resembles the lanthanoids, it is usually included in any discussion of the lanthanoids for which the general symbol Ln is often used. Similarly a discussion of the actinoids includes actinium besides the fourteen elements constituting the series.

Lanthanoids resemble one another more closely than do the members of ordinary transition elements in any series. They have only one stable oxidation state and their chemistry provides an excellent opportunity to examine the effect of small size and nuclear charge along a series of otherwise similar elements.

THE LANTHANOIDS

Electronic Configuration

It may be noted that the atoms of these elements have electronic configuration as $6s^2\ 5d^{0\ or\ 1}\ 4f^{1-14}$.

Electronic Configurations and Radii of Lanthanum and Lanthanoids

Atomic Number	Name	Symbol	Electronic configurations*			Radii/pm		
			Ln	Ln^{2+}	Ln^{3+}	Ln^{4+}	Ln	Ln^{3+}
57	Lanthanum	La	$5d^16s^2$	$5d^1$	$4f^0$		187	106
58	Cerium	Ce	$4f^15d^16s^2$	$4f^2$	$4f^1$	$4f^0$	183	103
59	Praseodymium	Pr	$4f^36s^2$	$4f^3$	$4f^2$	$4f^1$	182	101
60	Neodymium	Nd	$4f^46s^2$	$4f^4$	$4f^3$	$4f^2$	181	99
61	Promethium	Pm	$4f^56s^2$	$4f^5$	$4f^4$		181	98
62	Samarium	Sm	$4f^66s^2$	$4f^6$	$4f^5$		180	96
63	Europium	Eu	$4f^76s^2$	$4f^7$	$4f^6$		199	95
64	Gadolinium	Gd	$4f^75d^16s^2$	$4f^75d^1$	$4f^7$		180	94
65	Terbium	Tb	$4f^96s^2$	$4f^9$	$4f^8$	$4f^7$	178	92
66	Dysprosium	Dy	$4f^{10}6s^2$	$4f^{10}$	$4f^9$	$4f^8$	177	91
67	Holmium	Ho	$4f^{11}6s^2$	$4f^{11}$	$4f^{10}$		176	89
68	Erbium	Er	$4f^{12}6s^2$	$4f^{12}$	$4f^{11}$		175	88
69	Thulium	Tm	$4f^{13}6s^2$	$4f^{13}$	$4f^{12}$		174	87
70	Ytterbium	Yb	$4f^{14}6s^2$	$4f^{14}$	$4f^{13}$		173	86
71	Lutetium	Lu	$4f^{14}5d^16s^2$	$4f^{14}5d^1$	$4f^{14}$	–	–	–

Atomic Size and Ionic Size

Decrease in size from La to Lu is a unique feature in chemistry of lanthanoids. This is due to lanthanoid contraction. The decrease in atomic radii is not quite regular as it is regular in M^{3+} ion. This contraction is similar to that observed in an ordinary transition series and is attributed to same cause, the imperfect shielding of one electron by another in the same sub-shell. However, shielding of one 4*f* electron by another is less than one *d* electron by another with the increase in nuclear charge along the series.

Oxidation state

In the lanthanoids, Ln(III) compounds are predominant. However some element may show oxidation state of II and IV. Pr, Nd, Tb and Dy can exhibit +4 O.S. only in MO_2 oxide.

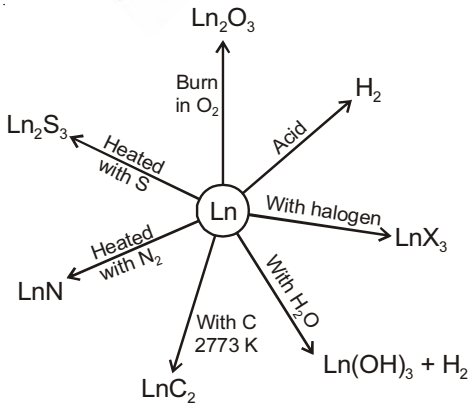
Eu^{2+} is formed by losing the two *s*-electron and its f^7 E.C. accounts for the formation of this ion. However Eu^{2+} is a strong reducing agent changing to the common +3 state. Tb^{IV} has half filled *f* orbital and is an oxidant. Sm also exhibit +2 oxidation state. The only +4 oxidation state of lanthanides which exists in solution and has aqueous chemistry is Ce^{4+}.

General characterstics

1. All the lanthanoids are silvery white soft metals and tarnish rapidly.
2. Hardness increases with increasing atomic number, samarium (Sm) being steel hard.
3. These are good conductor of electricity.
4. Density and other properties change smoothly except for Eu and Yb and occasionally for Sm and Tm.
5. Many trivalent lanthanoid ions are coloured both in solid state and in aq. solution. Colour of these ions may be attributed to the presence of *f* electrons.
   (i) For M^{3+} ion, species having same unpaired electrons have nearly same colour.
   (ii) Colour of *f* block ions are generally not affected by ligands.
6. IE_1 of the lanthanoids are around 600 kJ/mole and IE_2 is about 1200 kJ/mole comparable with those of Ca. A detailed discussion of IE_3's variation indicates that the exchange enthalpy considerations (as in 3*d* orbitals of the first transition series) appear to impart a certain degree of stability to empty, half filled and completely filled orbitals of *f* level. This is indicated from the abnormally low value of the IE_3 of La, Gd and Lu.

Note : In chemical behaviour in general, the earlier members of the series are quite reactive similar to calcium but with increasing atomic number, they behave more like aluminium.

Reaction :



Uses :

1. Best use of the lanthanoids is for the production of alloy steels for plate and pipe.

2. A well known Mischmetal consists of a lanthanoid metal (~95%) and iron (~5%) and traces of S, C, Ca and Al. It is used in Mg– based alloy to form bullets.
3. Mixed oxide of lanthanoids are employed as catalysts in petroleum cracking.
4. Some individual lanthanoid oxide are used in television screen and similar florescing surfaces.
5. Ce^{4+} solutions are widely used as an oxidizing agent in volumetric analysis instead of $KMnO_4$ and $K_2Cr_2O_7$.

Example 19 : *Why Ce^{4+} is a good oxidising agent?*

Solution : Due to high reduction potential of Ce^{4+}/Ce^{3+} is 1.74 V.

Example 20 : *Out of following which is more basic $Lu(OH)_3$ and $Ce(OH)_3$.*

Solution : $Ce(OH)_3$

THE ACTINOIDS

Actinoid include the fourteen elements from Th to Lr. The name symbol and some properties of these element are shown as

Atomic Number	Name	Symbol	Electronic conifigurations*			Radii/pm	
			M	M^{3+}	M^{4+}	M^{3+}	M^{4+}
89	Actinium	Ac	$6d^17s^2$	$5f^0$		111	
90	Thorium	Th	$6d^27s^2$	$5f^1$	$5f^0$		99
91	Protactinium	Pa	$5f^26d^17s^2$	$5f^2$	$5f^1$		96
92	Uranium	U	$5f^36d^17s^2$	$5f^3$	$5f^2$	103	93
93	Neptunium	Np	$5f^46d^17s^2$	$5f^4$	$5f^3$	101	92
94	Plutonium	Pu	$5f^67s^2$	$5f^5$	$5f^4$	100	90
95	Americium	Am	$5f^77s^2$	$5f^6$	$5f^5$	99	89
96	Curium	Cm	$5f^76d^17s^2$	$5f^7$	$5f^7$	99	88
97	Berkelium	Bk	$5f^97s^2$	$5f^8$	$5f^7$	98	87
98	Californium	Cf	$5f^{10}7s^2$	$5f^9$	$5f^8$	98	86
99	Einstenium	Es	$5f^{11}7s^2$	$5f^{10}$	$5f^9$	–	–
100	Fermium	Fm	$5f^{12}7s^2$	$5f^{11}$	$5f^{10}$	–	–
101	Mendelevium	Md	$5f^{13}7s^2$	$5f^{12}$	$5f^{11}$	–	–
102	Nobelium	No	$5f^{14}7s^2$	$5f^{13}$	$5f^{12}$	–	–
103	Lawrencium	Lr	$5f^{14}6d^17s^2$	$5f^{14}$	$5f^{13}$	–	–

The actinoids are radioactive elements and the earlier members have relatively long half life, the latter ones have half life values ranging from a day to 3 minute for **Lawrencium** (Z-103).

