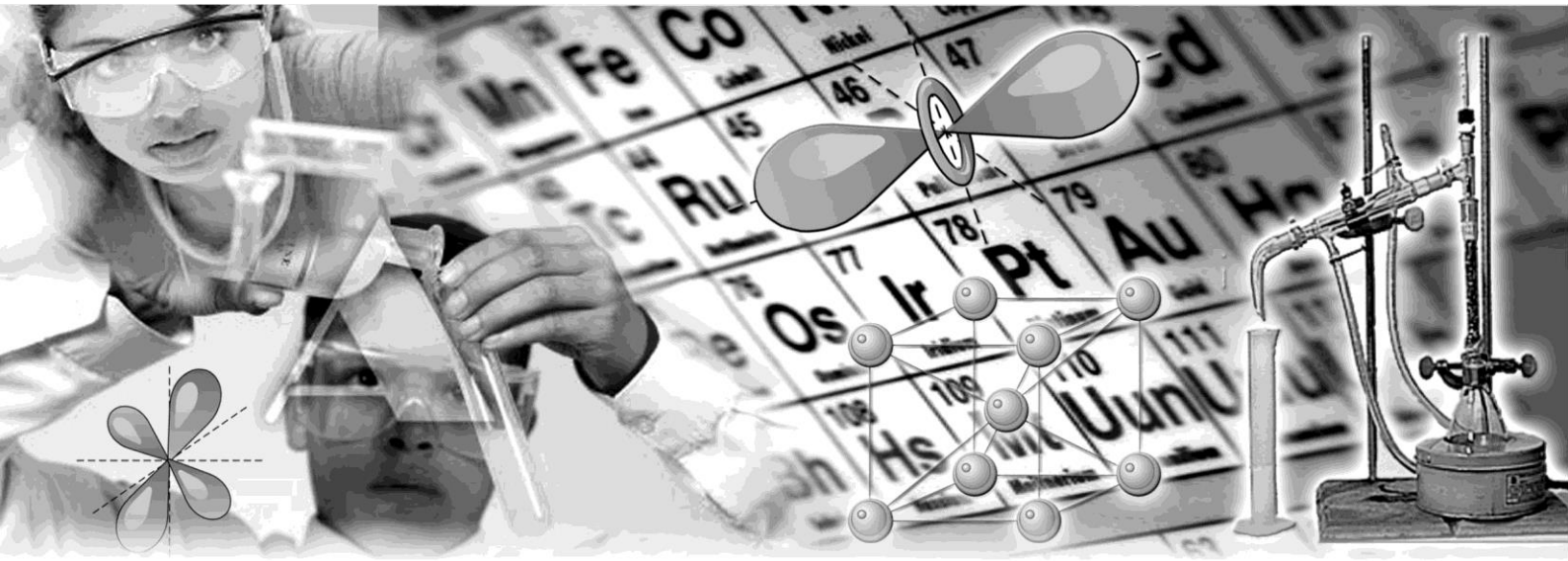


Chapter

31

Biomolecules

All living bodies are composed of several lifeless substances which are present in their cells in a very complex but highly organised form. These are called biomolecules. Some common examples are carbohydrates, proteins, enzymes, nucleic acids, lipids, amino acids, fats etc :

Living organisms → Organs → Tissues → Cells → Organelles → Biomolecules.

Carbohydrates

The carbohydrates are naturally occurring organic substances. They are present in both plants and animals.

"Carbohydrates are defined as a class of compounds that include polyhydric aldehydes or polyhydric ketones and large polymeric compounds that can be broken down (hydrolysed) into polyhydric aldehydes or ketones."

Carbohydrates contain $>C=O$ and $-OH$ groups. A carbonyl compound reacts with an alcohol to form hemiacetal.

The name of simpler carbohydrates end is –ose. Carbohydrate with an aldehydic structure are known as aldoses and those with ketonic structure as ketoses. The number of carbon atom in the molecule is indicated by Greek prefix.

Table : 31.1

Number of carbon atoms in the molecule	Aldose	Ketose
3	Aldotriose	Ketotriose
4	Aldotetrose	Ketotetrose
5	Aldopentose	Ketopentose
6	Aldohexose	Ketohexose
7	Aldoheptose	Ketoheptose

Monosaccharides

These are the simplest one unit non-hydrolysable sugars. They have the general formula $C_nH_{2n}O_n$ where n varies from 3 to 9 carbon atoms. About 20 monosaccharides occur in nature. The simplest are trioses (n=3)

$$\underset{\text{Triose}}{C_3H_6O_3}\ ;\ \begin{array}{l} H-C=O \\ \quad | \\ H-C-OH \\ \quad | \\ CH_2OH \\ \text{Glyceraldehyde} \end{array}\ ;\ \begin{array}{l} CH_2OH \\ \quad | \\ C=O \\ \quad | \\ CH_2OH \\ \text{Dihydroxyacetone} \end{array}$$

The most important naturally occurring monosaccharides are pentoses and hexoses. A common pentose is ribose and two common hexoses are glucose and fructose.

Except ketotriose {dihydroxyacetone}, all aldose and ketoses {monosaccharides} contain asymmetric carbon atoms and are optically active.

Glucose; ($C_6H_{12}O_6$) or Aldo-hexose

Glucose is known as **dextrose** because it occurs in nature as the optically active dextrorotatory isomer. It

is also called grape sugar as it is found in most sweet fruits especially grapes.

(1) ***Preparation :***

(i) ***Laboratory method***

$$\underset{\text{Cane sugar (Sucrose)}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

HCl (dil.) is used for hydrolysis. Glucose being much less soluble in alcohol than fructose separates out by crystallising on cooling.

(ii) ***Manufacture*** : It is obtained on a large scale by the hydrolysis of starch (corn starch or potato starch) with dilute sulphuric acid or hydrochloric acid.

$$\underset{\text{Starch}}{(C_6H_{10}O_5)_n} + nH_2O \xrightarrow[320\,^\circ C,\,2-3\,atm]{H^+} \underset{\text{Glucose}}{nC_6H_{12}O_6}$$

A thin paste of starch is boiled with dilute acid till the hydrolysis is complete. The excess of acid is neutralised with chalk (calcium carbonate) and the filtrate containing glucose is decolourised with animal charcoal. The solution is concentrated and evaporated under reduced pressure. Glucose is obtained in crystalline form.

(2) ***Physical properties*** **:** It is a colourless crystalline solid, melts at $146^\circ C$. It is readily soluble in water. From aqueous solution, it separates as a crystalline monohydrate $(C_6H_{12}O_6.H_2O)$ which melts at $86^\circ C$. It is sparingly soluble in alcohol but insoluble in ether. It is less sweet (three-fourth) than cane sugar. It is optically active and the ordinary naturally occuring form is (+) glucose or dextro form. It shows **mutarotation.**

(3) ***Chemical properties***

(i) ***Alcoholic reactions (Reactions due to –OH group)*** :

(a) *Reaction with acid chlorides and acid anhydride*

$$\begin{array}{l} CHO \\ | \\ (CHOH)_4 + 5CH_3COCl \xrightarrow{ZnCl_2} \\ | \\ CH_2OH \end{array} \begin{array}{l} CHO \\ | \\ (CHOOCCH_3)_4 + 5HCl \\ | \\ CH_2OOCCH_3 \end{array}$$

Acetylchloride; Glucose; Glucose penta-acetate

This shows that a molecule of glucose contains 5 –*OH* groups.

(b) *Reaction with PCl_5*

$$\begin{array}{l} CHO \\ | \\ (CHOH)_4 + 5PCl_5 \longrightarrow \\ | \\ CH_2OH \end{array} \begin{array}{l} CHO \\ | \\ (CHCl)_4 + 5POCl_3 + 5HCl \\ | \\ CH_2Cl \end{array}$$

Glucose; Penta-chloroglucose (Glucose penta-chloride)

(c) *Reaction with metallic hydroxides*

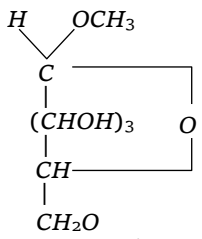
$$\underset{\text{Glucose}}{C_6H_{11}O_5\text{–}OH} + H\text{–}O\text{–}Ca\text{–}OH \longrightarrow \underset{\text{Calcium hydroxide}}{}$$

$$\underset{\text{Calcium glucosate}}{C_6H_{11}O_5\text{–}O\text{–}Ca\text{–}OH} + H_2O$$

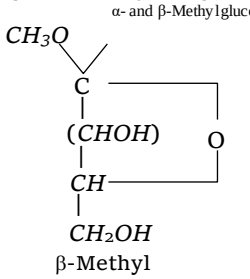
❒ Glucose behaves as a weak acid. Instead of $Ca(OH)_2$ we can take other metallic hydroxide like $Ba(OH)_2, Sr(OH)_2, Cu(OH)_2$ etc to form glucosate which is soluble in water.

(d) *Formation of glycosides*

$$\underset{\text{Glucose}}{C_6H_{11}O_5\text{–}OH} + H\text{–}OCH_3 \xrightarrow{HCl} \underset{\text{α- and β-Methylglucoside}}{C_6H_{11}O_5OCH_3} + H_2O$$



α-Methyl *glucoside*



β-Methyl

This reaction shows the presence of ring structure in glucose.

(ii) ***Reactions of carbonyl group (Aldehydic group)***

(a) *Reduction*

$$\underset{\text{Glucose}}{CH_2OH(CHOH)_4CHO} + 2H \xrightarrow[H_2O]{Na-Hg} \underset{\text{Sorbitol}}{CH_2OH(CHOH)_4CH_2OH}$$

On prolonged heating with concentrated *HI* and red phosphorus at $110^\circ C$, glucose forms a mixture of 2-iodohexane and *n*-hexane.

(b) *Oxidation*

❒ Reaction with Fehling solution

$$\underset{\text{Glucose}}{CH_2OH(CHOH)_4CHO} + 2CuO \longrightarrow \underset{\text{Gluconic acid}}{CH_2OH(CHOH)_4COOH} + \underset{\text{(red ppt.)}}{Cu_2O}\,.$$

❒ Reaction with Tollen's reagent

$$CH_2OH(CHOH)_4CHO + Ag_2O \longrightarrow CH_2OH(CHOH)_4COOH + \underset{\text{(Mirror) [or black ppt.]}}{2Ag}\,.$$

❒ Reaction with Bromine water

$$\underset{\text{Glucose}}{CH_2OH(CHOH)_4CHO} + [O] \xrightarrow{Br_2/H_2O} \underset{\text{Gluconic acid}}{CH_2OH(CHOH)_4COOH}\,.$$

❒ Reaction with Nitric acid

$$\underset{\text{Glucose }(C_6)}{CH_2OH(CHOH)_4CHO} + 3[O] \xrightarrow{HNO_3} \underset{\text{Saccharic acid }(C_6)}{COOH(CHOH)_4COOH} + H_2O\,.$$

(c) *Reaction with HCN*

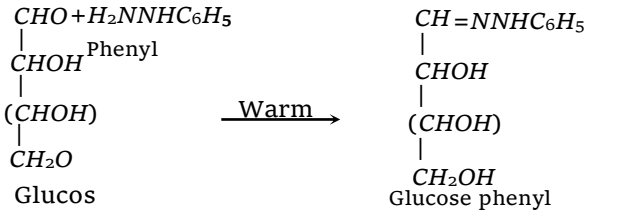
$$CH_2OH(CHOH)_4CHO + HCN \longrightarrow$$

$$\underset{\text{Glucose cyanohydrin}}{CH_2OH(CHOH)_4CH\begin{array}{l}CN\\OH\end{array}}$$

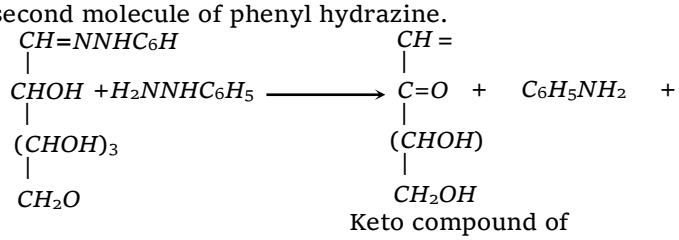
(d) *Reaction with hydroxyl amine*

$$CH_2OH(CHOH)_4CHO + NH_2OH \rightarrow \underset{\text{Glucose oxime}}{CH_2OH(CHOH)_4CH = NOH} + H_2O\,.$$

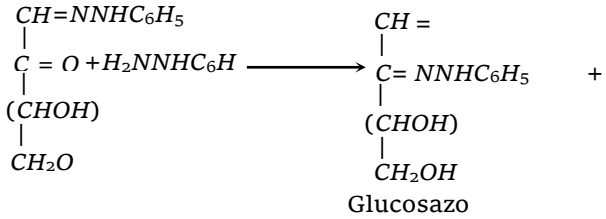
(e) *Reaction with Phenyl hydrazine (Fischer's mechanism)* : When warmed with excess of phenyl hydrazine, glucose first forms phenylhydrazone by condensation with – *CHO* group.



The adjacent – *CHOH* group is then oxidised by a second molecule of phenyl hydrazine.



The resulting carbonyl compounds reacts with a third molecule of phenyl hydrazine to yield glucosazone.



(iii) ***Miscellaneous reactions***

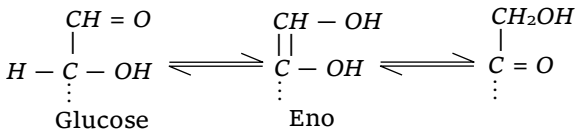
(a) *Fermentation*

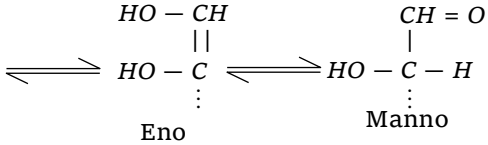
$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow{Zymase} \underset{\text{Ethanol}}{2C_2H_5OH} + 2CO_2$$

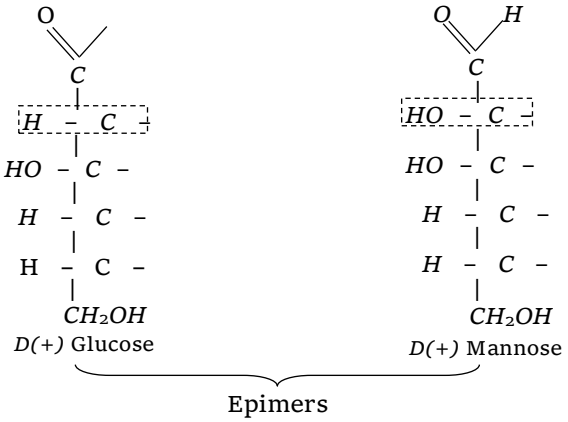
(b) *Dehydration* : When heated strongly or when treated with warm concentrated sulphuric acid, glucose is dehydrated to give a black mass (sugar carbon).

(c) *Reaction with alkalies* : When warmed with concentrated alkali, glucose first turns yellow; then brown and finally gives a resinous mass.

A dilute solution of glucose, when warmed with dilute solution of alkali, some glucose is converted into fructose and mannose. ***D*-glucose** and ***D*-mannose** are **epimers**.



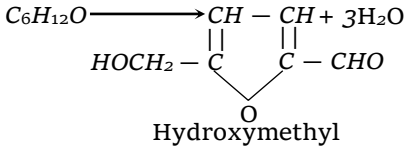




(d) *Action of concentrated hydrochloric acid*

$$C_6H_{12}O_6 \xrightarrow{Conc.\,HCl} \underset{\text{Laevulic acid}}{CH_3COCH_2CH_2COOH} + HCOOH + H_2O$$

On treatment with conc. *HCl*, glucose can also form hydroxymethyl furfural.



This on acid treatment gives laevulic acid

(4) ***Uses***

(i) In the preservation of fruits and preparation of jams and jellies.

(ii) In the preparation of confectionary and as a sweetening agent.

(iii) As a food for patients, invalids and children.

(iv) In the form of calcium glucosate as medicine in treatment of calcium deficiency.

(v) As a reducing agent in silvering of mirrors.

(vi) As a raw material for alcoholic preparations.

(vii) In industrial preparation of vitamin-*C*.

(viii) In the processing of tobacco.

(ix) As an intravenous injection to the patients with lower glucose content in blood.

(5) ***Test of glucose***

(i) When heated in a dry test tube, it melts, turns brown and finally black, giving a characteristic smell of burnt sugar.

(ii) When warmed with a little conc. H_2SO_4, it leaves a charred residue of carbon.

(iii) When it is boiled with dilute *NaOH* solution, it first turns yellow and then brown.

(iv) ***Molisch's test*** : This is a general test for carbohydrates. Two or three drops of alcoholic solution of α-naphthol is added to 2*mL* of glucose solution. 1 *mL* of concentrated H_2SO_4 is added carefully along the sides of the test tube. The formation of a violet ring, at the junction of two liquids confirms the presence of a carbohydrate.

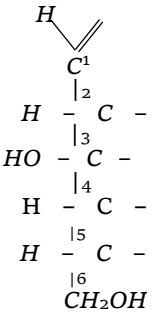
(v) ***Silver mirror test*** : A mixture of glucose and ammonical silver nitrate is warmed in a test tube. Appearance of silver mirror on the inner walls confirms glucose.