Electronic Configurations

General electronic configuration of all elements can be consulted from table. The fourteen electrons are formally added to 5*f* though not in thorium (Z-90) but from Pa onward the 5*f* orbitals are complete at element 103. The irregularities in the electronic configurations of the actinoids like those in the Lanthanoids are related to the stabilities of the f^0, f^7, f^{14} occupancies of the 5*f* orbitals.

Note :

Although the 5f orbitals resemble with the 4f orbitals in their angular part of the wave function, they are not as buried as 4f orbital and hence 5f electrons can participate in bonding to a far greater extent.

Ionic Sizes

There is gradual decrease in the size of atoms or M^{3+} ions across the series. This is referred to as actinoid contraction which is greater than lanthanoid contraction.

Oxidation States

There is greater range of oxidation states which is in part attributed to the fact that the 5*f*, 6*d* and 7*s* level are of comparable energies.

Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
3		3	3	3	3	3	3	3	3	3	3	3	3	3
	4	4	4	4	4	4	4	4						
		5	5	5	5	5								
			6	6	6	6								
				7	7									

The elements, in first half of actinoids frequently exhibit higher oxidation states. However, +3 and +4 ions tend to hydrolyse because the distribution of oxidation states among the actinoids is so uneven and so different for the former and later elements, it is unsatisfactory to review their chemistry in terms of oxidation states.

General Characteristics

1. All are silvery in appearance but display a variety of structure. This is due to irregularity in metallic radii.
2. These are highly reactive metal.
3. HCl react with all actinoids.
4. Most of them are slightly affected by HNO_3 owing to the formation of protective oxide layer. However, alkalies have no action.
5. Magnetic properties of the actinoids are more complex than those of lanthanoid.
6. Actinoids compound or their ions are **coloured** most probably due to charge **transfer or *f-f* transition**.

Differences :

Lanthanides	Actinides
1. In addition to +3 oxidation state, they exhibit +2 and +4 oxidation states only.	1. In addition to +3 oxidation state, they show +4, +5, +6 and +7 oxidation states.
2. Most of their ions are colourless	2. Most of their ions are coloured.
3. They do not form complexes easily.	3. They have much greater tendency to form complexes.
4. They do not form oxo cations.	4. They form oxocations such as UO_2^{2+}, PuO_2^{2+} and UO^+.
5. Their compounds are less basic	5. Their compounds are more basic.
6. Except promethium, they are non-radioactive.	6. They are radioactive.
7. Their magnetic properties can be easily explained.	7. Their magnetic properties can not be easily explained.

SOME APPLICATIONS OF *d* & *f*-BLOCK ELEMENTS

1. Iron and steels are the most important construction material. Their production is based on reduction of iron oxides, the removal of impurities and the addition of carbon and alloying metals like Cr, Mn and Ni.
2. Some compounds are manufactured for special purpose such as TiO for the pigment industry and MnO_2 for use in dry cell along with use of Zn.
3. Many of the elements or compounds of this block elements are important catalyst.
4. AgBr is an important chemical used in photography. Along with AgBr, Ag and AgI can also be used.
5. Some compounds like MnO_4^-, CrO_4^{2-} are good oxidising agents.

Example 21 : *Why actinoid contraction is more than lanthanoid contraction?*

Solution : This is due to poor screening of 5*f* orbital.

Example 22 : *Which element show highest oxidation state in actinoid?*

Solution : Np and Pu exhibit +7 oxidation state.

EXERCISE

21. In blue vitriol, number of water molecules joined by co-ordinate bonds with copper and by hydrogen bond is respectively
    (1) 3, 2 (2) 2, 3
    (3) 4, 1 (4) 5, 0
22. Correct electronic configuration of lanthanum is
    (1) $[Xe]5d^16s^2$ (2) $[Xe]4d^15s^2$
    (3) $[Xe]4f^15s^2$ (4) $[Xe]5f^16s^2$
23. General electronic configuration of actinides can be shown as
    (1) $(6–2)f^{1–14}\ (6–1)d^{1–10}\ 6s^2$ (2) $(6–2)f^{1–14}\ (6–1)d^{0–1}\ 6s^2$
    (3) $(7–2)f^{1–14}\ (7–1)d^{1–10}\ 7s^2$ (4) $(7–2)f^{1–14}\ (7–1)d^{0–1}\ 7s^2$
24. First synthetic elements is
    (1) Tc (2) La
    (3) Po (4) Y
25. Which is correct?
    (1) $Ce(OH)_3$ is weaker base than $Lu(OH)_3$
    (2) $E°_{Mn^{3+}/Mn^{2+}}$ is more positive than Fe^{3+}/Fe^{2+}
    (3) Ti > Zr > Hf (Group 4 atomic radii)
    (4) Lanthanides are not separated by ion exchange method
26. Lanthanides and Actinides are similar in
    (1) Oxoion formation (2) Radioactive nature
    (3) Tendency towards complex formation (4) Electronic configuration

27. The basic nature of the Lanthanide hydroxides decreases from $Ce(OH)_3$ to $Lu(OH)_3$. This is due to

(1) Decrease in ionic radius (2) Due to lanthanoid contraction

(3) Increase in metallic character (4) All of these

28. Which element among the lanthanides has the smallest atomic radius?

(1) Cerium (2) Lutetium

(3) Europium (4) Gadolinium

29. Which of the following elements belongs to actinide series?

(1) La (2) Gd

(3) Lu (4) Th

30. Zinc and mercury do not show variable valency like *d* elements because

(1) They are soft

(2) Their *d*-shells are complete

(3) They have only two electrons in the outermost shell

(4) Their *d*-subshells are incomplete

Note :

1. In molecules or complex ions, it is sometimes possible for electrons to make transitions from the orbitals of one atom to the orbital of another, giving rise to **electron transfer spectra or charge transfer spectra.** Generally, electron transfer is from a ligand orbital to an orbital of the central atom. It is responsible for the colours of oxyanions such as MnO_4^- (purple), CrO_4^{2-} (yellow) or $Cr_2O_7^{2-}$ (orange).
2. The transition elements (metals) exhibit all the three types of structures, that is, hexagonal close packed, face centred cubic and body centred cubic. The co-ordination numbers are high and range from 8 to 12.
3. **Basic copper acetate** is $(CH_3COO)_2Cu{\cdot}Cu(OH)_2$. It is also known as **verdigris.**
4. Silver has highest electrical and thermal conductivity among metals. Silver is highly malleable as well as ductile. Silver is noble metal because of its poor reactivity.
5. Gold is considered to be the king of metals. Gold is soluble in mercury. **Purple of Cassius** is the form of **colloidal gold** prepared by mixing very dilute solution of gold chloride with $SnCl_2$.
6. The **density** of Zn, Cd and Hg increases with increase in atomic numbers. **Malleability** and **ductility** gradually decrease from Zn to Cd. These properties are not found in Hg because it is liquid.
7. Zinc metal is fairly hard and brittle at room temperature, but at 100°C it becomes malleable and ductile. It does not react with water at ordinary temperatures because of protective layer of carbonate, $ZnCO_3$. $Zn(OH)_2$. ZnS is white and soluble in acids. Large quantities of zinc are used in galvanising of iron. ZnO is stable even to red heat, while HgO decomposes easily.
8. Unlike Cd and Zn, mercury exhibits +1 and +2 oxidation states. Hg forms **monovalent** mercurous ions and **bivalent** mercuric ions. Mercury compounds exist as dimers (Cl–Hg–Hg–Cl). The mercurous ions exists as Hg_2^{2+} and not as Hg^+. Mercury does not form **peroxide or hydroxide.** Mercuric chloride ($HgCl_2$) is **covalent in nature**. Hg remains unaffected by air and dilute acids.
9. ZnO is also known as **philosopher's wool, zinc white or chinese white.** It turns yellow on heating and white on cooling, gives green mass in cobalt nitrate test and used in medicine. It is **amphoteric oxide** and so dissolves both in acids and alkalies. ZnO is a white paint and used as a fluorescent paint.

10. Hg_2Cl_2 is known as **calomel** and $HgCl_2$ is called corrosive sublimate, on account of its corrosive properties. Mercuric sulphide, HgS is known as **vermilion.** It is a useful pigment. Hg forms amalgams with all metals except iron and platinum. **Hence Hg is transported in iron containers.** An amalgam consisting of Ag, Sn, Zn and Hg is used for **filling of teeth. Mercury fulminate,** Hg $(ONC)_2$ is called **Pharaoh's serpent.** It is used as explosive.
11. A mixture of TiO_2 and $BaSO_4$ is called titanox while **a mixture of ZnS and $BaSO_4$** is called **lithopone**.
12. Nessler's reagent is the alkaline solution of the complex formed by dissolving mercuric iodide in aqueous solution of potassium iodide useful to detect NH_3

    $HgI_2 + 2KI \longrightarrow K_2[HgI_4]$
13. Iodine of Millon's base, $(NH_2 - Hg - O - Hg - I)$

    $HgI_2 + 2NH_3 \longrightarrow I - Hg - NH_2 + NH_4I$

    $NH_2 - Hg - I + H - O - H + NH_2 - Hg - I$

    $\downarrow$

    $NH_2 - Hg - O - Hg - I + NH_4I$

    (Iodide of Millon's base brown ppt.)
14. Photography is the process of producing an exact image of an object on photographic film which consist of a celluloid strip that has been coated with a gelatin emulsion containing silver halides, usually AgBr. It is based on the chemical behaviour of silver halides which undergo decomposition in light and form black due to liberation of free silver.

    $$AgBr + 2Na_2S_2O_3 \rightarrow \underset{\text{Soluble}}{Na_3\left[Ag(S_2O_3)_2\right]} + NaBr$$
15. All actinoids are radioactive while in lanthanoid only Pm is radioactive.
16. For Lanthanoid +3 is most common oxidation state.
17. Decrease in size due to poor screening of 4f orbitals is known as lanthanoid contraction.
18. Generally lanthanoids and actinoids or their compounds are coloured.
19. Lanthanoids have little tendency to form complex.
20. Actinoids have more tendency to form complex.
21. All actinoides are radioactive therefore, it is very difficult to study about them.
22. Actinoides can show +3, +4, +5, +6, +7 oxidation state as ejecting out of electron from 5f subshell is easy.

❑ ❑ ❑

Assignment

SECTION - A

NCERT Based MCQs

1. In first series of transition metal, which of the following metal can't be oxidised by 1M H^+(aq) solution? **[NCERT Pg. 224]**

   (1) Zn (2) Mn

   (3) Cr (4) Cu

2. From Sc (Z = 21) to Zn (Z = 30) in 3d series, the lowest value of enthalpy of atomisation is for **[NCERT Pg. 218]**

   (1) Cu (2) V

   (3) Ni (4) Zn

3. MnO_4^{2-} in acidic medium undergo dispropartionation to give **[NCERT Pg. 231]**

   (1) $Mn_2O_3 + MnO_4^-$ (2) $MnO_2 + MnO_4^-$

   (3) $Mn_2O_7 + Mn_2O_3$ (4) $Mn_2O_7 + MnO_2$

4. Permanganate titrations in presence of hydrochloric acid are unsatisfactory since **[NCERT Pg. 234]**

   (1) Hydrochloric acid is oxidised to hydrogen

   (2) Hydrochloric acid is oxidised to chlorine

   (3) Hydrochloric acid is highly volatile in nature

   (4) Hydrochloric acid forms salt with permanganate ion

5. The value of magnetic moment in Bohr magneton for a transition metal of 3*d* series is $\sqrt{48}$. Its electronic configuration is **[NCERT Pg. 228]**

   (1) [Ar] $3d^5 4s^2$ (2) [Ar] $3d^6 4s^2$

   (3) [Ar] $3d^5 4s^1$ (4) [Ar] $3d^1 4s^2$

6. The transition element which does not exhibit variable oxidation state is **[NCERT Pg. 223]**

   (1) Sc (2) Fe

   (3) Mn (4) Co

7. Identify the paramagnetic lanthanoid ion among the following **[NCERT Pg. 236]**

   (1) Ce^{4+} (2) La^{3+}

   (3) Eu^{3+} (4) Yb^{2+}

8. The change in the oxidation state of Mn from permanganate ion to the product obtained from its reaction in faintly alkaline medium is **[NCERT Pg. 234]**

   (1) 2 (2) 3

   (3) 4 (4) 5

9. The equilibrium $2CrO_4^{2-} \rightleftharpoons Cr_2O_7^{2-}$ shifts to the right in **[NCERT Pg. 232]**

   (1) Acidic medium

   (2) Basic medium

   (3) Neutral medium

   (4) Faintly alkaline medium

10. In dichromate ion **[NCERT Pg. 232]**

    (1) All eight Cr–O bonds are equivalent and have Cr–O–Cr bond

    (2) Six Cr–O bonds are equivalent and have Cr–Cr bond

    (3) Six Cr–O bonds are equivalent and have Cr–O–Cr bond

    (4) Four Cr–O bonds are equivalent and have Cr–Cr bond

11. The correct match of the order of the ions/elements for the given properties is/are **[NCERT Pg. 235, 220, 228]**

    (i) $Mn^{2+} < Fe^{2+} < Co^{2+} < Ni^{2+}$ – Magnitude of hydration enthalpy

    (ii) Co > Ni > Fe > Mn – Atomic radii

    (iii) $Ni^{2+} < Co^{2+} < Fe^{2+} < Mn^{2+}$ – Number of unpaired electrons

    (1) Only (iii) (2) Both (i) and (ii)

    (3) Both (i) and (iii) (4) (i), (ii) and (iii)

12. The coloured product obtained on reaction of ferrous chromate with sodium carbonate in free access of air is **[NCERT Pg. 231]**