(vi) ***Fehling's solution test*** : A little glucose is warmed with Fehling's solution. A red precipitate of cuprous oxide is formed.

(vii) ***Osazone formation*** : Glucose on heating with excess of phenyl hydrazine in acetic acid gives a yellow crystalline compound, m.pt. 205^oC.

(6) ***Structure of glucose***

(i) ***Open chain structure*** : The structure of *D*-glucose as elucidated by Emil Fischer is,

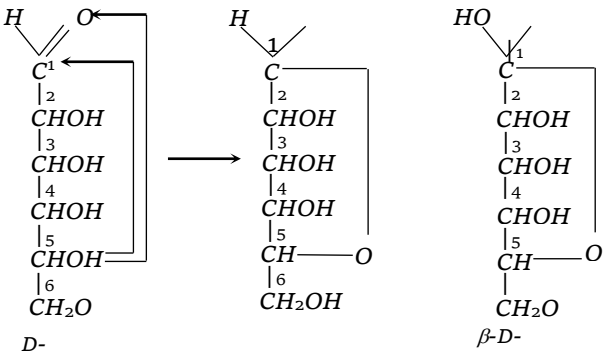


D-Glucose

(Specific rotation =

(b) Ordinary glucose is α-glucose, with a fresh aqueous solution has specific rotation, $[\alpha]_D + 111^o$. On keeping the solution for some time; α-glucose slowly changes into an equilibrium mixture of α-glucose (36%) and β-glucose (64%) and the mixture has specific rotation + 52.5°.

Similarly a fresh aqueous solution of β-glucose having specific rotation, $[\alpha]_D + 19.7^o$, on keeping (standing) gradually changes into the same equilibrium mixutre (having, specific rotation $+52.7^o$). So an aqueous solution of glucose shows a physical property, known as **mutarotation**, i.e., a change in the value of specific rotation (muta=change; rotation = specific rotation) is called **mutarotation.**



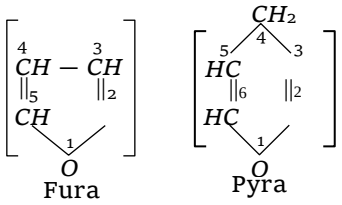
D-

$[\alpha]_D$ = + 52.5° $[\alpha]_D$ = + 111° $[\alpha]_D$ = + 19.7°

α-D-Glucose

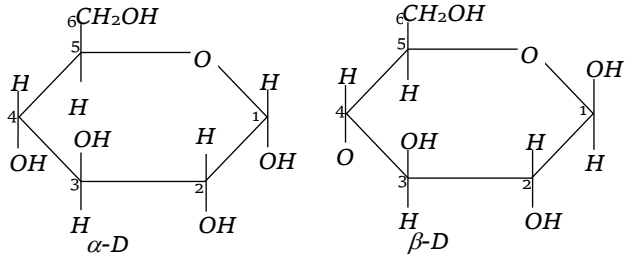
(c) Fischer and Tollen's proposed that the ring or the internal hemiacetal is formed between C^1 and C^4. It means the ring is **Furan type** or 5-membered ring; this is called **Furanose strucutre,**

However according to Haworth and Hirst the ring is formed between C^1 and C^5. It means the ring is **Pyran type** or 6-membered ring, this is called **Pyranose structure.**



Fura Pyra

(d) *Haworth structure* : The two forms of D-glucose are also shown by **Haworth** projection formula which are given below,



α-D *β-D*

Fructose, fruit sugar ($C_6H_{12}O_6$) or ketohexose

It is present in abundance in fruits and hence is called **fruit sugar.** It is also present in cane sugar and honey alongwith glucose in combined form. The polysaccharide **inulin** is a polymer of fructose an gives only fructose on hydrolysis. Since naturally occurring fructose is laevorotatory, it is also known as **laevulose**.

(1) **Preparation :**

(i) ***Hydrolysis of cane sugar***

$$\underset{\text{Cane sugar}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{Warm}]{H_2SO_4\,(\text{dil.})} \underset{\text{D-Glucose}}{C_6H_{12}O_6} + \underset{\text{D-Fructose}}{C_6H_{12}O_6}$$

The solution having equal molecules of D-glucose and D-fructose is termed **invert sugar** and the process is known as **inversion**.

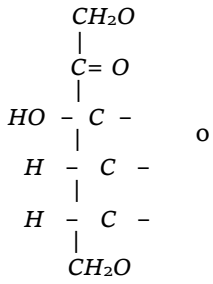
❒ The excess of sulphuric acid is neutralised by adding milk of lime. A little more of lime is added which converts both glucose and fructose into calcium glucosate and calcium fructose respectively.

$$\underset{\text{Calcium fructose}}{C_6H_{11}O_5 - O - CaOH} + CO_2 \longrightarrow \underset{\text{Fructose}}{C_6H_{12}O_6} + CaCO_3$$

(ii) ***Hydrolysis of Inulin with dilute sulphuric acid***

$$\underset{\text{Inulin}}{(C_6H_{10}O_5)_n} + nH_2O \xrightarrow{H_2SO_4\,(\text{dil.})} \underset{\text{Fructose}}{nC_6H_{12}O_6}$$

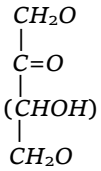
(2) **Properties :** The anhydrous fructose is a colourless crystalline compounds. It melts at 102^oC. It is soluble in water but insoluble in benzene and ether. It is less soluble in water than glucose. It is the **sweetest** of all sugars and its solution is laevorotatory. Like glucose, it also shows **mutarotation.**

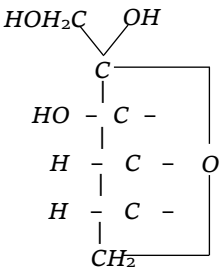


D-Fructose

$[\alpha]_D$ = –

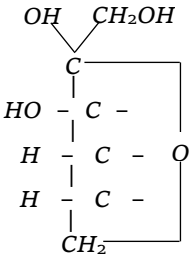
o





α- D- Fructose

$[\alpha]_D$ = – 21°



β- D- Fructose

$[\alpha]_D$ = – 133°

Table : 31.2 Comparison between glucose and fructose

Property	Glucose	Fructose
Molecular formula	$C_6H_{12}O_6$	$C_6H_{12}O_6$
Nature	Polyhydroxy aldehyde.	Polyhydroxy ketone
Melting point	146°C	102°C
Optical activity of natural form	Dextrorotatory	Laevorotatory
With ethyl alcohol	Almost insoluble	More soluble
Oxidation (a) With bromine water	Gluconic acid	No reaction
(b) With nitric acid	Saccharic acid (Glucaric acid)	Mixture of glycollic acid, tartaric acid and trihydroxy glutaric acid
Reduction	Sorbitol	Mixture of sorbitol and mannitol
Calcium hydroxide	Forms calcium glucosate, soluble in water	Forms calcium fructosate, insoluble in water
Molisch's reagent	Forms a violet ring	Forms a violet ring
Fehling's solution	Gives red precipitate	Gives red precipitate
Tollen's reagent	Forms silver mirror	Forms silver mirror
Phenyl hydrazine	Forms osazone	Forms osazone
Resorcinol + *HCl* (dil.) **(Selivanoff's test)**	No colouration	Gives red or brown colour or precipitate
Freshly prepared ammonium molybdate sol. + few drops of acetic acid (**Pinoff's test**).	Light blue colour	Bluish green colour on heating
Alcoholic α-naphthol + *HCl* (conc.) (**Furfural test**)	No colouration	A purple colour (violet) on boiling

❒ Fructose gives reactions similar to glucose. The difference in properties is due to the fact that it contains a ketonic group while glucose contains an aldehydic group.

Interconversions :

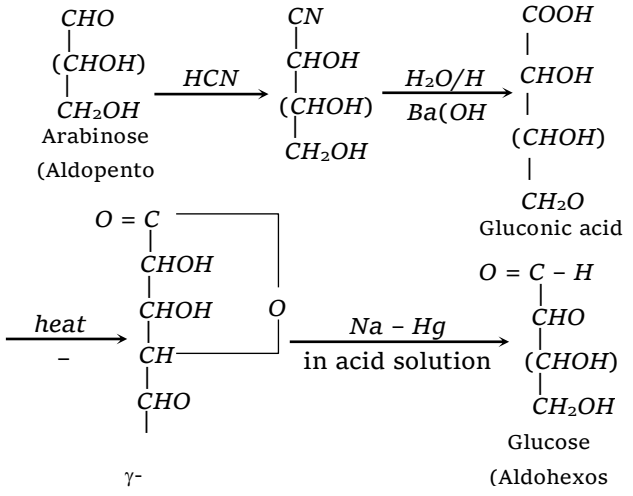
(1) **Chain Lengthening of Aldoses (Killiani-Fischer synthesis) :** The conversion of an aldose to the next higher member involves the following steps :

(i) Formation of a cyanohydrin.

(ii) Hydrolysis of – *CN* to – *COOH* forming aldonic acid.

(iii) Conversion of aldonic acid into lactone by heating.

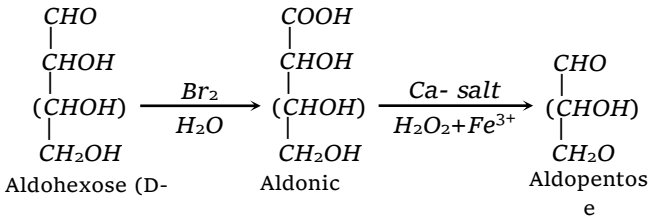
(iv) The lactone is finally reduced with sodium amalgam or sodium borohydride to give the higher aldose.



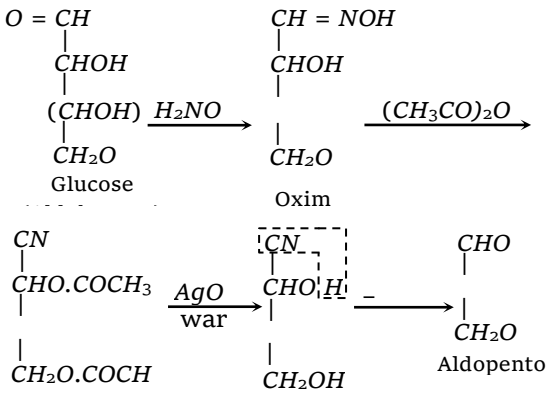
(2) **Chain Shortening of aldoses**

(i) An aldose can be converted to the next lower member by **Ruff Degradation**.

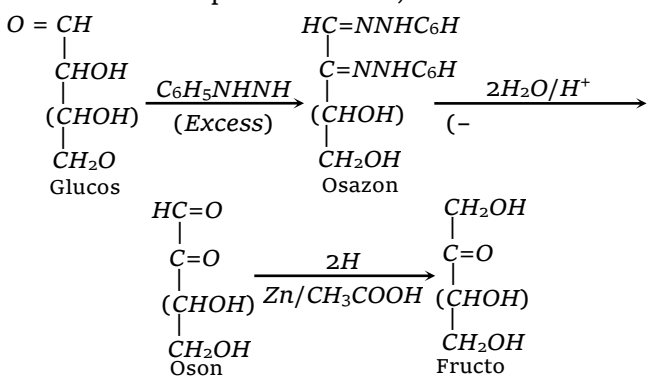
It involves two steps.



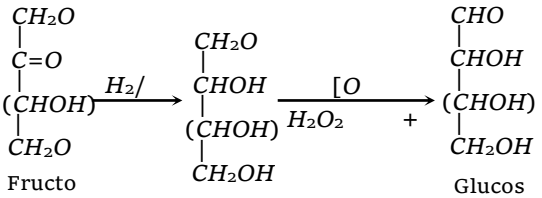
(ii) ***By Wohl's method***



(3) **Conversion of an aldose to the isomeric Ketose** Three steps are involved,



(4) **Conversion of a ketose to the isomeric aldose**



Disaccharides

The disaccharides yield on hydrolysis two monosaccharides. Those disaccharides which yield two hexoses on hydrolysis have a general formula $C_{12}H_{22}O_{11}$. The hexoses obtained on hydrolysis may be same or different.

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

$$\text{Lactose} \xrightarrow[H^+]{H_2O} \text{Glucose + Galactose}$$

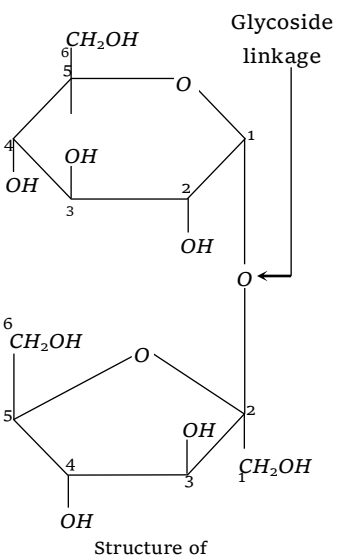
$$\text{Maltose} \xrightarrow[H^+]{H_2O} \text{Glucose + Glucose}$$

The hydrolysis is done by dilute acids or enzymes. The enzymes which bring hydrolysis of sucrose, lactose and maltose are *invertase, lactase* and *maltase,* respectively. Out of the three disaccharides, sucrose (cane-sugar) is the most important as it is an essential constituent of our diet.

In disaccharides, the two monosaccharides are joined together by glycoside linkage. A glycoside bond is formed when hydroxy group of the hemiacetal carbon of one monosaccharide condenses with a hydroxy group of another monosaccharide giving – O– bond.

(1) **Sucrose; Cane-sugar [$C_{12}H_{22}O_{11}$] :** It is our common table sugar. It is obtained from sugar cane and sugarbeets. It is actually found in all photosynthetic plants.

(i) ***Properties*** **:** It is a colourless, odourless, crystalline compound. It melts at 185 – 186°*C*. It is very soluble in water, slightly soluble in alcohol and insoluble in ether. It is dextrorotatory but does not show **mutarotation.** It is a non-reducing sugar as it does not reduce Tollen's



or Fehling's reagent. Sucrose, on heating slowly and carefully, melts and then if allowed to cool, it solidifies to pale yellow glassy mass called 'Barley sugar'. When heated to 200°*C,* it loses water to form brown amorphous mass called *Caramel*. On strong heating, it chars to almost pure carbon giving smell of burnt sugar. It is composed of α-D-glucopyranose unit and a β-D-fructofuranose unit. These units are joined by α-β-glycosidic linkage between *C* –1 of the glucose unit and *C* – 2 of the fructose unit.

(ii) ***Uses***

(a) As a sweetening agent for various food preparations, jams, syrups sweets, etc.

(b) In the manufacture of sucrose octa-acetate required to denature alcohol, to make paper transparent and to make anhydrous adhesives.

(2) **Inversion of cane-sugar :** The hydrolysis of sucrose by boiling with a mineral acid or by enzyme invertase, produces a mixture of equal molecules of *D*-glucose and *D*-fructose.

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\text{D-Glucose}}{C_6H_{12}O_6} + \underset{\text{D-Fructose}}{C_6H_{12}O_6}$$

(This mixture is laevorotat ory)

Sucrose solution is dextrorotatory. Its specific rotation is $+66.5^o$. But on hydrolysis, it becomes laevorotatory. The specific rotation of *D*-glucose is $+52^o$ and of *D*-fructose is -92^o. Therefore, the net specific rotation of an equimolar mixture of *D*-glucose and *D*-fructose is.

$$\frac{+52^o - 92^o}{2} = -20^o$$

Thus, in the process of hydrolysis of sucrose, the specific rotation changes from $+66.5°$ to $-20°$, *i.e.,* from dextro it becomes laevo and it is said that inversion has taken place. The process of hydrolysis of sucrose is thus termed as **inversion of sugar** and the hydrolysed mixture having equal molar quantities of D-glucose and D-fructose is called **invert sugar.** The enzyme that brings the inversion is named as **invertase.**

Table : 31.3 Distinction between glucose and sucrose

Test	Glucose	Sucrose
With conc. H_2SO_4 in cold	No effect	Charring occurs and turns black
Molisch's reagent	Violet ring is formed	Violet ring is formed
With *NaOH*	Turns yellow	No effect
With Tollen's Solution	Gives silver mirror	No effect
With Fehling's solution	Gives red precipitate of Cu_2O	No effect
On heating with phenyl hydrazine	Gives yellow precipitate of glucosazone	No effect, i.e., does not form osazone
Aqueous resorcinol + conc. *HCl* solution	No effect	Reddish-brown precipitate which dissolves in ethanol.

Polysaccharide (Starch and cellulose)

Polysaccharides are polymer of monosaccharide. The most important polysaccharides are starch and cellulose. They have a general formula $(C_6H_{10}O_5)_n$. Starch (Amylum) is most widely distributed in vegetable kingdom. It is found in the leaves, stems, fruits, roots and seeds. Concentrated form of starch is present in wheat, corn, barley, rice, potatoes, nuts, etc. It is the most important food source of carbohydrates.

(1) **Starch and its derivatives :** Starch is a white amorphous substance with no taste or smell. When heated to a temperature between $200 - 250^oC,$ it changes into dextrin. At higher temperature charring occurs. When boiled with dilute acid, starch ultimately yields glucose.

$$\underset{\text{Starch}}{(C_6H_{10}O_5)_n} \longrightarrow \underset{\text{Dextrin}}{(C_6H_{10}O_5)_{n_1}} \longrightarrow$$

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

Both n and n_1, are unknown, but n is believed to be greater than n_1.

When treated with enzyme, *diastase,* it yields maltose.

$$2(C_6H_{10}O_5)_n + nH_2O \longrightarrow \underset{\text{Maltose}}{nC_{12}H_{22}O_{11}}$$

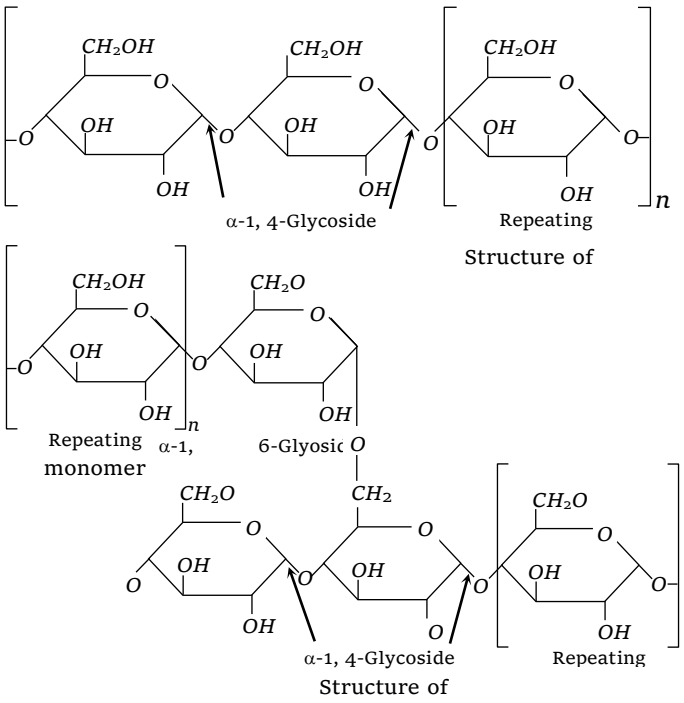
Starch solution gives a blue colour with a drop of iodine which disappears on heating to $75 - 80^oC$ and reappears on cooling. The exact chemical nature of starch varies from source to source. Even the starch obtained from same source consists of two fractions

(i) amylose and

(ii) amylopectin.

Amylose is a linear polymer while amylopectin is a highly branched polymer. Both are composed of α-*D*-glucose units linked by glycosidic linkages. The number of *D*-glucose units in amylose range from 60 – 300. It is

soluble in hot water, Amylopectin consists of *D*-glucose units from 300 – 600. It is insoluble in water.



Uses : Starch and its derivatives are used

(i) As the most valuable constituent of food as rice, bread, potato and corn-flour, etc.

(ii) In the manufacture of glucose, dextrin and adhesives (starch paste).

(iii) In paper and textile industry.

(iv) In calico printing as a thickening agent for colours.

(v) Nitro starch is used as an explosive.

(vi) Starch-acetate is a transparent gelatin like mass and is used mainly for making sweets.

(2) **Cellulose :** It is found in all plants and so is the most abundant of all carbohydrates. It is the material used to form cell walls and other structural features of the plants. Wood is about 50% cellulose and the rest is lignin. Cotton and paper are largely composed of cellulose.

Pure cellulose is obtained by successively treating cotton, wool, flax or paper with dilute alkali, dilute HCl or HF. This treatment removes mineral matter, water, alcohol and ether. Cellulose is left behind as a white amorphous powder.

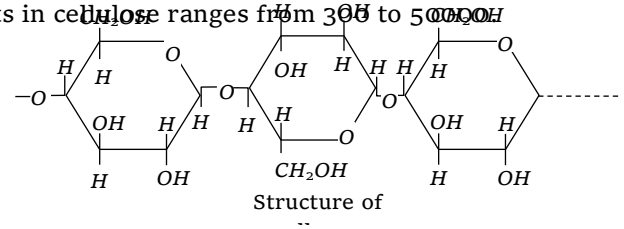
Cellulose is insoluble in water and in most of the organic solvents. It decomposes on heating but does not melt. It dissolves in ammonical copper hydroxide solution (Schwitzer's reagent). Cellulose also dissolves in a solution of zinc chloride in hydrochloric acid.

When it is treated with concentrated H_2SO_4 in cold, it slowly passes into solution. The solution when diluted with water, a starch like substance amyloid is precipitated and is called **parchment paper.** When boiled with dilute H_2SO_4, it is completely hydrolysed into *D*-glucose.

$$\underset{\text{Cellulose}}{(C_6H_{10}O_5)_n} + nH_2O \longrightarrow \underset{\text{Glucose}}{nC_6H_{12}O_6}$$

The cattle, goats and other ruminants can feed directly cellulose (grass, straw, etc.) as they have digestive enzymes (celluloses) capable of hydrolysing cellulose into glucose. Man and many other mammals lack the necessary enzymes in their digestive tract and thus cannot use cellulose as food stuff.

Cellulose is a straight chain polysaccharide composed of *D*-glucose units which are joined by *B*-glycosidic linkages between *C*-1 of one glucose unit and *C*-4 of the next glucose unit. The number of *D*-glucose units in cellulose ranges from 300 to 5000.



Uses : Cellulose is used

(i) As such in the manufacture of cloth (cotton), canvas and gunny bags (jute) and paper (wood, bamboo, straw, etc.)

(ii) In the form of cellulose nitrates for the manufacture of explosives (gun-powder), medicines, paints and lacquers. The cellulose nitrates with camphor yield *celluloid* which is used in the manufacture of toys, decorative articles and photographic films.

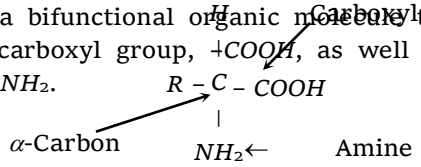
(iii) In the form of cellulose acetate for the manufacture of rayon (artificial silk) and plastics.

Table : 31.4 Distinction between glucose, sucrose, starch

Test	Glucose	Sucrose	Starch
With iodine solution	No effect	No effect	Blue colour
With Fehling's solution	Gives red precipitate	No effect	No effect
With Tollen's reagent	Gives silver mirror	No effect	No effect
With phenyl hydrazine	Forms yellow osazone	No effect	No effect
Solubility in water	Soluble	Soluble	Insoluble
Taste	Sweet	Sweet	No taste

Amino acids

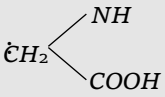
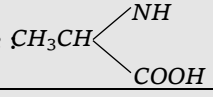
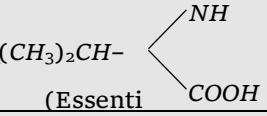
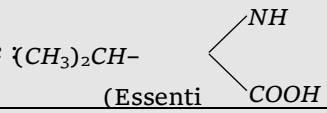
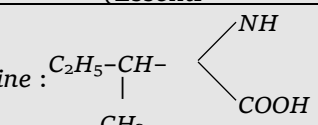
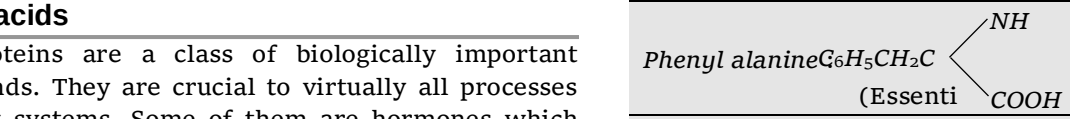
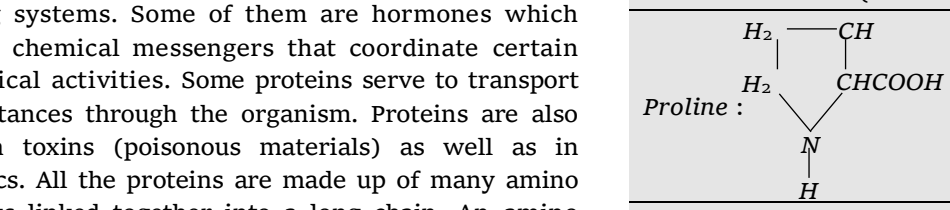
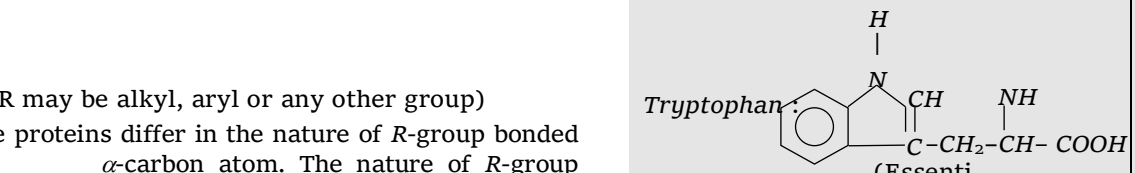
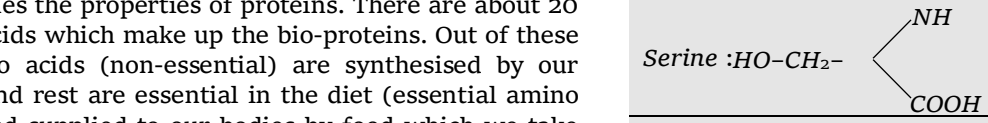
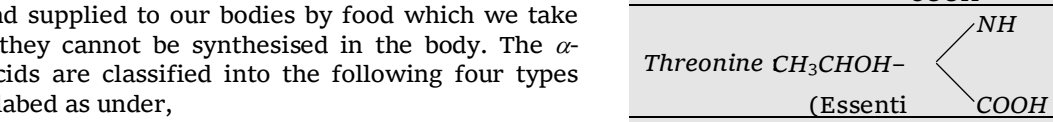
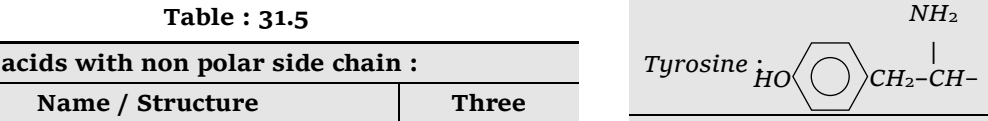
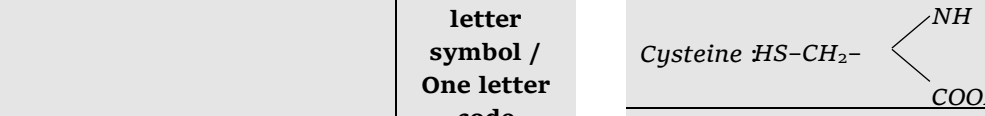
Proteins are a class of biologically important compounds. They are crucial to virtually all processes in living systems. Some of them are hormones which serve as chemical messengers that coordinate certain biochemical activities. Some proteins serve to transport the substances through the organism. Proteins are also found in toxins (poisonous materials) as well as in antibiotics. All the proteins are made up of many amino acid units linked together into a long chain. An amino acid is a bifunctional organic molecule that contains both a carboxyl group, $-COOH$, as well as an amine group, $-NH_2$.

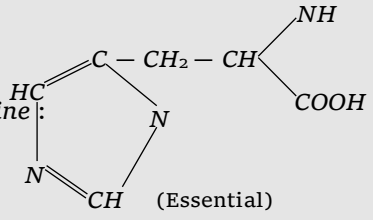


(R may be alkyl, aryl or any other group)

The proteins differ in the nature of *R*-group bonded to α-carbon atom. The nature of *R*-group determines the properties of proteins. There are about 20 amino acids which make up the bio-proteins. Out of these 10 amino acids (non-essential) are synthesised by our bodies and rest are essential in the diet (essential amino acids) and supplied to our bodies by food which we take because they cannot be synthesised in the body. The α-amino acids are classified into the following four types and tasulabed as under,

Table : 31.5

Amino acids with non polar side chain :	
Name / Structure	**Three letter symbol / One letter code**
Glycine : 	Gly / G
Alanine : 	Ala / A
Valine :  (Essenti	Val / V
Leucine :  (Essenti	Leu / L
Isoleucine :  (Essenti	Ile / I
Phenyl alanine :  (Essenti	Phe / F
Proline : 	Pro / P
Amino acids with polar but neutral side chain :	
Name / Structure	***Three letter symbol / One letter code***
Tryptophan :  (Essenti	Trp / W
Serine : 	Ser / S
Threonine :  (Essenti	Thr / T
Tyrosine : 	Tyr / Y
Cysteine : 	Cys / C
Methionine : (Essenti	Met / M
Aspargine :	Asn / N
Glutamine :	Gln / Q
Amino acids with acidic side chains :	
Aspartic acid :	Asp / D
Glutamic acid : 	Glu / E

Amino acids with basic side chains :	
Lysine : $H_2N(CH_2)_4C(NH)COOH$ (Essenti	*Lys / K*
Arginine : $HN=C(NH_2)\cdot NH.(CH_2)_3C(NH)COOH$ (Essenti	*Arg / R*
Histidine :  (Essential)	*His / H*

(1) **Methods of preparation of α-amino acids**

(i) ***Amination of α-halo acids***

$$\underset{\alpha\text{-Bromo propionic acid}}{CH_3CH(Br)COOH} + 2NH_3 \rightarrow \underset{\alpha\text{-Amino propionic acid (Alanine)}}{CH_3CH(NH_2)COOH} + NH_4Cl$$

Lab preparation of glycine

$$\underset{\alpha\text{-Chloro acetic acid}}{Cl.CH_2COOH} + 3\underset{\text{liquid}}{NH_3} \xrightarrow{50°C} \underset{\text{Amm.salt of glycine}}{H_2N.CH_2COONH_4} + NH_4Cl$$

The ammonium salt so obtained is boiled with copper carbonate and cooled when blue colour needles of copper salt of glycine are obtained.

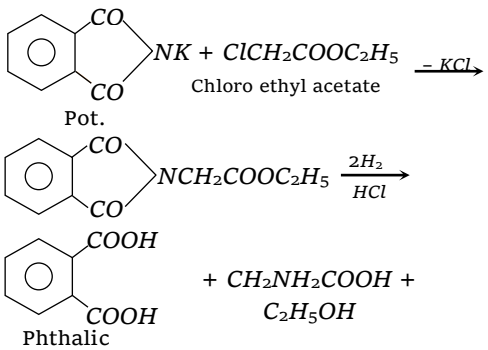
$$2[H_2N-CH_2COONH_4] + CuCO_3 \xrightarrow{\text{Boiled}}$$

$$\underset{\text{Copper salt of glycine}}{(H_2NCH_2COO)_2Cu} + (NH_4)_2CO_3$$

It is now dissolved in water and H_2S is passed till whole of the copper precipitates as copper sulphide leaving glycine as the aqueous solution.

$$(H_2N-CH_2COO)_2Cu + H_2S \rightarrow \underset{\text{Glycine}}{2H_2NCH_2COOH} + \underset{\text{Black ppt.}}{CuS}\downarrow$$

(ii) ***Gabriel pthalimide synthesis***



(iii) ***Knoop synthesis***

$$\underset{\text{Pyruvic acid}}{CH_3COCOOH} \xrightarrow{NH_3} CH_3C(=NH)-COOH \xrightarrow[\text{or } Na/C_2H_5OH]{H_2/Pd} \underset{\text{Alanine}}{CH_3-CH(NH_2)-COOH}$$

(iv) ***Streker synthesis***

$$\underset{\text{Aldehyde}}{R-CHO} \xrightarrow{HCN} \underset{\text{Cyanohydrin}}{R-CH(CN)-OH} \xrightarrow{NH_3} \underset{\text{Amino nitrile}}{R-CH(CN)-NH_2} \xrightarrow[H^+]{H_2O} \underset{\alpha\text{-Amino acid}}{R-CH(COOH)-NH_2}$$

(v) ***From natural protein*** : Natural proteins are hydrolysed with dil. HCl or H_2SO_4 at 250°C in an autoclave when a mixture of α-amino acids is obtained. This mixture is esterified and the various esters are separated by fractional distillation. The esters are then hydrolysed into respective α-amino acids.

(2) **Physical properties**

(i) Amino acids are colourless, crystalline substances having sweet taste. They melt with decomposition at higher temperature (more than 200°C). They are soluble in water but insoluble in organic solvents.

(ii) Except glycine, all the α-amino acids are optically active and have an asymmetric carbon atom (α-carbon atom). Hence, each of these amino acids can exist in two optical isomers. In proteins, however, only one isomer of each is commonly involved.