(1) Purple solution of ferric dichromate

(2) Yellow solution of sodium chromate

(3) Green solution of sodium dichromate

(4) Brownish solution of ferrous oxide

13. The transition metals form a large number of complex compounds due to **[NCERT Pg. 229]**

(1) Their lower ionic charges

(2) Availability of *f*-orbitals for bond formation

(3) Their inability to adopt multiple oxidation states

(4) Smaller size of metal ions

14. Among lanthanoids, the basic nature of hydroxides gradually **[NCERT Pg. 237]**

(1) Decreases

(2) Increases

(3) First decreases then increases

(4) First increases then decreases

15. Consider the following statements.

(i) Zr and Hf have almost identical radii

(ii) Ce^{4+} is a strong reductant

(iii) Ln (lanthanoids) combine with nitrogen and form LnN_3

The correct statement(s) is/are

[NCERT Pg. 235, 237]

(1) Only (i) (2) Only (ii)

(3) Both (i) & (ii) (4) Both (i) & (iii)

SECTION - B

Objective Type Questions

1. The calomel is

(1) $HgCl_2$ (2) Hg_2Cl_2

(3) $Hg_2(NO_3)_2$ (4) $HgSO_4$

2. Chromite ore $\xrightarrow{Na_2CO_3 + O_2}$ A $\underset{NaOH}{\overset{H_2SO_4}{\rightleftharpoons}}$ B

anions present in products A and B is/are

(1) A = $Cr_2O_4^{2-}$ (2) B = $Cr_2O_7^{2-}$

(3) A = CrO_4^{2-} (4) Both (2) & (3)

3. Which of the following ions can show *d*-*d* transition?

(1) CrO_4^{2-} (2) $Cr_2O_7^{2-}$

(3) MnO_4^{2-} (4) MnO_4^-

4. Which of the following pairs of oxides are of basic nature?

(1) MnO, Cr_2O_3 (2) MnO, CrO

(3) CrO, Mn_2O_7 (4) CrO_3, Mn_2O_7

5. When H_2O_2 is added to acidified $K_2Cr_2O_7$, in ether a blue colour is formed due to formation of

(1) CrO_3 (2) CrO_5

(3) Cr_2O_3 (4) CrO

6. Chromyl chloride test is not given by

(1) $HgCl_2$ (2) $PbCl_2$

(3) AgCl (4) All of these

7. Which of the following have f^7 configuration?

(1) Eu (2) Gd

(3) Am (4) All of these

8. Equivalent weight of $K_2Cr_2O_7$ in acidic medium is equal to

(1) $\frac{M}{2}$ (2) $\frac{M}{5}$

(3) $\frac{M}{6}$ (4) $\frac{M}{8}$

9. Which of the following is not correctly matched?

(1) Pyrolusite — MnO_2

(2) Mohr's salt — $FeSO_4 \cdot (NH_4)_2 SO_4 \cdot 6H_2O$

(3) Cinnabar — HgS

(4) Azurite — $CaCO_3 \cdot CuCO_3$

10. Which of the following metals is common in gun metal, monel metal and brass alloy?

(1) Zn (2) Cu

(3) Ag (4) Fe

11. Which of the following statement(s) is/are correct when a mixture of NaCl and $K_2Cr_2O_7$ is gently warmed with conc. H_2SO_4?

(1) A deep red vapour is evolved

(2) Chromyl chloride is formed

(3) Chlorine gas is evolved

(4) Both (1) & (2)

12. Which of the following pairs of ions are coloured in aqueous solution?

(1) Ni^{2+} & Ti^{3+}

(2) Sc^{3+} & Ti^{3+}

(3) Ni^{2+} & Sc^{3+}

(4) Sc^{3+} & Cu^{+}

13. Which of the following statements is incorrect?

(1) Zn is not considered as transition element

(2) Promethium (Pm) is radioactive

(3) $La(OH)_3$ is more basic than $Lu(OH)_3$

(4) Separation of lanthanoid is not possible by ion exchange method

14. The transition element which does not exhibit variable oxidation states is/are

(1) Mn

(2) Sc

(3) Cr

(4) Both (2) & (3)

15. Which of the following characteristic property of $KMnO_4$ is/are correct?

(1) $KMnO_4$ forms dark purple crystals

(2) SO_2 is oxidised to SO_4^{2-} with $KMnO_4$ in acidic medium

(3) Purple colour of MnO_4^- ion is due to charge transfer

(4) All of these

16. Which of the following is the electronic configuration of Gd (Z = 64)?

(1) $[Xe]4f^7 5d^1 6s^2$

(2) $[Rn]5f^7 6d^1 7s^2$

(3) $[Xe]4f^7 6s^2$

(4) $[Rn]5f^7 7s^2$

17. $Cr_2O_7^{2-} \underset{pH=Y}{\overset{pH=X}{\rightleftharpoons}} CrO_4^{2-}$

The value of Y and X respectively are

(1) 3, 8 (2) 8, 4

(3) 8, 10 (4) 10, 2

18. Ground state electronic configuration of Ce is

(Atomic number of Ce = 58)

(1) [Xe] $4f^2\ 5d^0\ 6s^1$

(2) [Xe] $4f^1\ 5d^1\ 6s^2$

(3) [Xe] $5d^1\ 6s^2$

(4) [Xe] $4f^2\ 5d^1\ 6s^1$

19. (Cr–O–Cr) bond angle in $Cr_2O_7^{2-}$ is nearly

(1) 126° (2) 105.5°

(3) 150° (4) 97°

20. Which of the following does not correctly represent the order of the property indicated against it?

(1) Ti < V < Cr < Mn : Increasing number of oxidation states

(2) $Cr_2O_7^{2-} < MnO_4^-$: Increasing oxidising power

(3) Ti < V < Cr < Mn : Increasing melting point

(4) $Lu^{3+} < Eu^{3+} < La^{3+}$: Increasing order of ionic radii

21. *n*-factor of KI when treated with alkaline $KMnO_4$ solution is

(1) 2 (2) 3

(3) 5 (4) 6

22. Which of the following is/are correct statements?

(1) $K_2Cr_2O_7$ has orange colour due to charge transfer

(2) Zn, Cd and Hg are not considered as transition metals

(3) Tungsten has a very high melting point

(4) All of these

23. The tendency to form complexes is maximum for

(1) Inner-transition elements

(2) Representative elements

(3) Transition elements

(4) Metals containing fully filled d-orbitals

24. The highest magnetic moment will be shown by

(1) Zn

(2) Co

(3) Mn

(4) Fe

SECTION - C

Previous Years Questions

1. Match the catalyst with the process

	Catalyst		Process
(i)	V_2O_5	(a)	The oxidation of ethyne to ethanal
(ii)	$TiCl_4$+ $Al(CH_3)_3$	(b)	Polymerisation of alkynes
(iii)	$PdCl_2$	(c)	Oxidation of SO_2 in the manufacture of H_2SO_4
(iv)	Nickel complexes	(d)	Polymerisation of ethylene

Which of the following is the correct option?