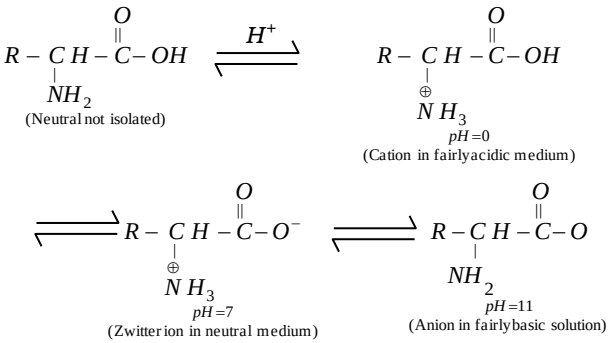
(iii) *Zwitter ion and isoelectric point* : Since the $-NH_2$ group is basic and – $COOH$ group is acidic, in neutral solution it exists in an internal ionic form called a **Zwitter ion** where the proton of –$COOH$ group is transferred to the $-NH_2$ group to form **inner salt**, also known as **dipolar ion**.

$$\underset{\alpha\text{-Amino acid}}{H_2\ddot{N}-CH(R)-COOH} \xrightarrow{\text{In water}}$$

$$H_2\ddot{N}-CH(R)-COO^- + H^+ \rightarrow \underset{\text{Zwitter ion (Dipolar ion)}}{H_3N^+-CH(R)-COO^-}$$

The Zwitter ion is dipolar, charged but overall electrically neutral and contains both a positive and negative charge.

(3) **Chemical properties :** Amino acids are amphoteric in nature. Depending on the *pH* of the solution, the amino acid can donate or accept proton.



When an ionised form of amino acid is placed in an electric field, it will migrate towards the opposite electrode. Depending on the *pH* of the medium, following three things may happen

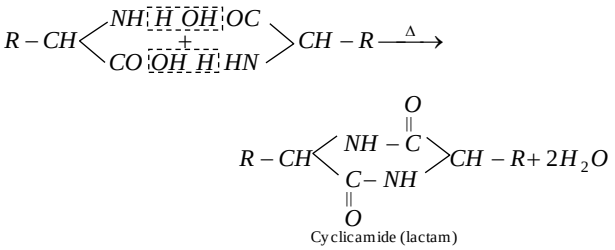
- In acidic solution (low *pH*), the positive ion moves towards cathode.
- In basic solution (high *pH*), the negative ion moves towards anode.
- The Zwitter ion does not move towards any of the electrodes.

The intermediate *pH* at which the amino acid shows no tendency to migrate towards any of the electrodes and exists the equilibrium when placed in an electric field is known as **isoelectric point**.

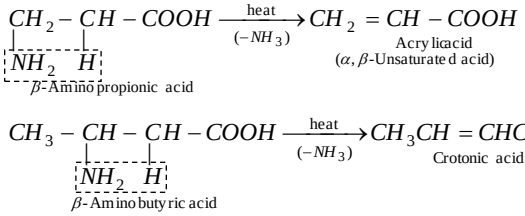
This is characteristic of a given amino acid and depends on the nature of *R*-linked to α-carbon atom.

(i) ***Action of heat***

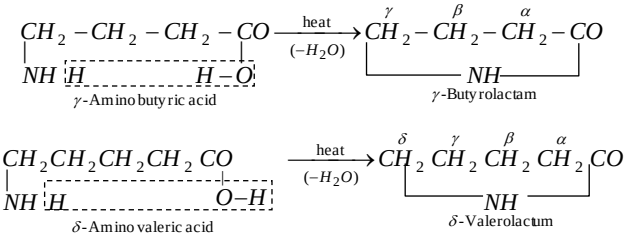
(a) *For α-amino acids*



(b) *For β-amino acids*

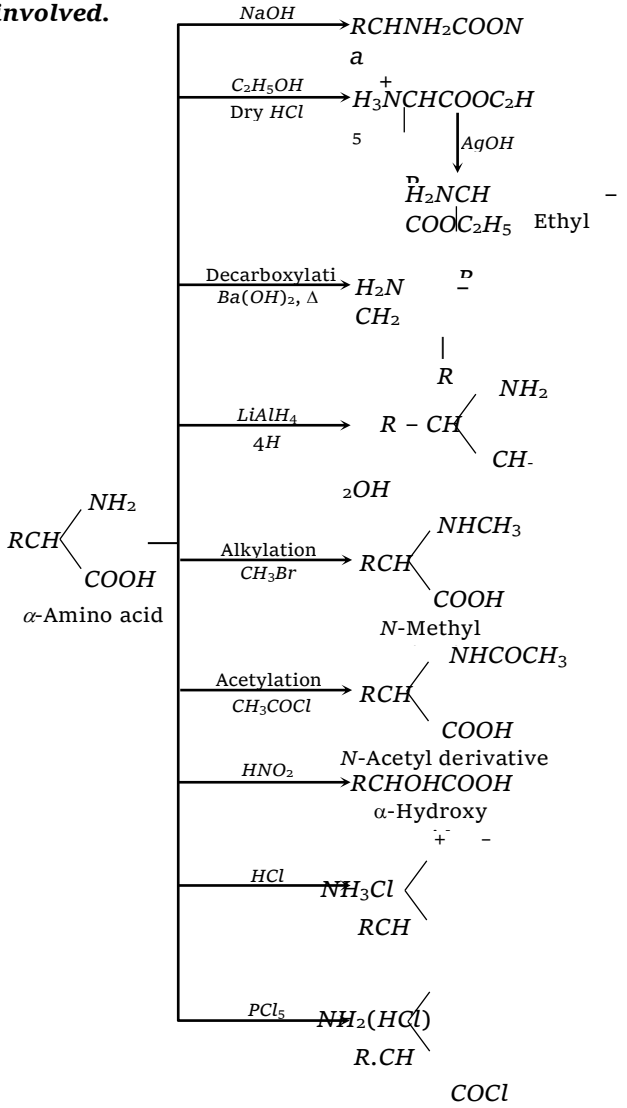


(c) *For γ and δ amino acids*



These lactams have stable five or six membered rings.

(ii) ***α-amino acids show the reactions of $-NH_2$ group, $-COOH$ groups and in which both the groups are involved.***

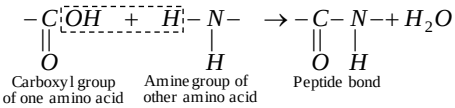


❒ Proline is the only natural α-amino acid which is a secondary amine.

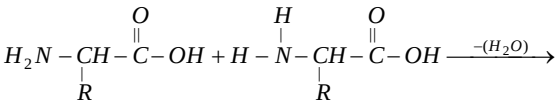
❒ Only achiral α-amino acid found in protein is glycine.

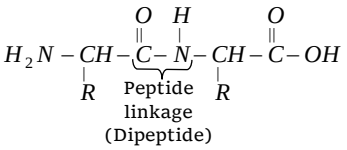
(iii) ***Formation of proteins-peptide bond*** : Proteins are formed by joining the carboxyl group of one amino acid to the α-amino group of another amino acid. **The bond formed between two amino acids by**

the elimination of a water molecule is called a peptide linkage or bond. The peptide bond is simply another name for amide bond.

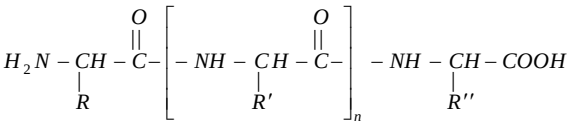


The product formed by linking amino acid molecules through peptide linkages, $-CO-NH-$, is called a **peptide**. Peptides are further designated as *di*, *tri*, *tetra* or *penta* peptides accordingly as they contain two, three, four or five amino acid molecules, same or different, joined together in the following fashions.





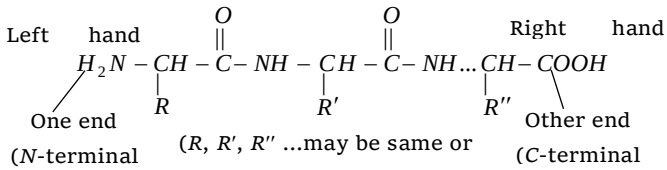
When the number of amino molecules is large, the product is termed polypeptide which may be represented as,



(4) **Composition :** Composition of a protein varies with source. An approximate composition is as follows :

Carbon 50-53%; hydrogen 6-7%; oxygen 23-25%; nitrogen 16-17%; Sulphur about 1%. Other elements may also be present, *e.g.*, phosphorus (in nucleoproteins), iodine (in thyroid proteins) and iron (in haemoglobin).

(5) **Structure of proteins :** The structure of proteins is very complex. The **primary structure** of a protein refers to the number and sequence of the amino acids in its **polypeptide chains** (discussed in the formation of proteins). The primary structure is represented beginning with the amino acid whose amino group is free (the *N*-terminal end) and it forms the one end of the chain. Free carboxyl group (*C*-terminal end) forms the other end of the chain.



Side chains may have basic groups or acidic groups as $-NH_2$ in lysine and $-COOH$ in aspartic acid. Because of these acidic and basic side chains, there are positively and negatively charged centres. Though the peptide linkage is stable, the reactivity is due to these charged centres in the side chains.

Primary structure tells us nothing about the shape or conformation of the molecule. Most of the bonds in protein molecules being single bonds can assume infinite number of shapes due to free rotation about single bonds. However, it has been confirmed that each protein has only a single three dimensional conformation. The fixed configuration of a polypeptide skeleton is referred to as the **secondary structure** of a protein. It gives information :

- About the manner in which the protein chain is folded and bent;
- About the nature of the bonds which stabilise this structure.

Secondary structure of protein is mainly of two types

(i) ***α-helix* :** This structure is formed when the chain of α-amino acids coils as a right handed screw (called α-helix) because of the formation of **hydrogen bonds** between amide groups of the same peptide chain, *i.e.*, *NH* group in one unit is linked to carbonyl oxygen of the third unit by hydrogen bonding. This hydrogen bonding between different units is responsible for holding helix in a position. The side chains of these units project outward from the coiled backbone.

Such proteins are elastic, *i.e.*, they can be stretched. On stretching weak hydrogen bonds break up and the peptide chain acts like a spring. The hydrogen bonds are reformed on releasing the tension. Wool and hair have α-helix structure.

(ii) ***β-pleated sheet* :** A different type of secondary structure is possible when polypeptide chains are arranged side by side. The chains are held together by a very large number of hydrogen bonds between *C = O* and *NH* of different chains. Thus, the chains are bonded together forming a sheet. These sheets can slide over each other to form a three dimensional structure called a beta pleated sheet. Silk has a beta pleated structure.

Globular proteins possess tertiary structure. In general globular proteins are very tightly folded into a compact spherical form.

(6) **Classification of proteins** : According to chemical composition, proteins are divided into two classes

(i) ***Simple proteins*** **:** Simple proteins are composed of chains of amino acid units only joined by peptide linkages. These proteins on hydrolysis yield only mixture of amino acids. Examples are :

Egg albumin, serum globulins, glutenin in wheat, coryzenin in rice, tissue globulin, etc.

(ii) ***Conjugated proteins*** **:** The molecules of conjugated proteins are composed of simple proteins and non protein material. The non-protein material is called **prosthetic group** or **cofactor**. These proteins on hydrolysis yield amino acids and non-protein material. Examples are

Mucin in saliva (prosthetic group, carbohydrate), casein in milk (prosthetic group, phosphoric acid), haemoglobin in blood (prosthetic group, iron pigment), etc.

According to molecular shape, proteins are divided into two types

(i) ***Fibrous proteins*** **:** These are made up of polypeptide chains that run parallel to the axis and are held together by strong hydrogen and disulphide bonds. They can be stretched and contracted like a thread. These are usually insoluble in water. Examples are : α-keratin (hair, wool, silk and nails); myosin (muscles); collagen (tendons, bones), etc.

(ii) ***Globular proteins*** **:** These have more or less spherical shape (compact structure). α-helics are tightly held up by weak attractive forces of various types: Hydrogen bonding, disulphide bridges, ionic or salt bridges. These are usually soluble in water. Examples are: Insulin, pepsin, haemoglobin, cytochromes, albumins, etc.

Proteins can also be classified on the basis of their function

Table : 31.6

Protein	Function	Examples
Enzymes	Biological catalysts, vital to all living systems.	Trypsin, pepsin.
Structural proteins	Proteins that hold living systems together.	Collagen.
Harmones	Act as messengers.	Insulin.
Transport proteins	Carry ions or molecules from place to another in the living system.	Haemoglobin.
Protective proteins (antibiotics)	Destroy any foreign substance released into the living system.	Gamma globulin.
Toxins	Poisonous in nature.	Snake venom.

(7) **General and physical characteristic of proteins**

(i) Most of them (except chromoproteins) are colourless, tasteless, and odourless. Many are amorphous but few are crystalline. They are nonvolatile and do not have a sharp melting point .

(ii) Most of them are insoluble in water and alcohol. But many of them dissolve in salt solutions, dilute acids and alkalies. Some proteins such as keratins (skin, hair and nails) are completely insoluble.

(iii) Protein molecules are very complex and possess very high molecular masses. They are hydrophilic colloids which cannot pass through vegetable or animal membrane. On addition of sodium chloride, ammonium sulphate magnesium sulphate, etc., some proteins are precipitated. The precipitate can be filtered and redissolved in water.

(iv) The solution of proteins are optically active. Most of them are laevorotatory. The optical activity is due to the presence of asymmetric carbon atoms in the constituent α-amino acids.

(v) ***Isoelectric point*** **:** Every protein has a characteristic isoelectric point at which its ionisation is minimum. Like amino acids, proteins, having charged groups ($\overset{+}{N}H_3$ and COO^-) at the ends of the peptide chain, are amphoteric in nature. In strong acid solution, protein molecule accepts a proton while in strong basic solution it loses a proton. **The *pH* at which the protein molecule has no net charge is called its isoelectric point**. This property can be used to separate proteins from mixture by electrophoresis.

(vi) ***Denaturation*** **:** The structure of the natural proteins is responsible for their biological activity. These structures are maintained by various attractive forces between different parts of the polypeptide chains. The breaking of these forces by a physical or a chemical change makes the proteins to lose all or part of their biological activity. This is called denaturation of proteins. The denaturing of proteins can be done by

adding chemicals such as acids, bases, organic solvents, heavy metal ions, or urea. It can also be done with the help of heat and ultraviolet light. Denaturation can be irreversible or reversible. In irreversible denaturation, the denaturated protein does not return to its original shape. For example, the heating of white of an egg (water soluble) gives a hard and rubbery insoluble mass.

(8) **Chemical properties**

(i) ***Salt formation*** : Due to presence of both $-NH_2$ and $-COOH$ groups in proteins, they form salts with acids and bases. Casein is present in milk as calcium salt.

(ii) ***Hydrolysis*** : The simple proteins are hydrolysed by acids, alkalies or enzymes to produce amino acids. Following steps are involved in the hydrolysis and the final product is a mixture of amino acids.

Protein $\rightarrow$ Proteose $\rightarrow$ Peptone $\rightarrow$ Polypeptide $\rightarrow$ Simple peptide $\rightarrow$ Mixture of amino acids

(iii) ***Oxidation*** : Proteins are oxidised on burning and putrefaction. The products include amines, nitrogen, carbon dioxide and water. The bad smell from decaying dead animals is largely due to the formation of amines by bacterial oxidation of body proteins.

(9) **Test of proteins**

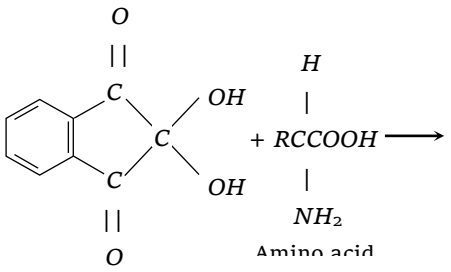
(i) ***Biuret test*** **:** On adding a dilute solution of copper sulphate to alkaline solution of protein, a violet colour is developed. This test is due to the presence of peptide ($-CO-NH-$) linkage.

(ii) ***Xanthoproteic test*** **:** Some proteins give yellow colour with concentrated nitric acid (formation of yellow stains on fingers while working with nitric acid in laboratory). The formation of yellow colour is due to reaction of nitric acid with benzenoid structures. Thus, when a protein solution is warmed with nitric acid a yellow colour may be developed which turns orange on addition of NH_4OH solution.

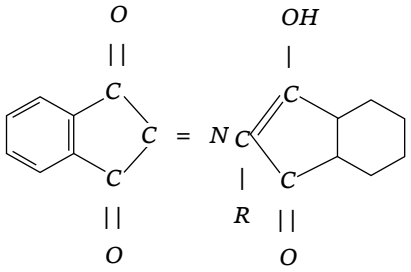
(iii) ***Millon's test*** **:** When millon's reagent (mercurous and mercuric nitrate in nitric acid) is added to a protein solution, a white precipitate which turns brick red on heating, may be formed. This test is given by proteins which yield tyrosine on hydrolysis. This is due to presence of phenolic group.

(iv) ***Ninhydrin test*** **:** This test is given by all proteins. When a protein is boiled with a dilute solution of ninhydrin, a violet colour is produced.

(v) ***Nitroprusside test*** **:** Proteins containing $-SH$ group give this test. When sodium nitroprusside solution is added to proteins having $-SH$ group, a violet colour is developed.



Ninhydri



Violet

(vi) ***Molisch's test*** **:** This test is given by those proteins which contain carbohydrate residue. On adding a few drops of alcoholic solution of α-naphthol and concentrated sulphuric acid to the protein solution, a violet ring is formed.

(vii) ***Hopkins-Cole test*** **:** On adding concentrated sulphuric acid down the side containing a solution of protein and glyoxalic acid, a violet colour is developed.

(10) **Uses**

(i) Proteins constitute as essential part of our food. Meat, eggs, fish, cheese provide proteins to human beings.

(ii) ***In textile*** **:** Casein (a milk protein) is used in the manufacture of artificial wool and silk.

(iii) ***In the manufacture of amino acids*** **:** Amino acids, needed for medicinal use and feeding experiments, are prepared by hydrolysis of proteins.

(iv) ***In industry*** **:** Gelatin (protein) is used in food products, capsules and photographic plates. Glue (protein) is used as adhesive and in sizing paper.

Leather is obtained by tanning the proteins of animal hides.

(v) ***In controlling body processes*** **:** Haemoglobin present in blood is responsible for carrying oxygen and carbon dioxide. Harmones (proteins) control various body processes.

(vi) ***As enzymes*** **:** Reactions in living systems always occur with the aid of substances called enzymes. Enzymes are proteins produced by living systems and catalyse specific biological reactions.

Important enzymes tabulated as under,

Table : 31.7

Enzymes	Reaction catalysed
Urease	Urea $\rightarrow CO_2 + NH_3$
Invertase	Sucrose $\rightarrow$ Glucose + Fructose
Maltase	Maltose $\rightarrow$ 2 Glucose
Amylase	Starch $\rightarrow n$ Glucose
Pepsin	Proteins $\rightarrow$ Amino acids
Trypsin	Proteins $\rightarrow$ Amino acids
Carbonic anhydrase	$H_2CO_3 \rightarrow H_2O + CO_2$
Nuclease	DNA, RNA $\rightarrow$ Nucleotides

Nucleic acids

In every living cell there are found nucleo-proteins which are made up of proteins and natural polymers of great biological importance called nucleic acids.

Two types of nucleic acids are found in biological systems, these are

Deoxyribonucleic acid (DNA) and Ribonucleic acid (RNA)

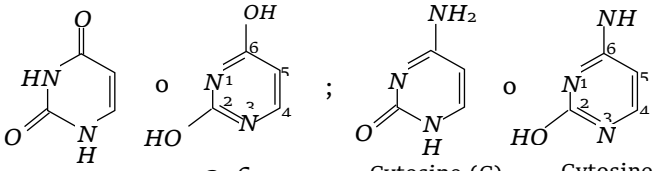
The nucleic acid was first isolated by Friedrich Miescher in 1868 from the nuclei of pus cells and was named nuclein. The term nuclein was given by Altman.

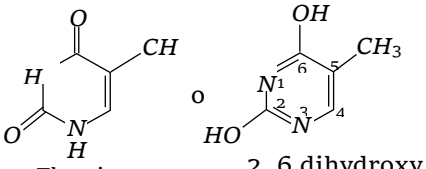
(1) **Composition :** Nucleic acids like proteins and carbohydrates are polymer. The simple units that make up the nucleic acid are called **nucleotides**. Nucleotides are themselves composed of following three simple molecules.

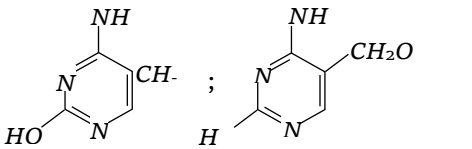
(i) ***Nitrogenous base*** **:** These are heterocyclic organic compound having two or more nitrogen atoms in ring skeleton. These are called bases because the lone pairs of electrons on the nitrogen atoms make them as Lewis bases.

Their structures are given below

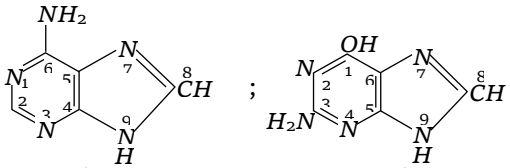
(a) *Pyrimidine derivatives*


Uracil (U) o 2, 6 dihydroxy ; Cytosine (C) o Cytosine

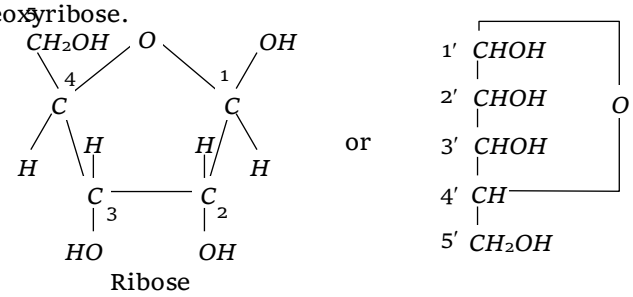

Thymine (T) 2, 6 dihydroxy 5-methyl

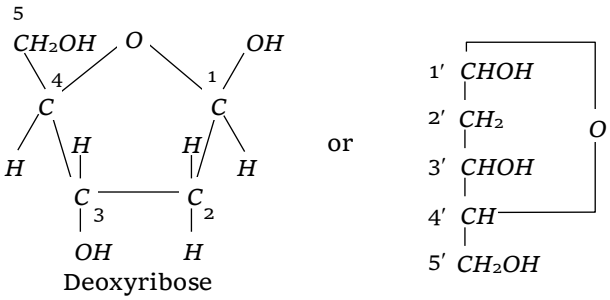

5-Methyl ; 5-Hydroxy methyl

(b) *Purine derivatives*


Adenine (A) DNA, RNA ; Guanine (G) DNA, RNA

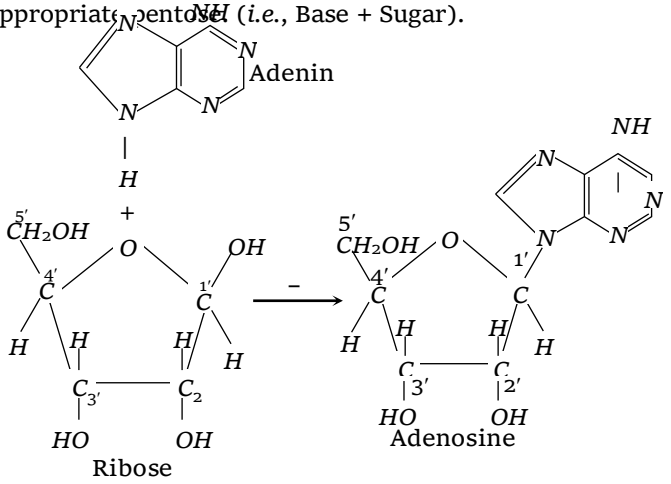
(ii) ***Five carbon sugar (Pentose)*** **:** In RNA, the sugar is ribose where as in DNA, the sugar is deoxyribose.


Ribose or

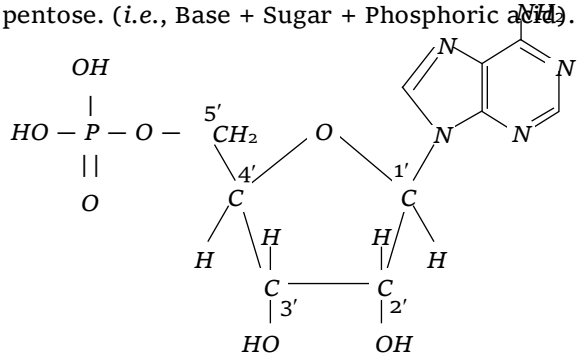

Deoxyribose or

Both differ only at carbon atom 2′ in the ring.

(iii) ***Phosphoric acid, H_3PO_4 :*** Phosphoric acid forms esters to *–OH* groups of the sugars to bind nucleotide segments together. A molecule called **nucleoside** is formed by condensing a molecules of the base with the appropriate pentose (*i.e.*, Base + Sugar).

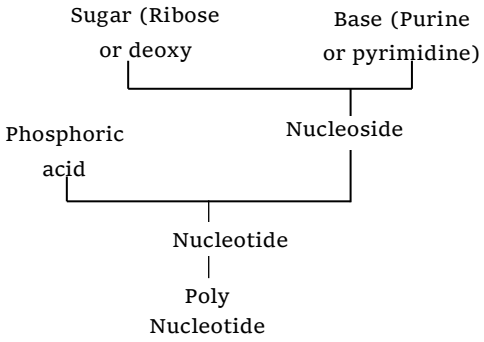


A **nucleotide** results when the nucleoside combined with phosphoric acid mainly at carbon 5′ of the pentose. (*i.e.*, Base + Sugar + Phosphoric acid).



This nucleotide is the building block of both DNA and RNA. The nucleic acids are condensation polymers of the nucleotide monomers and are formed by the creation of an ester linkage from phosphoric residue on one nucleotide to the hydroxy group on carbon 3′ in the pentose of the second nucleotide. The result is a very long chain possessing upto a billion or so nucleotides units in DNA.

Thus, the formation of a nucleic acid can be summarised in the following general way



RNA nucleotides

Base	+	Ribose	→	(Nucleoside)	+	Phosphoric acid	→	Nucleotide
Adenine	+	Ribose	→	(Adenosine)	+	Phosphoric acid	→	Adenylic acid
Guanine	+	Ribose	→	(Guanosine)	+	Phosphoric acid	→	Guanylic acid
Cytosine	+	Ribose	→	(Cytidine)	+	Phosphoric acid	→	Cytidylic acid
Uracil	+	Ribose	→	(Uridine)	+	Phosphoric acid	→	Uridylic acid

DNA nucleotides

Adenine	+	Deoxy ribose sugar	+	Phosphate	→	Adenosine phosphate
Guanine	+	Deoxy ribose sugar	+	Phosphate	→	Guanosine phosphate
Cytosine	+	Deoxy ribose sugar	+	Phosphate	→	Cytosine phosphate
Thymine	+	Deoxy ribose sugar	+	Phosphate	→	Thymidine phosphate

(2) **Structure** : The sequence of bases along the DNA and RNA chain establishes its primary structure which controls the specific properties of the nucleic acid. An RNA molecule is usually a single chain of ribose-containing nucleotides. DNA molecule is a long and highly complex, spirally twisted, double helix, ladder like structure. The two polynucleotide chains or strands are linked up by hydrogen bonding between the nitrogenous base molecules of their nucleotide monomers. Adenine (purine) always links with thymine

(pyrimidine) with the help of two hydrogen bonds and guanine (purine) with cytosine (pyrimidine) with the help of three hydrogen bonds. Hence, the two strands extend in opposite directions, *i.e.*, are antiparallel and complimentary. The following fundamental relationship exist.

❒ *Thymine combines only with deoxyribose sugar and uracil only with ribose sugar. Other bases can combine with either of the two sugars.*

• *The sum of purines equals the sum of pyrimidines.*

• *The molar proportion of adenine equals to that of thymine.*

• *The molar proportion of guanine equals to that of cytosine.*

❒ *The double helix is 20 Å. It completes a spiral at every 10 nucleotide pairs at a length of 34 Å. Sequences of monomers (nucleotides) may present innumerable variations. Evidently, innumerable varities of DNA exist in the organism.*

❒ ***Watson, Crick and Witkins were awarded Noble prize in 1962*** *for suggesting the structure of DNA.*

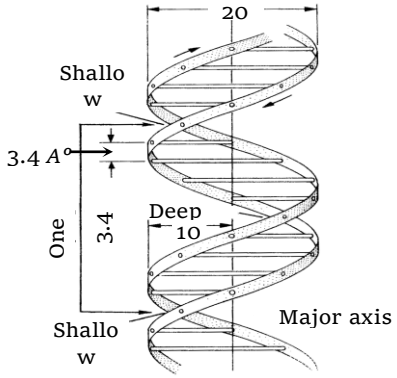


Fig :31.1 Helical structure of DNA as suggested by Watson and Crick

Table : 31.8 Difference between DNA and RNA

DNA	RNA
It has a double helix structure.	It has a single helix structure.
Sugar unit is deoxyribose.	Sugar unit is Ribose.
Base units are adenine, guanine, thyamine and cytosine.	It contains uracil base instead of thyamine, other bases being same as those in DNA.
Responsible for inheritance of character.	It is responsible for protein synthesis.

(3) **Functions of nucleic acid :** Nucleic acid have two important functions

(i) Replication and (ii) Protein synthesis.

(i) ***Replication*** **:** The genetic information for the cell is contained in the sequence of the bases A, T, G and C (adenine, thymine, guanine and cytosine) in the DNA molecule. The sequence of bases in one chain of the double helix controls the sequence in other chain. The two chains fit together like a hand and a glove. They separate and about the hand is formed a new glove, and inside the glove is formed a new hand. Thus, the pattern is preserved in the two new molecules of DNA.

[If one strand of DNA has the sequence ATGCTTGA, then the sequence of complimentary strand will be TACGAACT].

(ii) ***Synthesis of proteins*** **:** The DNA contains the genetic code and directs protein synthesis through RNA. The double helix of DNA partially uncoils and about the individual strands are formed chains of RNA. The new chains contain ribose instead of deoxyribose and the base sequence is different which is determined by DNA, *i.e.*, opposite each adenine of DNA, there appears on RNA a uracil; opposite guanine, cytosine; opposite thymine, adenine, opposite cytosine, guanine. Thus, AATCAGTT on DNA becomes UUAGUCAA on RNA.

One kind of RNA, called messenger RNA, carries a message to the ribosome, where protein synthesis actually takes place. At the ribosome, messenger RNA calls up a series of transport RNA molecules, each of which is loaded with a particular amino acid. The order in which the transport RNA molecules are called (–the sequence in which the amino acids are arranged to form the protein chain) depends upon the sequence of bases along the messenger RNA chain. Thus GAU is the code for aspartic acid; UUU, phenyl alanine; GUG, valine. There are 64-three letter code words (codons) and only 20-odd amino acids, so that more than one codon call the same amino acid.

The relation between the nucleotide triplets and the amino acids is called Genetic code. Nirenberg, Hollay and Khorana presented the genetic code for which they were awarded Noble prize in 1968.

(4) **Mutation :** A mutation is a chemical or physical change that alters the sequence of bases in DNA molecule. Anything that causes mutation is called **mutagen**. A mutation results from ultraviolet light, ionisation radiations, chemicals or viruses. The changes in sequence of bases in DNA are repaired by special enzymes in the cell. If it is not, the protein produced has no biological activity and the cell dies.

These mutations often prove harmful and give rise to symptoms that cause diseases. Sickle-cell anaemia is one such example. Such disease is passed on from one generation to the next generation.

Lipids

Lipids are constituents of plants and tissues which are insoluble in water but soluble in organic

solvents such as chloroform, carbon tetrachloride, ether or benzene. They include a large variety of compounds of varying structures such as oils and fats; phospholipids, steroids, etc. Lipids are mainly made of carbon, hydrogen and oxygen. The number of oxygen atoms in a lipid molecule is always small as compared to the number of carbon atoms. Sometimes small amounts of phosphorus, nitrogen and sulphur are also present. They have a major portion of their structure like a hydrocarbon (aliphatic or fused carbon rings). Lipids serve as energy reserve for use in metabolism and as a major structural material in cell membranes for regulating the activities of cell and tissues.

Simple lipids are esters of glycerol with long chain monocarboxylic acids which can be saturated or unsaturated. These are generally called glycerides of fats and oils. Waxes are esters of fatty acids with certain alcohols, not glycerol. Fats and oils have biological importance but waxes have no value as these are not digested.

The functions of triglycerides are the following

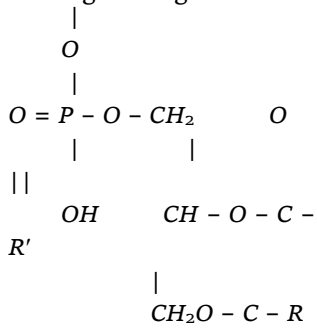
(1) They are energy reserves in the cells and tissues of living system. When digested, triglycerides are hydrolysed to fatty acids and glycerol.

(2) Catabolism of fatty acids form acetyl-coenzyme-A. Most of the energy of fatty acids is converted into ATP.

(3) Acetyl coenzyme is the starting material for the synthesis of many compounds.

(4) Fats deposited beneath the skin and around the internal organs minimize loss of body heat and also act as cushions to absorb mechanical impacts.

Another very important class of lipids are the phospholipids. These are polar lipids and like the fats, are esters of glycerol. In this case, however, only two fatty acid molecules are esterified to glycerol, at the first and second carbon atom. The remaining end position of the glycerol is esterified to a molecule of phosphoric acid, which in turn is also esterified to another alcohol. This gives a general structure.



The alcoholic compound linked to phosphoric group may be choline, ethanol, amine, serine or inositol. The phosphate groups forms a polar end, *i.e.*, hydrophilic (water-attracting) and the two fatty acid chains constitute the non-polar tail, *i.e.*, hydrophobic (water repelling). This structure gives the phospholipids good emulsifying and membrane forming properties.

Cell membranes are composed of phopholipids and proteins in about equal, proportion. The phospholipids in the membrane appear to be arranged in a double layer or bilayer in which the non-polar tails face each other, thereby exposing the polar heads to the aqueous environment on either side of the membrane. Proteins found in the membrane are embedded in the mossaic formed by the lipids. Phospholipids facilitate the transport of ions and molecules in and out of the cell and regulate the concentration of molecules and ions within the cell. They provide structural support for certain proteins.