[NEET-2019 (Odisha)]

(1) (i)-(c), (ii)-(a), (iii)-(d), (iv)-(b)

(2) (i)-(c), (ii)-(d), (iii)-(a), (iv)-(b)

(3) (i)-(a), (ii)-(b), (iii)-(c), (iv)-(d)

(4) (i)-(a), (ii)-(c), (iii)-(b), (iv)-(d)

2. When neutral or faintly alkaline $KMnO_4$ is treated with potassium iodide, iodide ion is converted into 'X'. 'X' is **[NEET-2019 (Odisha)]**

(1) IO^- (2) I_2

(3) IO_4^- (4) IO_3^-

3. The manganate and permanganate ions are tetrahedral, due to **[NEET-2019]**

(1) The π-bonding involves overlap of p-orbitals of oxygen with d-orbitals of manganese

(2) There is no π-bonding

(3) The π-bonding involves overlap of p-orbitals of oxygen with p-orbitals of manganese

(4) The π-bonding involves overlap of d-orbitals of oxygen with d-orbitals of manganese

4. Which one of the following ions exhibits d-d transition and paramagnetism as well?

[NEET-2018]

(1) CrO_4^{2-} (2) $Cr_2O_7^{2-}$

(3) MnO_4^{2-} (4) MnO_4^-

5. The reason for greater range of oxidation states in actinoids is attributed to **[NEET-2017]**

(1) The radioactive nature of actinoids

(2) Actinoid contraction

(3) 5*f*, 6*d* and 7*s* levels having comparable energies

(4) 4*f* and 5*d* levels being close in energies

6. Which one of the following statements related to lanthanons is **incorrect**? **[NEET(Phase-2)-2016]**

(1) Europium shows +2 oxidation state

(2) The basicity decreases as the ionic radius decreases from Pr to Lu

(3) All the lanthanons are much more reactive than aluminium

(4) Ce(+4) solutions are widely used as oxidizing agent in volumetric analysis

7. Which one of the following statements is corrected when SO_2 is passed through acidified $K_2Cr_2O_7$ solution? **[NEET-2016]**

(1) Green $Cr_2(SO_4)_3$ is formed

(2) The solution turns blue

(3) The solution is decolourized

(4) SO_2 is reduced

8. The electronic configurations of Eu (Atomic No. 63), Gd (Atomic No. 64) and Tb (Atomic No. 65) are

[NEET-2016]

(1) $[Xe]4f^76s^2$, $[Xe]4f^75d^16s^2$ and $[Xe]4f^96s^2$

(2) $[Xe]4f^76s^2$, $[Xe]4f^86s^2$ and $[Xe]4f^85d^16s^2$

(3) $[Xe]4f^65d^16s^2$, $[Xe]4f^75f^1$ and $[Xe]4f^96s^2$

(4) $[Xe]4f^65d^16s^2$, $[Xe]4f^75d^16s^2$ and $[Xe]4f^85d^16s^2$

9. Gadolinium belongs to 4*f* series. Its atomic number is 64. Which of the following is the correct electronic configuration of gadolinium?

[Re-AIPMT-2015]

(1) $[Xe]4f^75d^16s^2$

(2) $[Xe]4f^65d^26s^2$

(3) $[Xe]4f^86d^2$

(4) $[Xe]4f^95s^1$

10. Because of lanthanoid contraction, which of the following pairs of elements have nearly same atomic radii? (Numbers in the parenthesis are atomic numbers) **[AIPMT-2015]**

(1) Zr (40) and Ta (73) (2) Ti (22) and Zr (40)

(3) Zr (40) and Nb (41) (4) Zr (40) and Hf (72)

11. The pair of compounds that can exist together is **[AIPMT-2014]**

(1) $FeCl_3$, $SnCl_2$ (2) $HgCl_2$, $SnCl_2$

(3) $FeCl_2$, $SnCl_2$ (4) $FeCl_3$, KI

12. The reaction of aqueous $KMnO_4$ with H_2O_2 in acidic conditions gives **[AIPMT-2014]**

(1) Mn^{4+} and O_2

(2) Mn^{2+} and O_2

(3) Mn^{2+} and O_3

(4) Mn^{4+} and MnO_2

13. Magnetic moment 2.83 BM is given by which of the following ions ? (At. nos. Ti = 22, Cr = 24, Mn = 25, Ni = 28) **[AIPMT-2014]**

(1) Ti^{3+} (2) Ni^{2+}

(3) Cr^{3+} (4) Mn^{2+}

14. Reason of lanthanoid contraction is **[AIPMT-2014]**

(1) Negligible screening effect of 'f' orbitals

(2) Increasing nuclear charge

(3) Decreasing nuclear charge

(4) Decreasing screening effect

15. Which of the following lanthanoid ions is diamagnetic? (At No. Ce = 58, Sm = 62, Eu = 63, Yb = 70) **[NEET-2013]**

(1) Sm^{2+} (2) Eu^{2+}

(3) Yb^{2+} (4) Ce^{2+}

16. Which of the following statements about the interstitial compounds is incorrect ? **[NEET-2013]**

(1) They are chemically reactive

(2) They are much harder than the pure metal

(3) They have higher melting points than the pure metal

(4) They retain metallic conductivity

17. Which of the statements is not true ? **[AIPMT (Prelims)-2012]**

(1) $K_2Cr_2O_7$ solution in acidic medium is orange

(2) $K_2Cr_2O_7$ solution becomes yellow on increasing the pH beyond 7

(3) On passing H_2S through acidified $K_2Cr_2O_7$ solution, a milky colour is observed

(4) $Na_2Cr_2O_7$ is preferred over $K_2Cr_2O_7$ in volumetric analysis

18. Which one of the following does not correctly represent the correct order of the property indicated against it ? **[AIPMT (Mains)-2012]**

(1) Ti < V < Cr < Mn : increasing number of oxidation states

(2) $Ti^{3+} < V^{3+} < Cr^{3+} < Mn^{3+}$: increasing magnetic moment

(3) Ti < V < Cr < Mn : increasing melting points

(4) Ti < V < Mn < Cr : increasing 2nd ionization enthalpy

19. Which of the following exhibits only +3 oxidation state ? **[AIPMT (Mains)-2012]**

(1) U (2) Th

(3) Ac (4) Pa

20. Four successive members of the first series of the transition metals are listed below. For which one of them the standard potential ($E^\circ_{M^{2+}/M}$) value has a positive sign ? **[AIPMT (Mains)-2012]**

(1) Co (Z = 27) (2) Ni (Z = 28)

(3) Cu (Z = 29) (4) Fe (Z = 26)

21. Acidified $K_2Cr_2O_7$ solution turns green when Na_2SO_3 is added to it. This is due to the formation of **[AIPMT (Prelims)-2011]**

(1) $CrSO_4$ (2) $Cr_2(SO_4)_3$

(3) CrO_4^{2-} (4) $Cr_2(SO_3)_3$

22. For the four successive transition elements (Cr, Mn, Fe and Co), the stability of +2 oxidation state will be there in which of the following order?