The above mentioned lipids are mainly straight chain compounds. There is a third class of lipids which are not straight chain compounds. They are called **Sterols**. The sterols are composed of fused hydrocarbon rings and a long hydrocarbon side chain. Cholestrol is most important compound of this class and is found in animals only. It exists either free or as ester with a fatty acid. Cholestrol is also the precursor of hormones. Cholestrol and its esters are insoluble in water. So they are deposited in the arteries and veins if the blood cholestrol rises. This leads to high blood pressure and heart diseases. Cholestrol is a part of animal cell membrane and is used to synthesized steroid hormones, vitamin-*D* and bile salts.

Energy cycle or metabolism

A cell has small molecules (micromolecules) as well as large molecules (macromolecules). The chemical reactions of a living organism can be divided into main two types

(1) *The chemical reactions by which the large molecules are constantly broken down into smaller ones* are called **catabolism**.

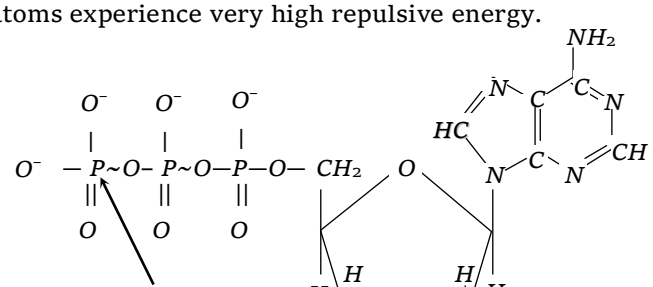
(2) *The chemical reactions by which the macromolecules are synthesised within the cell* are called **anabolism**.

The two processes *i.e.*, degradation and synthesis are collectively called **metabolism**. Catabolism reactions are usually accompanied by *release of energy* whereas anabolism reactions require energy to occur.

The primary energy found in living cells is chemical energy, which can be easily stored, transferred and transformed. For this, the living cells contain a chemical compound called **adenosine triphosphate** (ATP). It is regarded as **energy currency** of living cells because it can trap, store and release small packets of energy with ease.

ATP consists of a purine base called **adenine** linked to a five carbon sugar named **ribose** which is further attached to **three molecules of phosphate.**

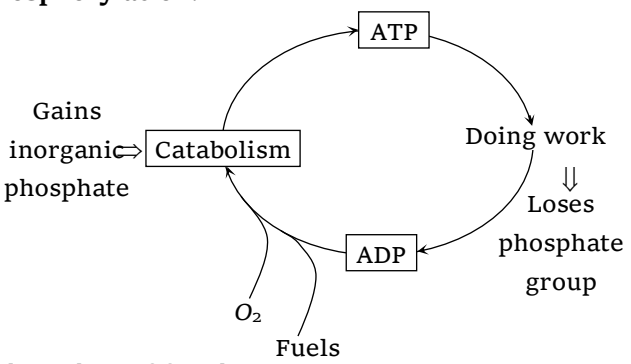
ATP is energy rich molecule this is because of the presence of four negatively charged oxygen atom very close to each other. These four negatively charged *o*-atoms experience very high repulsive energy.



$$ATP \xrightarrow{\text{Hydrolysis}} \underset{\text{Adenosine diphosphate}}{ADP} + Pi \quad \Delta H = -30.93\ kJ\ mol^{-1}$$

$$ADP \xrightarrow{\text{Hydrolysis}} \underset{\text{Adenosine monophosphate}}{AMP} + 2Pi \quad \Delta H = -28.4\ kJ\ mol^{-1}$$

ADP can change to ATP in the presence of inoraganic phosphate. This process is called **phosphorylation**.



Digestion of food

Digestion is the process by which complex constituents of food are broken down into simple molecules by a number of enzymes in mouth, stomach and small intestine. The simple molecules thus formed are absorbed into blood stream and reach various organs.

Raw food may be taken as such or after cooking. It is chewed in the mouth and swallowed when it passes through a long passage in the body called alimentary canal. During this passage it gets mixed with various enzymes in different parts of the alimentary canal. The carbohydrates, proteins and fats are converted into simpler forms which are then carried by blood to different parts of the body for utilization. Digestion of food can be summarized in the following form

(1) Polysaccharide $\xrightarrow[\text{(Saliva (mouth); Pancreatic juice (Intestine))}]{\text{Amylase}}$ Disaccharides

Disaccharides (maltose, etc.) $\xrightarrow[\text{(Intestine)}]{\text{Maltase}}$ Glucose

(2)

Proteins $\xrightarrow[\text{(Stomach)}]{\text{Pepsin/}HCl}$ Proteases and Peptones $\xrightarrow[\text{(Chemotrypsin Pancreatic juice (Intestine))}]{\text{Trypsin}}$

Peptides $\xrightarrow[\text{(Intestine)}]{\text{Peptidases}}$ Amino acids

(3) Fats $\xrightarrow[\text{(From liver)}]{\text{Bile salts}}$ Emulsified fat $\xrightarrow[\text{(Pancreatic and intestine juice)}]{\text{Lipases}}$ Fatty acids + Glycerol

After digestion, there are present glucose, aminoacids, fatty acids along with vitamins and mineral salts. Undigested food and secretions are pushed forward into the rectum from where these are excreted.

Vitamins

In addition to air, water, carbohydrates, proteins, fats and mineral salts, certain organic substances required for regulating some of the body processes and preventing certain diseases are called **vitamins**. These compounds cannot be synthesised by an organism. On the basis of solubility, the vitamins are divided into two groups.

(1) Fat soluble; Vitamin A, D, E and K.

(2) Water soluble; Vitamin B and C.

Table : 31.9

Name	Sources	Functions	Effects of defficiency
Water soluble vitamins			
Vitamin B_1 (Thiamine or Aneurin) ($C_{12}H_{18}N_4SOCl_2$)	Rice polishings, wheat flour, oat meal, eggs, yeast, meat, liver, etc.	Major component of co-enzyme co-carboxylase required for carbohydrate and amino acid metabolism.	**Beri-beri**, loss of appetite and vigour, constipation, weak heart beat, muscle atrophy, even paralysis.
Vitamin B_2 or G (Riboflavin or Lactoflavin) ($C_{17}H_{20}N_4O_6$)	Cheese, eggs, yeast, tomatoes, green vegetables, liver, meat, cereals, etc.	Combines with phosphoric acid to form coenzyme FAD essential for oxidative metabolism.	**Cheilosis**, digestive disorders, burning sensations in skin and eyes, headache, mental depession, scaly dermatitis at angles of nares, corneal opacity, etc.
Vitamin B_3 (Pantothenic acid) ($C_9H_{17}O_5N$)	All food; more in yeast, liver, kidneys, eggs, meat, milk, sugarcane, groundnut, tomatoes.	Important component of Co-A required for oxidative metabolism.	**Dermatitis**, in cocks; greying of hairs, retarded body and mental growth, reproductive debility.

Vitamin B_5 or *P-P* (Nicotinic acid or Niacin) $C_6H_5NO_2$ (C_5H_4N–*COOH*)	Fresh meat, liver, fish, cereals, milk, pulses, yeast, etc.	Active group in coenzyme NAD required for oxidative metabolism.	**Pellagra,** dermatitis, diarrhoea, demenia, muscle atrophy, inflammation of mucous membrane of gut.
Vitamin B_6 (Pyridoxine or Adermin) ($C_8H_{11}O_3N$)	Milk, cereals, fish, meat, liver, yeast synthesised by intestinal bacteria.	Important coenzyme required in protein and amino acid metabolism.	**Dermatitis, anaemia**, convulsions, nausea, insomnia, vomiting, mental disorders, depressed appetite.
Vitamin *H* (Biotin) ($C_{10}H_{16}N_2O_3S$)	Yeast, vegetables, fruits, wheat, chocolate, eggs, groundnut synthesised by intestinal bacteria.	Essential for fat synthesis and energy production.	**Skin lesions**, loss of appetite, weakness, hairfall, paralysis.
Folic acid group	Green vegetables, soyabean, yeast, kidneys, liver, synthesised by intestinal bacteria.	Essential for synthesis of DNA and maturation of blood corpuscles.	Retarded growth**, anaemia**.
Vitamin B_{12} (Cyanocobalamine) ($C_{63}H_{88}O_{14}N_{14}PCo$)	Meat, fish, liver, eggs, milk synthesised by intestinal bacteria.	Required for chromosome duplication and formation of blood corpuscles.	Retarded growth, **pernicious anaemia**
Vitamin *C* (Ascorbic acid) ($C_6H_8O_6$)	Lemon, orange and other citrus fruits, tomatoes, green vegetables, potatoes, carrots, pepper, etc.	Essential for formation of collagen, cartilage, bone, teeth, connective tissue and RBCs and for iron metabolism.	Wound-healing and growth retarded, **scurvy, breakdown of immune defence system**, spongy and **bleeding gums, fragile blood vessels** and **bones**, exhaustion, nervous breakdown, high fever.
Fat soluble vitamins Vitamin *A* (Retinol or Axerophthol) ($C_{20}H_{30}O$)	Synthesised in cells of liver and intestinal mucous membrane from carotenoid pigments found in milk, butter, kidneys, egg yolk, liver, fish oil, etc.	Essential for synthesis of visual pigments; growth and division of epithelial cells.	Xerophthalmia-keratini-zed conjunctive and opaque and soft cornea. Stratification and keratinization in epithelia of skin, respiratory passages, urinary bladder, ureters and intestinal mucosa, **night-blindness, impaired growth, glandular secretion and reproduction**.
Vitamin *D* (Ergocalciferol), (Sun shine vitamin) $C_{28}H_{44}O$ and cholecalciferol	Synthesised in skin cells in sunlight from 7-dehydro-cholesterol also found in butter, liver, kidneys, egg yolk, fish oil, etc.	Regulates absorption of calcium and phosphorus in intestine, mineral deposition in bones and teeth.	**Rickets** with osteomalacia; soft and fragile teeth.
Vitamin *E* group Tocopherols (α, β, γ) ($C_{29}G_{50}O_2$)	Green vegetables, oil, egg yolk, wheat, animal tissues.	Essential for proper spermatogenesis, pregnancy, lactation and muscular function.	**Sterility** (impotency) and muscular atrophy.
Vitamin *K* (Phylloquinone) ($C_{31}H_{46}O_2$)	Carrots, lettuce, cabbage, tomatoes, liver, egg yolk, cheese; synthesized by colon bacteria.	Essential for synthesis of prothrombin in liver, which is required for blood clotting.	**Haemorrhages,** excessive bleeding in injury, poor coagulation of blood.

Tips & Tricks

✍ Monosaccharides which differ in configuration at C_1 and C_2 in aldoses in ketoses are called **anomers**. Thus α-*D* glucose and β-*D* glucose are anomers and so are α-*D* fructose and β-*D* fructose.

✍ Monosaccharides which differ in configuration at a carbon atom other than the anomeric carbon are called epimers. Thus glucose and mannose which differ in configuration at C_2 are called C_2 epimers while glucose and galactose which differ in configuration at C_4 are called C_4 epimers.

✍ In amino acids $-COO^-$ group acts as the base while $-\overset{+}{N}H_3$ acts as the acid.

✍ Insulin is a protein harmone. It consists of 51 amino acids arranged in two polypeptide chains containing 21 and 30 α amino acids residues respectively. The two peptide chains are held together by two cystine disulphide cross links.

✍ Certain enzymes are associated with coenzymes mostly derived from vitamins for their biological activity.

✍ Each segment of a DNA molecule that codes for a specific protein or a polypeptide is called gene and the relationship between the nucleotide triplet and the amino acids is called the genetic code.

✍ Phospholipids are major constituents of cell walls.

✍ The deficiency of essential amino acids causes the disease called kwashiorkor.

✍ Lecithin (present in eggs) and cephalins are phospholipids in which two of the hydroxyl groups of glycerol are esterified with palmitic acid whereas the third *OH* group in lecithin is esterified with chlone $(CH_3)_3N^+ - CH_2CH_2OH$ while in cephalin it is esterified with ethanolamine, $\overset{+}{N}H_3CH_2CH_2OH$.

✍ Adenosine (ribose + adenine) is a nucleoside while adenosine monophosphate (AMP), adenosine diphosphate and adenosine triphosphate (ATP) are all nucleotides.

✍ Haemoglobin is a globular protein and the red colour of haemoglobin is due to the iron protoporphyrin complex called the heme.

✍ The bicarbonate/carbonic acid system *i.e.*, HCO_3^-/H_2CO_3 acts as the buffer and maintains the *pH* of blood between 7.36-7.42.

✍ Vitamin *C* is a derivative of monosaccharide *i.e.*, glucose while Vitamin *D* is derivative of steroid *i.e.* ergosterol.

✍ Vitamin *K* and Vitamin *A* contain isoprene units.

✍ Of all the vitamins, Vitamin B_{12} does not occur in plants but occurs only in animals and micro organisms. In fact, it is exclusively synthesized by the micro organisms and is conserved in the liver. Vitamin B_{12} has been found in rain water where its presence is attributed to micro organisms sucked up by the winds.

Ordinary Thinking

Objective Questions

Carbohydrates

1. The change in optical rotation, with time, of freshly prepared solution of sugar is known as **[CPMT 1982, 85; BHU 1997]**
(a) Rotatory motion (b) Inversion
(c) Specific rotation (d) Mutarotation

2. Gun-cotton is
(a) Nitrosucrose (b) Nitrocellulose
(c) Nitroglucose (d) Nitropicrin

3. Which of the following monosaccharide is a pentose **[CPMT 1982, 87, 89, 93]**
(a) Galactose (b) Glucose
(c) Fructose (d) Arabinose

4. Amide group is present in
(a) Lipids (b) Carbohydrates
(c) Amino acids (d) Proteins

5. Which of the following is a carbohydrate
(a) Leucine (b) Albumin
(c) Inulin (d) Maltase

6. General formula for carbohydrates is
(a) $C_nH_{2n}O_{2n+2}$ (b) $C_x(H_2O)_{2x}$
(c) $C_x(H_2O)_y$ (d) None of these

7. Benedict solution provides **[CPMT 1983]**
(a) Ag^+ (b) Li^+
(c) Cu^{+2} (d) Ba^{+2}

8. Glucose gives silver mirror with Tollen's reagent. It shows the presence of **[MNR 1981; CPMT 1974, 81; MP PMT 1994]**
(a) An acidic group (b) An alcoholic group
(c) A ketonic group (d) An aldehydic group

9. A certain compound gives negative test with ninhydrin and positive test with Benedict's solution. The compound is **[NCERT 1978; KCET 2000]**
(a) A protein (b) A monosaccharide
(c) A lipid (d) An amino acid

10. An organic compound answers Molisch's test as well as Benedict's test. But it does not answer Scliwanoff's test. Most probably, it is **[KCET 2003]**
(a) Sucrose (b) Protein
(c) Fructose (d) Maltose

11. Glucose when heated with CH_3OH in presence of dry HCl gas gives α and $\beta-$methyl glucosides because it contains **[CPMT 1982, 85]**
(a) An aldehyde group (b) A $-CH_2OH$ group
(c) A ring structure (d) Five hydroxyl groups

12. Which one is a disaccharide **[CPMT 1981, 83]**
(a) Glucose (b) Fructose
(c) Xylose (d) Sucrose

13. Molecular formula $C_6H_{12}O_6$ is of
(a) Glucose (b) Fructose
(c) Both (a) and (b) (d) None of these

14. Hydrolysis of sucrose is called **[BHU 1979, 83; Pb. PMT 1999; Pb. CET 2000]**
(a) Esterification (b) Saponification
(c) Inversion (d) Hydration

15. In the '*glycolipids*', the two sugars known to occur are glucose and
(a) Fructose (b) Lactose
(c) Galactose (d) Sucrose

16. The '*epimerisation*' involves
(a) Change of configuration
(b) Addition of one more '*C*'
(c) Substration of a '*C*'
(d) Conversion of $-CHO$ to $-C=O$

17. The compound which does not contain an asymmetric carbon atom is
(a) Glycolaldehyde (b) Glyceraldehyde
(c) Glucose (d) Galactose

18. Which of the following sign indicate that the sugar is actually '*dextrorotatory*'
(a) – (b) +
(c) *R* – (d) All of these

19. The standard compound for determination of configuration in the '*sugar chemistry*' is
(a) Glycolaldehyde (b) Glyceraldehyde
(c) Glucose (d) Fructose

20. Sugars are
(a) Optically active polyhydroxy aldehydes
(b) Optically active polyhydroxy ketones
(c) Optically active polyhydroxy aldehydes or ketones
(d) Polyhydroxy aldehydes or ketones which may or may not be optically active

21. Molecular formula of pentahydroxy acid obtained when glucose is oxidised with Br_2 water is
(a) $C_6H_{12}O_7$ (b) $C_6H_{12}O_8$
(c) $C_6H_{12}O_6$ (d) $C_6H_{10}O_6$

22. The '*phosphoglycerides*' occur in
(a) The brain and the spinal chord
(b) Nails and hairs
(c) Oils and fats
(d) Waxes

23. Sucrose is a **[CPMT 1983]**
(a) Monosaccharide (b) Disaccharide

(c) Trisaccharide (d) Polysaccharide

24. The commonest disaccharide has the molecular formula **[CPMT 1982; Manipal MEE 1995; MP PET 1999; AIIMS 1999]**

(a) $C_{10}H_{18}O_9$ (b) $C_{10}H_{20}O_{10}$

(c) $C_{18}H_{22}O_{11}$ (d) $C_{12}H_{22}O_{11}$

25. On complete hydrolysis of starch, we finally get **[MNR 1982; DPMT 1979; CBSE PMT 1991; MP PMT 1987; MP PET 1993]**

(a) Glucose (b) Fructose

(c) Glucose and fructose (d) Sucrose

26. Which is monosaccharide

(a) Glucose (b) Fructose

(c) Galactose (d) All of these

27. Which is polysaccharide

(a) Starch (b) Cellulose

(c) Glycogen (d) All of these

28. The calorific values of fats, carbohydrates and proteins vary in the order

(a) Fats > Carbohydrates > Proteins

(b) Fats > Proteins > Carbohydrates

(c) Carbohydrates > Proteins > Fats

(d) Proteins > Carbohydrates > Fats

29. Gun-cotton is obtained when conc. nitric acid reacts with

(a) Glycerine (b) Glycol

(c) Cellulose (d) Starch

30. A carbohydrate consists of **[NCERT 1971]**

(a) *C* and *O* (b) *C*, *H* and *O*

(c) *C*, *H*, *N* and *O* (d) *C* and *H*

31. Glucose forms many derivatives. The derivative which will help to prove the furanose structure is **[AIIMS 1980; DPMT 1985]**

(a) Acetyl (b) Benzoyl

(c) Osazone (d) Isopropylidene

32. Glucose and fructose form **[MP PMT 1986]**

(a) Same osazone

(b) Same acid on oxidation

(c) Same alcohol when reduced

(d) Different osazone

33. On heating with conc. H_2SO_4, sucrose gives **[DPMT 1984]**

(a) *CO* and CO_2 (b) *CO* and SO_2

(c) *CO*, CO_2 and SO_2 (d) None of these

34. The letter '*D*' in carbohydrates represents

(a) Its direct synthesis (b) Its dextrorotation

(c) Its mutarotation (d) Its configuration

35. Starch can be used as an indicator for the detection of traces of **[CPMT 1986]**

(a) Glucose in aqueous solution

(b) Protein in blood

(c) Iodine in aqueous solution

(d) Urea in blood

36. It is best to carry out reactions with sugars in neutral or acid medium and not in alkaline medium. This is because in alkaline medium sugars undergo one of the following changes

(a) Racemisation (b) Decomposition

(c) Inversion (d) Rearrangement

37. Which one of the following compounds is found abundantly in nature **[BHU 1983; Manipal MEE 1995; DCE 20**

(a) Fructose (b) Starch

(c) Glucose (d) Cellulose

38. The substance that forms the plant cell walls is or Which carbohydrates is an essential constituents of plant cells **[KCET 1984; MP PET 1999; CPMT 2002]**

(a) Cellulose (b) Sucrose

(c) Vitamins (d) Starch

39. Sugar can be tested in urine by

(a) Molisch test (b) Dunstan's test

(c) Benedict's test (d) Legal's test

40. When sucrose is heated with conc. HNO_3 the product is **[CPMT 1979]**

(a) Sucrose nitrate (b) Formic acid

(c) Oxalic acid (d) Citric acid

41. Amylopectin is **[KCET 2005]**

(a) Water soluble

(b) Water insoluble

(c) Forms colloidal solution with water

(d) Both (b) and (c)

42. Which of the following statements about ribose is incorrect **[CPMT 1985]**

(a) It is a polyhydroxy compound

(b) It is an aldehyde sugar

(c) It has six carbon atoms

(d) It exhibits optical activity

43. Maltose contains how many oxygen atoms

(a) 6 (b) 10

(c) 11 (b) 22

44. The correct name of 'sucrose' is

(a) $\alpha - D - \text{glucopyranosyl} - \beta - D - \text{fructofuranoside}$

(b) $\beta - D - \text{glucopyranosyl} - \beta - D - \text{fructofuranoside}$

(c) $\alpha - D - \text{glucopyranosyl} - \alpha - D - \text{fructofuranoside}$

(d) $\beta - D - \text{glucopyranosyl} - \alpha - L - \text{fructofuranoside}$

45. Sucrose is

(a) Laevorotatory (b) Dextrorotatory

(c) Racemic mixture (d) Optically inactive

46. The hydrolysis of sucrose produces a mixture which is
(a) Laevorotatory
(b) Dextrorotatory
(c) Equally both (+) and (–) rotatory
(d) Optically inactive

47. Sucrose is
(a) A reducing sugar
(b) Not a reducing sugar
(c) Partial reducing sugar
(d) Mixed sugar

48. Sucrose contains which of the following groups
(a) $-CHO$ (b) $>C=O$
(c) Both (a) and (b) (d) None of these

49. The fructose molecule in sucrose exists as
(a) Furanose (b) Pyranose
(c) Open chain (d) All

50. Which one of the following is laevorotatory **[DPMT 1989]**
(a) Glucose (b) Sucrose
(c) Fructose (d) None of these

51. Chemically '*digestion*' is **[NCERT 1978]**
(a) Hydrolysis (b) Change in bacteria
(c) Hydrogenation (d) Dehydrogenation

52. Which one of the following is the reagent used to identify glucose **[MP PMT 1993]**
(a) Neutral ferric chloride
(b) Chloroform and alcoholic *KOH*
(c) Ammoniacal silver nitrate
(d) Sodium ethoxide

53. Sucrose on hydrolysis gives **[MP PMT 1993; Bihar MEE 1997]**
(a) Two molecules of glucose
(b) Two molecules of fructose
(c) One molecule each of glucose and fructose
(d) One molecule each of glucose and mannose

54. Which of the following is a disaccharide **[CPMT 1990, 94]**
(a) Lactose (b) Starch
(c) Cellulose (d) Glucose

55. Glucose cannot be classified as **[CPMT 1989]**
(a) A hexose (b) A carbohydrate
(c) An oligosaccharide (d) An aldose

56. The reagent which forms crystalline osazone derivative when reacted with glucose, is **[CPMT 1990]**
(a) Fehling solution (b) Phenylhydrazine
(c) Benedict solution (d) Hydroxylamine

57. An enzyme which brings about the conversion of starch into maltose is known as **[BHU 1979]**
(a) Maltase (b) Zymase
(c) Invertase (d) Diastase

58. Canesugar on hydrolysis gives **[MADT Bihar 1984; NCERT 1977; AMU 1985]**
(a) Glucose and maltose (b) Glucose and lactose
(c) Glucose and fructose (d) Only glucose

59. Glucose is a **[CPMT 1984]**
(a) Monosaccharide (b) Disaccharide
(c) Trisaccharide (d) Polysaccharide

60. Which carbohydrate is used in silvering of mirrors **[BHU 1973; CPMT 1991]**
(a) Sucrose (b) Starch
(c) Glucose (d) Fructose

61. A carbohydrate that cannot be hydrolysed to simpler forms is called
(a) Disaccharide (b) Monosaccharide
(c) Polysaccharide (d) Trisaccharide

62. If monosaccharide contains an aldehyde group, it is known as
(a) Epimer (b) Osones
(c) Osazone (d) Aldose

63. If a monosaccharide contains a ketogroup, it is known as
(a) Ketose (b) Osones
(c) Epimer (d) Osazone

64. The aqueous solution of a carbohydrate gives dark blue colour with iodine. It is
(a) Glucose (b) Fructose
(c) Sucrose (d) Starch

65. Which of the following carbohydrates is a disaccharide
(a) Glucose (b) Fructose
(c) Raffinose (d) Maltose

66. Optical activity is shown by
(a) Glucose (b) Fructose
(c) Sucrose (d) All of these

67. Which is a reducing sugar
(a) Glucose (b) Fructose
(c) Galactose (d) All of these

68. The ultimate product of oxidation of most of hydrogen and carbon in foodstuffs are **[CPMT 1981]**
(a) H_2O alone (b) CO_2 alone

(c) H_2O and CO_2 (d) None of these

69. Osazone formation involves only 2 carbon atoms of glucose because of **[MP PMT 1986]**

(a) Chelation (b) Oxidation

(c) Reduction (d) Hydrolysis

70. Glucose will show mutarotation when solvent is **[MP PMT 1986]**

(a) Acidic (b) Basic

(c) Neutral (d) Amphoteric

71. Glucose contains **[CPMT 1982]**

(a) One $-CHO$ group

(b) Five $-OH$ groups

(c) One primary alcoholic group

(d) Four secondary alcoholic groups

(e) All are correct

72. Carbohydrates are stored in human body as **[MP PMT 1999; Kerala PMT 2004]**

(a) Glucose (b) Glycogen

(c) Starch (d) Fructose

73. An example of a disaccharide made up of two units of the same monosaccharides is **[KCET 1989; MP PET 1996; AFMC 2005]**

(a) Sucrose (b) Maltose

(c) Lactose (d) None of these

74. The sugar present in fruits is **[KCET 1984]**

(a) Fructose (b) Glucose

(c) Sucrose (d) Galactose

75. Carbohydrates are **[MADT Bihar 1983]**

(a) Hydrates of carbon

(b) Polyhydroxy aldehydes or ketones

(c) Polyhydroxy acid compounds

(d) None of these

76. Glucose and fructose are **[Bihar MADT 1982]**

(a) Isotopes

(b) Isotones

(c) Isomers

(d) Homologues of each other

77. Hydrolytic conversion of sucrose into glucose and fructose is known as **[BHU 1979, 97]**

(a) Induction (b) Saponification

(c) Inversion (d) Esterification

78. Starch is a polymer of **[DPMT 1982; CPMT 1975, 80; MP PMT 1994]**

(a) Glucose (b) Fructose

(c) Both (a) and (b) (d) None of these

79. To become a carbohydrate a compound must contain at least **[AFMC 1991]**

(a) 2 carbons (b) 3 carbons

(c) 4 carbons (d) 6 carbons

80. Lactose on hydrolysis gives **[KCET 1983]**

(a) Two glucose molecules

(b) Two galactose molecules

(c) A galactose molecule and a fructose molecule

(d) A galactose molecule and a glucose molecule

81. An example of non-reducing sugar is **[KCET 1988]**

(a) Cane sugar (b) Fructose

(c) Lactose (d) Cellobiose

82. Cellulose is a polymer of **[KCET 1984]**

(a) L-fructose (b) D-mannose

(c) D-glucose (d) Amylose

83. The intermediate compound formed in the conversion of starch to glucose is **[KCET 1984]**

(a) Lactose (b) Sucrose

(c) Maltose (d) Fructose

84. Invertase brings about the conversion of **[KCET 1986]**

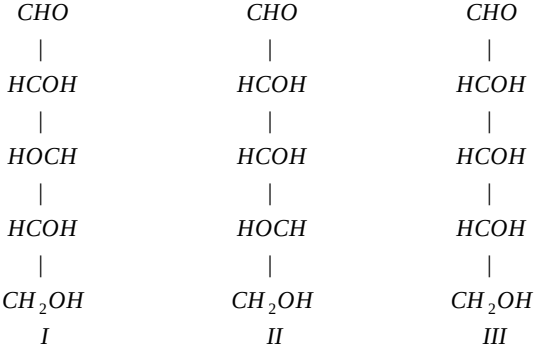
(a) Starch to glucose

(b) Sucrose to glucose and fructose

(c) Maltose to glucose

(d) Glucose to C_2H_5OH and CO_2

85. Which of the following pentoses will be optically active



[MP PET 1994]

(a) All (b) II and III

(c) I (d) II

86. $\alpha-D-$glucose and $\beta-D-$glucose differ from each other due to difference in one of the carbons with respect to its **[CBSE PMT 1995; AFMC 1999]**

(a) Size of hemiacetal ring (b)Number of OH groups

(c) Configuration (d) Conformation

87. Which carbohydrates has highest abundance in human blood **[MP PET 1995]**

(a) *d*-fructose (b) *d*-glucose

(c) Sucrose (d) Lactose

88. Formation of silver mirror by glucose shows that it is a/an

(a) Oxidising agent (b) Acid
(c) Reducing agent (d) A salt of silver

89. Which of the following statements is right
(a) Cellulose are linear polymers of $\beta-$glucose molecules with $\beta-1,4-$linkages
(b) Starches are polymers of $\alpha-$glucose molecules with $\beta-1,4-$linkages and some $\beta-1,6-$cross-linkages
(c) Proteins are polyamides of $\beta-$amino acids
(d) The structural information about their biosynthesis is contained in a class of compounds called nucleic acids, e.g. RNA and DNA

90. The number of atoms in the cyclic structure of D-fructose is **[MP PMT 1997]**
(a) 5 (b) 6
(c) 4 (d) 7

91. Which is used in motion picture films
(a) Cellulose acetate (b) Glucose acetate
(c) Starch acetate (d) Sucrose acetate

92. Glucose reacts with acetic anhydride to form **[KCET 1996]**
(a) Mono-acetate (b) Tetra-acetate
(c) Penta-acetate (d) Hexa-acetate

93. Which of the following does not show any reducing test of aldehyde **[CPMT 1996; Orissa JEE 2004]**
(a) Sucrose (b) Fructose
(c) Maltose (d) Lactose

94. When amylases catalyse the hydrolysis of starch, the final product obtained is chiefly **[Pb. PMT 1998]**
(a) Cellobiose (b) Glucose
(c) Maltose (d) Sucrose

95. Galactose is converted into glucose in **[AFMC 1998]**
(a) Mouth (b) Stomach
(c) Liver (d) Intestine

96. Which among the following is the simplest **[CPMT 1999]**
(a) Glucose (b) Cellulose
(c) Starch (d) None of these

97. Indigestible carbohydrate, which is also a constituent of our diet, is **[Kerala (Med.) 1999]**
(a) Cellulose (b) Galactose
(c) Maltose (d) Starch

98. Starch is converted into maltose by the **[DPMT 1979; CPMT 1982; BHU 1999]**
(a) Maltase (b) Invertase
(c) Zymase (d) Diastase

99. The disaccharide present in milk is **[CPMT 1982, 87, 91; MP PET 2001]**
(a) Maltose (b) Lactose
(c) Sucrose (d) Cellobiose

100. Carbohydrates are used by body mainly **[DCE 1999]**
(a) For obtaining vitamins
(b) As source of energy
(c) For all its developmental needs
(d) For building muscles

101. In the viscose process the solvent for cellulose consists of **[JIPMER 1999]**
(a) Ether and alcohol
(b) Copper sulphate and ammonia
(c) Sodium hydroxide and carbon disulphide
(d) Acetic acid and acetic anhydride

102. Which of the following does not reduce Benedict's solution **[KCET 2000]**
(a) Sucrose (b) Aldehyde
(c) Glucose (d) Fructose

103. In polysaccharides the linkage connecting monosaccharide units is called
(a) Glycoside linkage (b) Nucleoside linkage
(c) Glycogen linkage (d) Peptide linkage

104. Blood sugar is the same as **[DPMT 2000]**
(a) Glucose (b) Galactose
(c) Glycogen (d) Fructose

105. Glucose has functional group **[MH CET 2000]**
(a) Aldehydic
(b) Aldehydic and alcoholic
(c) Alcoholic
(d) Ketonic and alcoholic

106. Which of the following is an aldohexose **[KCET (Engg.) 2001]**
(a) Cellulose (b) Sucrose
(c) Glucose (d) Raffinose

107. The calorific value is maximum in case of **[Kerala (Med.) 2000]**
(a) Milk (b) Proteins
(c) Minerals (d) Carbohydrates

108. An invert sugar is **[AFMC 2000]**
(a) Isorotatory (b) Dextrorotatory
(c) Laevorotatory (d) Optically inactive

109. The change in optical rotation with time of freshly prepared solutions of sugar is known as **[JIPMER 2000]**
(a) Maturation (b) Rotatory motion
(c) Inversion (d) Specific rotation

110. Yeast cell derive their energy from glucose by **[AIIMS 2001]**

(a) Glycolysis (b) Respiration formation

(c) Formation (d) None of these

111. Which of the following is correct statement **[CBSE PMT 2001]**

(a) Troleins are amino acid

(b) α-hydrogen is present in fructose

(c) Starch is polymer of α-glucose

(d) Amylose is compound of cellulose

112. Which of the following is a aldohexose **[KCET 2001]**

(a) Cellulose (b) Sucrose

(c) Galactose (d) Raffinose

113. The ultimate product of the hydrolysis of starch is **[DPMT 2001]**

(a) Fructose (b) Glucose

(c) Sucrose (d) None of these

114. Raffinose is **[Pb. PMT 2001]**

(a) Trisaccharide (b) Monosaccharide

(c) Disaccharide (d) None of these

115. A sugar, that is not a disaccharide, among the following is **[KCET (Med./Engg.) 2002]**

(a) Lactose (b) Galactose

(c) Sucrose (d) Maltose

116. To detect the reducing and non reducing sugars, which of the following test is used **[MH CET 2002]**

(a) Molisch test (b) Biuret test

(c) Fehling's test (d) Millions test

117. Which of the following is a disaccharide **[MH CET 2002]**

(a) Glucose (b) Ribulose

(c) Lactose (d) Arabinose

118. On heating glucose with Fehling's solution we get a precipitate whose colour is **[CPMT 1979; CBSE PMT 1988; KCET 1992; DPMT 1983, 86; MP PMT 1996]**