(At. No. Cr = 24, Mn = 25, Fe = 26, Co = 27) **[AIPMT (Prelims)-2011]**

(1) Cr > Mn > Co > Fe

(2) Mn > Fe > Cr > Co

(3) Fe > Mn > Co > Cr

(4) Co > Mn > Fe > Cr

23. Which of the following ions will exhibit colour in aqueous solutions ? **[AIPMT (Prelims)-2010]**

(1) La^{3+} (Z = 57) (2) Ti^{3+} (Z = 22)

(3) Lu^{3+} (Z = 71) (4) Sc^{3+} (Z = 21)

24. Which one of the following ions has electronic configuration [Ar] $3d^6$? **[AIPMT (Prelims)-2010]**

(1) Ni^{3+} (2) Mn^{3+}

(3) Fe^{3+} (4) Co^{3+}

25. Which of the following pairs has the same size ? **[AIPMT (Prelims)-2010]**

(1) Fe^{2+}, Ni^{2+} (2) Zr^{4+}, Ti^{4+}

(3) Zr^{4+}, Hf^{4+} (4) Zn^{2+}, Hf^{4+}

26. Which of the following oxidation states is the most common among the lanthanoids ? **[AIPMT (Mains)-2010]**

(1) 4 (2) 2

(3) 5 (4) 3

27. Which one of the elements with the following outer orbital configurations may exhibit the largest number of oxidation states? **[AIPMT (Prelims)-2009]**

(1) $3d^5 4s^1$ (2) $3d^5 4s^2$

(3) $3d^2 4s^2$ (4) $3d^3 4s^2$

28. The correct order of decreasing second ionisation enthalpy of Ti(22), V(23), Cr(24) and Mn(25) is **[AIPMT (Prelims)-2008]**

(1) Ti > V > Cr > Mn (2) Cr > Mn > V > Ti

(3) V > Mn > Cr > Ti (4) Mn > Cr > Ti > V

29. Number of moles of MnO_4^- required to oxidize one mole of ferrous oxalate completely in acidic medium will be **[AIPMT (Prelims)-2008]**

(1) 0.2 moles (2) 0.6 moles

(3) 0.4 moles (4) 7.5 moles

30. Identify the incorrect statement among the following **[AIPMT (Prelims)-2007]**

(1) Shielding power of 4f electrons is quite weak

(2) There is a decrease in the radii of the atoms or ions as one proceeds from La to Lu

(3) Lanthanoid contraction is the accumulation of successive shrinkages

(4) As a result of lanthanoid contraction, the properties of 4d series of the transition elements have no similarities with the 5d series of elements

31. Which one of the following ions is the most stable in aqueous solution? (Atomic number. Ti = 22, V = 23, Cr = 24, Mn = 25) **[AIPMT (Prelims)-2007]**

(1) Mn^{2+} (2) Cr^{3+}

(3) V^{3+} (4) Ti^{3+}

32. More number of oxidation states are exhibited by the actinoids than by the lanthanoids. The main reason for this is **[AIPMT (Prelims)-2006]**

(1) More energy difference between 5f and 6d orbitals than that between 4f and 5d orbitals

(2) Lesser energy difference between 5f and 6d orbitals than that between 4f and 5d orbitals

(3) Greater metallic character of the lanthanoids than that of the corresponding actinoids

(4) More active nature of the actinoids

33. Copper sulphate dissolves in excess of KCN to give **[AIPMT (Prelims)-2006]**

(1) CuCN (2) $[Cu(CN)_4]^{3-}$

(3) $[Cu(CN)_4]^{2-}$ (4) $Cu(CN)_2$

34. In which of the following pairs are both the ions coloured in aqueous solution? (At. no.: Sc = 21, Ti = 22, Ni = 28, Cu = 29, Co = 27) **[AIPMT (Prelims)-2006]**

(1) Ni^{2+}, Ti^{3+}

(2) Sc^{3+}, Ti^{3+}

(3) Sc^{3+}, Co^{2+}

(4) Ni^{2+}, Cu^{+}

35. The number of moles of $KMnO_4$ reduced one mole of KI in alkaline medium is **[AIPMT (Prelims)-2005]**

(1) One fifth

(2) Five

(3) One

(4) Two

36. The aqueous solution containing which one of the following ions will be colourless? (Atomic no. Sc = 21, Fe = 26, Ti = 22, Mn = 25) **[AIPMT (Prelims)-2005]**

(1) Sc^{3+}

(2) Fe^{2+}

(3) Ti^{3+}

(4) Mn^{2+}

37. Four successive members of the first row transition elements are listed below with their atomic numbers. Which one of them expected to have the highest third ionization enthalpy? **[AIPMT (Prelims)-2005]**

(1) Vanadium (Z = 23)

(2) Chromium (Z = 24)

(3) Iron (Z = 26)

(4) Manganese (Z = 25)

38. The main reason for larger number of oxidation states exhibited by the actinides than the corresponding lanthanides, is **[AIPMT (Prelims)-2005]**

(1) Lesser energy difference between 5f and 6d orbitals than between 4f and 5d orbitals

(2) Larger atomic size of actinides than the lanthanides

(3) More energy difference between 5f and 6d orbitals than between 4f and 5d orbitals

(4) Greater reactive nature of the actinides than the lanthanides

Questions asked Prior to Medical Ent. Exams. 2005

39. The catalytic activity of transition metals and their compounds is ascribed mainly to

(1) Their magnetic behaviour

(2) Their unfilled *d*-orbitals

(3) Their ability to adopt variable oxidation states

(4) Their chemical reactivity

40. Which one of the following elements shows maximum number of different oxidation states in its compounds?

(1) Gd (2) La

(3) Eu (4) Am

41. Without losing its concentration $ZnCl_2$ solution cannot be kept in contact with

(1) Pb (2) Al

(3) Au (4) Ag

42. Which ion is colourless?

(1) Cr^{4+}

(2) Sc^{3+}

(3) Ti^{3+}

(4) V^{3+}

43. General electronic configuration of lanthanides is

(1) $(n-2)\, f^{1-14}\, (n-1)\, d^{0-1}\, ns^2$

(2) $(n-2)\, f^{10-14}\, (n-1)\, d^{0-1}\, ns^2$

(3) $(n-2)\, f^{0-14}\, (n-1)\, d^{10}\, ns^2$

(4) $(n-2)\, d^{0-1}\, (n-1)\, f^{1-14}\, ns^2$

44. Which of the following shows maximum number of oxidation states?

(1) Cr (2) Fe

(3) Mn (4) V

45. In the silver plating of copper, $K[Ag(CN)_2]$ is used instead of $AgNO_3$. The reason is

(1) A thin layer of Ag is formed on Cu

(2) More voltage is required

(3) Ag^+ ions are completely removed from solution

(4) Less availability of Ag^+ ions, as Cu cannot displace Ag from $[Ag(CN)_2]^-$ ion

46. $CuSO_4$ when reacts with KCN forms CuCN, which is insoluble in water. It is soluble in excess of KCN, due to formation of the following complex

(1) $K_2[Cu(CN)_4]$ (2) $K_3[Cu(CN)_4]$

(3) $CuCN_2$ (4) $Cu[K\ Cu(CN)_4]$

47. Which of the following is expected to be coloured in solutions?

(1) Cu^+ (2) Cu^{2+}

(3) Ti^{4+} (4) Sc^{3+}

48. The basic character of the transition metal monoxides follows the order (Atomic nos. Ti = 22, V = 23, Cr = 24, Fe = 26)

(1) VO > CrO > TiO > FeO

(2) CrO > VO > FeO > TiO

(3) TiO > FeO > VO > CrO

(4) TiO > VO > CrO > FeO

49. The correct order of ionic radii of Y^{3+}, La^{3+}, Eu^{3+} and Lu^{3+} is (Atomic nos. Y = 39, La = 57, Eu = 63, Lu = 71)

(1) $Y^{3+} < La^{3+} < Eu^{3+} < Lu^{3+}$

(2) $Lu^{3+} < Y^{3+} < Eu^{3+} < La^{3+}$

(3) $Lu^{3+} < Eu^{3+} < La^{3+} < Y^{3+}$

(4) $La^{3+} < Eu^{3+} < Lu^{3+} < Y^{3+}$

50. Among the following series of transition metal ions, the one where all metal ions have $3d^2$ electronic configuration is [At. No. Ti = 22, V = 23, Cr = 24, Mn = 25]
(1) Ti^{3+}, V^{2+}, Cr^{3+}, Mn^{4+} (2) Ti^{+}, V^{4+}, Cr^{6+}, Mn^{7+}
(3) Ti^{4+}, V^{3+}, Cr^{2+}, Mn^{3+} (4) Ti^{2+}, V^{3+}, Cr^{4+}, Mn^{5+}

51. Lanthanoids are
(1) 14 elements in the sixth period (atomic number 90 to 103) that are filling 4*f* sublevel
(2) 14 elements in the seventh period (atomic number = 90 to 103) that are filling 5*f* sublevel
(3) 14 elements in the sixth period (atomic number = 58 to 71) that are filling the 4*f* sublevel
(4) 14 elements in the seventh period (atomic number = 50 to 71) that are filling 4*f* sublevel

52. Which of the following statement is not correct?
(1) $La(OH)_2$ is less basic than $Lu(OH)_3$
(2) In lanthanide series ionic radius of Lu^{+3} ion decreases
(3) La is actually an element of transition series rather lanthanides
(4) Atomic radius of Zr and Hf are same because of lanthanide contraction

53. Which one of the elements with the following outer orbital configurations may exhibit the largest number of oxidations states?
(1) $3d^2 4s^2$ (2) $3d^3 4s^2$
(3) $3d^5 4s^1$ (4) $3d^5 4s^2$

54. The highest possible oxidation state shown by osmium in its compound is
(1) +4 (2) +8
(3) +6 (4) +10

SECTION - D

NEET Booster Questions

1. The melting point of Zn is lower as compared to those of the other element of 3d series elements because
(1) The d-orbitals are completely filled
(2) The d-orbitals are partially filled
(3) Zn is a transition element
(4) All of these

2. First IE of 5d series elements are higher than those of 3d and 4d series elements. This is due to
(1) Bigger size of atoms of 5d-series elements than the size of 3d-series elements
(2) Greater effective nuclear charge is experienced by valence electrons because of the weak shielding of the nucleus by 4f-electrons in 5d series
(3) *d-d* transition
(4) All of these

3. +8 oxidation state is shown by
(1) Os (2) Mn
(3) Cr (4) Co

4. Magnetic moment of Cr^{2+}, Mn^{2+} and Fe^{2+} are x, y, z. They are in order
(1) x < y < z (2) x > y > z
(3) z < x = y (4) x = z < y

5. $MnO_4^{(-)}$ is of pale pink colour due to
(1) Charge transfer from metal to oxygen
(2) Charge transfer from oxygen to metal
(3) *d-d* transition
(4) All of these

6. The yellow colour of chromates changes to orange on acidification due to formation of
(1) Cr^{3+} (2) Cr_2O_3
(3) $Cr_2O_7^{2-}$ (4) CrO_4^{-}

7. The catalytic activity of the transition metal and their compound is due to their
(1) Chemical reactivity
(2) Magnetic behaviour
(3) Filled d-orbitals
(4) Ability to adopt multiple oxidation state and their complexing ability

8. Which of the following forms interstitial compounds?
(1) Fe (2) Co
(3) Ni (4) All of these

9. In dilute alkaline solution, MnO_4^{-} changes to
(1) MnO_4^{2-} (2) MnO_2
(3) Mn_2O_3 (4) MnO

10. The radius of La^{3+} (*Z* = 57) is 1.06 Å, which one of the following given values will be closest to the radius of Lu^{3+} (*Z* = 71)?
(1) 1.60 Å (2) 1.40 Å
(3) 1.06 Å (4) 0.85 Å

11. The lanthanoids contraction is responsible for the fact that
    (1) Zr and Y have about the same radius
    (2) Zr and Nb have similar oxidation state
    (3) Zr and Hf have about the same radius
    (4) Zr and Zn have same oxidation number

12. Larger number of oxidation states are exhibited by the actinoids than those by the lanthanoids, the main reason being
    (1) Lesser energy difference between 5f and 6d than between 4f and 5d orbitals
    (2) More energy difference between 5f and 6d than between 4f and 5d orbitals
    (3) More reactive nature of the actinoids than the lanthanoids
    (4) 4f orbitals more diffused than the 5f orbitals

13. Which of the following mangnese oxide is not formed?
    (1) MnO (2) MnO_2
    (3) Mn_2O_3 (4) Mn_2O_5

14. Which of the following group of transition metal is called coinage metals?
    (1) Cu, Ag, Au (2) Ru, Rh, Pb
    (3) Fe, Co, Ni (4) Os, Ir, Pt

15. Among the following, the coloured compound is
    (1) CuCl (2) $K_3[Cu(CN)_4]$
    (3) $CuF_2 \cdot xH_2O$ (4) $[Cu(CH_3CN)_4]BF_4$

16. Which is the correct statement about $Cr_2O_7^{2-}$ structure?
    (1) It has neither Cr – Cr bond nor O – O bond
    (2) It has one Cr – Cr bond and six O – O bonds
    (3) It has no Cr – Cr bond but has six O – O bonds
    (4) It has one Cr – Cr bond and seven Cr – O bonds

17. The spin only magnetic moment of Fe^{3+} ion in (BM) is approximately.
    (1) 4 (2) 7
    (3) 5 (4) 6

18. When dil.H_2SO_4 is added to aqueous solution of potassium chromate, yellow colour of solution turns to orange colour. It indicates
    (1) Chromate ions are reduced
    (2) Chromate ions are oxidised
    (3) Monocentric complex is convert into dicentric complex
    (4) Oxygen get removed from chromate ions

19. The correct formula of mercurous ion is
    (1) Hg^+ (2) Hg_2^+
    (3) Hg_2^{2+} (4) All of these

20. Which of the following pair of transition metal ions are the best oxidising agents in aqueous solutions?
    (1) V^{2+} and Cr^{2+} (2) Ti^{2+} and Cr^{2+}
    (3) Mn^{3+} and Co^{3+} (4) V^{2+} and Fe^{2+}

21. Which of the following is red in colour?
    (1) Cu_2O (2) CuF
    (3) ZnF_2 (4) $ZnCl_2$

22. Fenton's reagent is
    (1) $SnCl_2$ + HCl (2) $AgNO_3$ + NH_4OH
    (3) $CuSO_4$ + NaOH (4) $FeSO_4$ + H_2O_2

23. The following is known as "Bordeaux mixture".
    (1) Borax and copper sulphate
    (2) Orthoboric acid and ferrous sulphate
    (3) Sodium borate and zinc sulphate
    (4) Copper sulphate and lime

24. Ce^{4+} is stable. This is because of
    (1) Half-filled 5*d*-orbitals
    (2) All paired electrons in 5*d*-orbitals
    (3) Noble gas configuration
    (4) Fully filled 5*d*-orbitals

25. The point of dissimilarity between lanthanoids and actionoids is
    (1) Outermost shells configuration
    (2) General oxidation state (+3)
    (3) Group number
    (4) Radioactive - nature

26. Choose the correct
    (1) Cr^{2+} is stronger reducing agent than Fe^{2+} in aqueous medium
    (2) Cu^{2+} undergoes disproportionation in aqueous medium
    (3) Silver is not a transition element
    (4) All are correct

27. CrO_4^{2-} (yellow) changes to $Cr_2O_7^{2-}$ (orange) in pH = x and vice-versa in pH = y. Hence, x and y are

(1) 6, 8 (2) 6, 5

(3) 8, 6 (4) 7, 7

28. The product of I^- with MnO_4^- in alkaline medium is

(1) I_2 (2) IO_3^-

(3) IO^- (4) IO_4^-

29. When Zn is treated with excess of NaOH, the product obtained is

(1) $Zn(OH)_2$ (2) ZnOH

(3) Na_2ZnO_2 (4) ZnO

30. Which of the following is most stable

(1) Cr^{+4} (2) Cr^{+2}

(3) Cr^{+3} (4) Cr^{+5}

31. Which of the following pair of ions has same value of ''spin-only'' magnetic moment

(1) Cu^+, Cu^{2+} (2) Co^{3+}, Fe^{2+}

(3) Ti^{2+}, V^{2+} (4) Sc^{2+}, Zn^{+2}

32. Coinage metals are

(1) Normal metals (2) Transition metals

(3) Active metals (4) Highly electropositive

33. Pyrolusite is used to prepare potassium permanganate $MnO_2 \xrightarrow{X} MnO_4^{-2} \xrightarrow{Y} MnO_4^-$

X and Y are

(1) Fuse with KOH/air, electrolytic reduction

(2) Fuse with KOH/air, electrolytic oxidation

(3) Fuse with con. HNO_3/air, electrolytic reduction

(4) All are correct

34. Which one of the following exhibits highest oxidation state?

(1) Zr (2) V

(3) Mn (4) Ni

35. A purple coloured solution is made alkaline with KOH and is treated with KI forming potassium iodate. The same solution is acidified with H_2SO_4 and again it is treated with KI. However this time instead of potassium iodate, iodine gas is released. The purple coloured solution is of

(1) $K_2Cr_2O_7$ (2) $K_2Cr_2O_4$

(3) $KMnO_4$ (4) K_2MnO_4

36. Acidified solution of chromic acid on treatment with H_2O_2 gives blue colour which is due to

(1) $CrO_3 + H_2O + O_2$

(2) $Cr_2O_3 + H_2O + O_2$

(3) $CrO_5 + H_2O$

(4) $H_2Cr_2O_7 + H_2O + CO_2$

37. $FeSO_4$ on heating gives

(1) SO_2 and SO_3 (2) SO_2 only

(3) SO_3 only (4) SO_2 and O_2

38. What are the species X and Y in the following?

$$X + H_2O \longrightarrow H_2Cr_2O_7 \xrightarrow{OH^-} Y$$

(1) CrO_4^{-2}, $Cr_2O_7^{-2}$ (2) CrO_3, Cr_2O_3

(3) H_2CrO_4, $H_2Cr_2O_7$ (4) CrO_3, CrO_4^{-2}

39. The correct statement

(1) Green vitriol and blue vitriol are isomorphus

(2) $KMnO_4$ and $K_2Cr_2O_7$ are coloured due to d-d transitions

(3) Cu_2Cl_2 and Ag_2S are coloured

(4) Upon strong heating paramagnetic gases are evolved by $NaNO_3$ and $AgNO_3$

40. Which oxide of manganese is acidic in nature?

(1) MnO (2) Mn_2O_7

(3) Mn_2O_3 (4) MnO_2

41. The blue colour produced on adding H_2O_2 to acidified $K_2Cr_2O_7$ is due to the formation of

(1) CrO_5 (2) Cr_2O_3

(3) CrO_4^{2-} (4) CrO_3

42. $4K_2Cr_2O_7 \xrightarrow{\Delta} 4K_2CrO_4 + 3O_2 + X$, in this reaction X is

(1) CrO_3 (2) Cr_2O_7

(3) Cr_2O_3 (4) CrO_5

43. Which of the following is not coloured?

(1) Mn^{2+} (2) Cr^{3+}

(3) Zn^{2+} (4) Cu^{2+}

44. Ammonium dichromate is used in fireworks.The green coloured powder blown in the air is

(1) CrO_3 (2) Cr_2O_3

(3) Cr (4) $CrO(O)_2$

45. Which of the following statement is correct for 3*d*-transition element?
(1) All the metals except Sc forms 'MO' oxide
(2) All the metals except Zn forms 'MO' oxide
(3) All the metals except Zn and Sc form 'MO' oxide
(4) All the metals except Mn forms 'MO' oxide

46. Which of the following belongs to group '8'?
(1) Ni, Pd, Pt (2) F, Cl, Br
(3) Fe, Ru, Os (4) Xe, Ar, Kr

47. Which one of the following pairs of ions have same electronic configuration?
(1) Cr^{3+}, Fe^{3+} (2) Mn^{2+}, Fe^{3+}
(3) Fe^{3+}, Co^{3+} (4) Sc^{3+}, Cr^{3+}

48. The equivalent weight of $MnSO_4$ is equal to its molecular weight when it is converted to
(1) Mn_2O_3 (2) MnO_2
(3) MnO_4^- (4) MnO_4^{2-}

49. Gun metal contains
(1) Cu, Sn, Zn (2) Cu, Ni
(3) Cu, Ni, Fe (4) Cu, Sn, P

50. The colour of $K_2Cr_2O_7$ and Fe^{+2} ions are respectively due to
(1) *d-d* transition and charge transfer spectra
(2) Charge transfer spectra and *d-d* transition
(3) Crystal defects and charge transfer spectra
(4) Charge transfer spectra and crystal defects

51. The element which does not show d^0 configuration in its highest oxidation state
(1) V (2) Mn
(3) Cr (4) Fe

52. CrO_3 is coloured due to
(1) Crystal defect
(2) Unpaired electrons
(3) Charge transfer spectra
(4) Low I.E.

53. Which of the following occur when $AgNO_3$ becomes, red hot?
(1) $2AgNO_3 \longrightarrow 2Ag + 2NO_2 + O_2$
(2) $AgNO_3 \longrightarrow Ag + NO + O_2$
(3) $2AgNO_3 \longrightarrow AgNO_2 + O_2$
(4) $2AgNO_3 \longrightarrow 2Ag + N_2 + 3O_2$

54. Which one alloy does not contain copper?
(1) Bronze (2) Brass
(3) German silver (4) Mischmetal

55. The metal which can form cation having metal - metal bond
(1) Mercury (2) Copper
(3) Osmium (4) Iron

56. Value of magnetic moment of a divalent metal ion is 5.92 BM. Total number of electron in its atom would be
(1) 24 (2) 25
(3) 26 (4) 27

57. In black and white photography, the developed film is fixed by washing with
(1) AgBr solution (2) Hypo solution
(3) $Na_2S_4O_6$ solution (4) FeC_2O_4 solution

58. Gold dissolves in aqua regia to give
(1) $H[AuCl_4]$ (2) $AuNO_3$
(3) $H_2[AuCl_6]$ (4) $Au(NO_3)_3$

59. Ce(Z = 58) and Yb(Z = 70) exhibits stable +4 and +2 oxidation states respectively. This is because
(1) Ce^{4+} and Yb^{2+} acquire f^7 configuration
(2) Ce^{4+} and Yb^{2+} acquire f^0 configuration
(3) Ce^{4+} and Yb^{2+} acquire f^0 and f^{14} configuration
(4) Ce^{4+} and Yb^{2+} acquire f^7 and f^{14} configuration

60. Transuranic elements begin with
(1) Np (2) Cm
(3) Pu (4) U

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