(a) Yellow (b) Red

(c) Black (d) White

119. Glycolysis is **[CBSE PMT 2003]**

(a) Conversion of glucose to haem

(b) Oxidation of glucose to glutamate

(c) Conversion of pyruvate to citrate

(d) Oxidation of glucose to pyruvate

120. Which of the following is an example of ketohexose **[Orissa JEE 2003]**

(a) Mannose (b) Galactose

(c) Maltose (d) Fructose

121. The safest and the most common alternative of sugar is **[MP PMT 2003]**

(a) Glucose (b) Aspartame

(c) Saccharin (d) Cyclodextrin

122. The specific rotation of equilibrium mixture of α-*D*-glucose and β-*D*-glucose, is

(a) $+19^o$ (b) $+112^o$

(c) $+52^o$ (d) $+100^o$

123. The charring of sugar, when treated with conc. H_2SO_4, is due to **[Pb. CET 2002]**

(a) Oxidation (b) Reduction

(c) Dehydration (d) Hydrolysis

124. Which among the following is the simplest sugar **[Pb. CET 2002]**

(a) Glucose (b) Cellulose

(b) Starch (d) Glycogen

125. Glucose and mannose are

(a) Epimers (b) Anomers

(c) Ketohexoses (d) Disaccharides

126. On hydrolysis, which produces only glucose **[BVP 2004]**

(a) Galactose (b) Maltose

(c) Sucrose (d) None

127. Pick out the one which does not belong to the family **[KCET 2004]**

(a) Pepsin (b) Cellulose

(c) Ptyalin (d) Lipase

128. Which of the following is the sweetest sugar **[MP PMT 1997; CBSE PMT 1999; AIIMS 2000 Manipal MEE 1995; CPMT 1996; BHU 1997;]**

(a) Glucose (b) Fructose

(c) Lactose (d) Sucrose

129. 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 **[CBSE PMT 1995]**

(a) 38 (b) 12

(c) 18 (d) 28

130. Glucose has difference from fructose in that it **[BHU 2005]**

(a) Does not undergo hydrolysis

(b) Gives silver mirror with Tollen's reagent

(c) Monosaccharide

(d) None of these

131. In fructose, the possible optical isomers are **[Orissa JEE 2005]**

(a) 12 (b) 8
(c) 16 (d) 4

132. If an aqueous solution of glucoseis allowed to freeze than crystal of which will be separated out first **[DPMT 2005]**
(a) Glucose (b) Water
(c) Both of these (d) None of these

133. Which is false **[J & K 2005]**
(a) Glucose is a disaccharide
(b) Starch is a polysaccharide
(c) Glucose and fructose are not anomers
(d) Invert sugar consists of glucose and fructose

Proteins, Amino Acids and Enzymes

1. Insulin is **[CBSE PMT 1991]**
(a) An amino acid (b) Protein
(c) A carbohydrate (d) A lipid

2. Peptides are
(a) Esters (b) Salts
(c) Amides (d) Ketones

3. The proteins which are insoluble in water are
(a) Fibrous proteins (b) Globular proteins
(c) Both (a) and (b) (d) None of these

4. Irreversible precipitation of proteins is called
(a) Denaturation (b) Hydrolysis
(c) Rearrangement (d) Electrophoresis

5. The proteins with a prosthetic group are called
(a) Pseudo proteins (b) Complex proteins
(c) Conjugated proteins (d) Polypeptides

6. The prosthetic group of haemoglobin is
(a) Porphin (b) Haem
(c) Globin (d) Globulin

7. When collagen is boiled with water, it forms
(a) Precipitate (b) Solution
(c) Gelatin (d) Complex collagen

8. Which of the following is not essential amino acid
(a) Valine (b) Lysine
(c) Histidine (d) Glycine

9. Amino acids are
(a) Liquids
(b) Volatile solids
(c) Non-volatile crystalline compounds
(d) Mixture of amines and acids

10. Isoelectric point is a
(a) Specific temperature
(b) Suitable concentration of amino acid
(c) Hydrogen ion concentration that does not allow migration of amino acid under electric field
(d) Melting point of an amino acid under the influence of electric field

11. Proteins are hydrolysed by enzymes into **[CPMT 1981; BHU 1987; MP PMT 1994, 2002]**
(a) Dicarboxylic acids (b) Hydroxy acids
(c) Amino acids (d) Aromatic acids

12. Proteins when heated with conc. HNO_3 give a yellow colour. This is **[CPMT 1989]**
(a) Oxidising test (b) Xanthoprotic test
(c) Hoppe's test (d) Acid-base test

13. Enzymes are **[DPMT 1980; MP PMT 1993, 96]**
(a) Proteins (b) Minerals
(c) Oils (d) Fatty acids

14. Proteins are built up of **[CPMT 1981, 99; BHU 1987; CBSE PMT 2001; MP PMT 1987, 96; KCET 1984]**
(a) Dicarboxylic acids (b) Amino acids
(c) Alcohols (d) Hydroxy acids

15. The main structural feature of proteins is **[MNR 1987; MP PET 1993, 97, 2004]**
(a) The ester linkage (b) The ether linkage
(c) The peptide linkage (d) All of these

16. Pepsin enzyme hydrolyses **[NCERT 1984; MP PET 1999; MP PMT 2001]**
(a) Proteins to amino acids
(b) Fats to fatty acids
(c) Glucose to ethyl alcohol
(d) Polysaccharides to monosaccharides

17. Which one of the following proteins transports oxygen in the blood stream
(a) Myoglobin (b) Insulin
(c) Albumin (d) Haemoglobin

18. Enzymes are **[MP PET 1993]**
(a) Living organisms
(b) Dead organisms
(c) Complex nitrogenous substances produced in living cells
(d) None of these

19. Which is an essential constituent of diet **[AFMC 1980]**
(a) Starch (b) Glucose
(c) Carbohydrate (d) Protein

20. Proteins can be used
(a) As food (b) In textile
(c) As enzyme (d) All of these

21. Which of the following foodstuffs contains nitrogen **[DPMT 1986; MH CET 2002]**

(a) Carbohydrates (b) Fats

(c) Proteins (d) None of these

22. *pH* in stomach is approximately

(a) 7 (b) 2.0

(c) 6.5 (d) 10

23. The helical structure of proteins is established by **[CPMT 1988]**

(a) Peptide bonds (b) Dipeptide bond

(c) Hydrogen bond (d) Vander Waal's forces

24. Natural silk is a

(a) Polyester (b) Polyamide

(c) Polyacid (d) Polysaccharide

25. Protein contains **[CPMT 1975; MP PMT 2002]**

(a) C, H, O and N (b) Only C and H

(c) Cl, H and O (d) All of these

26. The end product of protein digestion is **[CPMT 1981; KCET 1984]**

(a) Amino acid (b) Glucose

(c) Glycerol (d) Oxalic acid

27. Protein can be most easily removed from **[MNR 1988]**

(a) Alkanes (b) Alkenes

(c) Alkynes (d) Benzene

28. Which of the following contains the highest percentage of protein **[CPMT 1984]**

(a) Groundnut (b) Cow's milk

(c) Egg (d) Wheat

29. The enzyme ptylin used for the digestion of food is present in **[CPMT 1981; Pb. PMT 2004]**

(a) Saliva (b) Blood

(c) Intestines (d) Adrenal glands

30. Which one of the following is an amino acid **[KCET 1984]**

(a) CH_3CONH_2 (b) $CH_3CONHCH_3$

(c) CH_3NHCHO (d) $NH_2CH_2.COOH$

31. Biuret test is used for the detection of **[KCET 1993]**

(a) Saturated oils (b) Sugars

(c) Proteins (d) Fats

32. Out of the following the best category of proteins is **[SCRA 1991]**

(a) Polyamides (b) Polythioethers

(c) Glycerides (d) Polysaccharides

33. The molecular weight of protein is **[KCET 1984]**

(a) < 10000 (b) > 10000

(c) > 1000 (d) > 1000 and < 10000

34. Which of the following is not a classification of proteins **[KCET 1984]**

(a) Enzymes (b) Antibodies

(c) Antigens (d) Hormones

35. The protein that is a structural material is **[KCET 1984]**

(a) Albumin (b) Oxytocin

(c) Haemoglobin (d) Keratin

36. For $\alpha-$amino acids having the structure

$$R-\underset{\displaystyle NH_2}{\underset{|}{CH}}-CO_2H$$

Which of the following statements are true

(A) Water solubility is maximum at a *pH* when concentrations of anions and cations are equal

(B) They give ninhydrin test

(C) On reacting with nitrous acid give off N_2 **[MP PET 1994]**

(a) All (b) B and C

(c) A and B (d) A

37. Which of the following reacts with haemoglobin in the blood to form carboxyhaemoglobin **[Manipal MEE 199**

(a) CO (b) CO_2

(c) $HCOOH$ (d) H_2CO_3

38. Secondary structure of a protein refers to **[CBSE PMT 1995]**

(a) Mainly denatured proteins and structures of prosthetic groups

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

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

(d) Regular folding patterns of continuous portions of the polypeptide chain

39. Of the following statements about enzymes which ones are true

(i) Enzymes lack in nucleophilic groups

(ii) Enzymes are highly specific both in binding chiral substrates and in catalyzing their reactions

(iii) Enzymes catalyse chemical reactions by lowering the activation energy

(iv) Pepsin is a proteolytic enzyme

(a) (i) and (iv) (b) (i) and (iii)

(c) (ii), (iii) and (iv) (d) (i)

40. Proteins are composed of **[MP PMT 1995; J & K 2005]**

(a) $\alpha-$amino acids (b) Carbohydrates

(c) Vitamins (d) Mineral salts

41. Read the following statements carefully

(A) Albumin is a simple protein

(B) The amino acid alanine contains an acidic side chain

(C) Insulin is a hormone

(D) Muscles contain the protein keratin

Point out the wrong statements in the above set of statements

(a) A, B (b) C, D

(c) A, C (d) B, D

42. Enzymes in the living systems **[CPMT 1999; AIIMS 2000; CBSE PMT 1997; MP PET 1999;]**

(a) Provide energy

(b) Provide immunity

(c) Transport oxygen

(d) Catalyse biological processes

43. Which of the following statements about proteins is not true **[MP PET 2001]**

(a) Amino acid residues join together to make a protein molecule

(b) Proteins are polymers with formula $(C_6H_{10}O_5)_n$

(c) Eggs are rich in protein

(d) Pulses are good source of proteins

44. Enzymes **[AIIMS 1996]**

(a) Accelerate biochemical reactions

(b) Have optimum activity at body temperature

(c) Consist of amino acids

(d) Have all these properties

45. The functional group which is found in amino acid is **[AFMC 1998; AIEEE 2002]**

(a) $-COOH$ group (b) $-NH_2$ group

(c) $-CH_3$ group (d) Both (a) and (b)

46. Amino acids are produced on hydrolysis of **[AIIMS 1996]**

(a) Nucleic acid (b) Carbohydrates

(c) Fats (d) Proteins

47. Enzymes belong to which class of compounds **[KCET 1996]**

(a) Polysaccharides

(b) Polypeptides

(c) Polynitrogen heterocyclic compounds

(d) Hydrocarbons

48. By the action of enzymes, the rate of biochemical reaction **[CBSE PMT 1994]**

(a) Decreases (b) Increases

(c) Does not change (d) Either (a) or (c)

49. Metal present in blood is **[CPMT 1997]**

(a) Al (b) Mg

(c) Cu (d) Fe

50. Which compound can exist in a dipolar (zwitter ion) state **[Pb. PMT 1998]**

(a) $C_6H_5CH_2CH(N=CH_2)COOH$

(b) $(CH_3)_2CH.CH(NH_2)COOH$

(c) $C_6H_5CONHCH_2COOH$

(d) $HOOC.CH_2CH_2COCOOH$

51. What is the monomer of polypeptide **[KCET 1998; JIPMER 1999; Pb. CET 2002]**

(a) Amino acid (b) Glucose

(c) Nucleoside (d) Nucleotide

52. Which of the following enzymes is not useful in the digestion of proteins **[KCET 1998]**

(a) Chymotrypsin (b) Pepsin

(c) Trypsin (d) Lipase

53. Haemoglobin is **[CBSE PMT 1997; BHU 2004]**

(a) An enzyme (b) A globular protein

(c) A vitamin (d) A carbohydrate

54. Albumin proteins are most abundant in **[BHU 1998]**

(a) Meat (b) Milk

(c) Egg (d) Soyabean

55. Dialysis can separate **[BHU 1998]**

(a) Glucose and fructose

(b) Glucose and sucrose

(c) Glucose and $NaCl$

(d) Glucose and proteins

56. Which one of the following is an example of a globular protein **[Orissa JEE 1997]**

(a) Keratin (b) Insulin

(c) Collagen (d) Myoglobin

57. Leucine amino acids is the **[Pb. PMT 1999]**

(a) Essential (b) Non-essential

(c) Aromatic (d) Basic

58. Which of the following tests is not used for testing proteins **[Kerala PMT 1999; KCET 1999]**

(a) Millon's test (b) Molisch's test

(c) Biuret test (d) Ninhydrin test

59. Amino acids usually exist in the form of Zwitter ions. This means that it consists of **[KCET 2000]**

(a) The basic group $-NH_2$ and the acidic group $-COOH$

(b) The basic group $-NH_3^+$ and the acidic group $-CO_2$

(c) The basic group $-CO_2^-$ and the acidic group NH_3^+

(d) No acidic or basic group

60. The most important energy carrier in all the living cells is **[MP PET 2000; KCET 2000]**

(a) AMP (b) ATP

(c) ADP (d) UDP

61. The 10% energy transfer law of food chain was given by **[BHU 2000]**

(a) Stanley (b) Weismann

(c) Lindemann (d) Tansley

62. Which of the following is a conjugated protein **[BHU 2000]**

(a) Glycoprotein (b) Phosphoprotein

(c) Chromoprotein (d) All of these

63. The number of essential amino acids in man is **[CBSE PMT 2000]**

(a) 8 (b) 10

(c) 18 (d) 20

64. Pick out wrong combination **[DCE 2000]**

(a) $Fe^{+2} \rightarrow$ Haemoglobin

(b) $Mg^{2+} \rightarrow$ Photosynthesis

(c) $Se^{2+} \rightarrow$ Kreb Cycle

(d) $CO^{+2} \rightarrow$ Vitamin B-12

65. The decomposition of complex organic compounds into simpler compound with the help of enzyme is known as **[Pb. PMT 2000]**

(a) Catabolism (b) Anabolism

(c) Fermentation (d) Metabolism

66. A biological catalyst is essentially **[Pb. PMT 2000; BHU 2004]**

(a) A carbohydrates (b) An amino acids

(c) A nitrogen molecule (d) Fats

67. The test used for identifying peptide linkage in proteins is **[KCET (Engg.) 2001]**

(a) Borsche's test (b) Molisch's test

(c) Ninhydrin test (d) Biuret test

68. Which of the following is not a function of proteins **[MP PMT 2001]**

(a) Nails formation

(b) Skin formation

(c) Muscle formation

(d) Providing energy for metabolism

69. The helical structure of proteins is stabilized by **[MP PMT 2001]**

(a) Peptide bonds (b) Dipeptide bond

(c) Hydrogen bond (d) Vander Waal's forces

70. The optically inactive amino acid is **[MP PMT 2001; BHU 2005]**

(a) Lysine (b) Glycine

(c) Arginine (d) Alanine

71. Which α amino acid can cross link peptide chains **[AIIMS 2001]**

(a) Serine (b) Cysteine

(c) Glutamine (d) Tyrosine

72. Amino acids are the building blocks of **[MH CET 2001]**

(a) Fat (b) Vitamin

(c) Protein (d) Carbohydrate

73. Which of the following protein destroys the antigen when it enters in body cell **[AIIMS 2001; Pb. PMT 20**

(a) Antibodies (b) Insulin

(c) Chromoprotein (d) Phosphoprotein

74. An antibiotic with a broad spectrum **[AFMC 2001]**

(a) Kills the antibodies

(b) Acts on a specific antigen

(c) Acts on different antigents

(d) Acts on both the antigens and antibodies

75. Antibodies are **[CBSE PMT 2001]**

(a) Carbohydrate (b) Globular protein

(c) Immunoglobulins (d) Cellulose compounds

76. Excess of Na^+ ions in our system causes **[BHU 2001]**

(a) High B.P. (b) Low B.P.

(c) Diabetes (d) Anaemia

77. The example of a protein is **[MP PET 2003]**

(a) Narvone (b) Lacithin

(c) Cellulose (d) Insulin

78. Enzymes are made up of **[CBSE PMT 2002]**

(a) Carbohydrates

(b) Edible proteins

(c) Nitrogen containing carbohydrates

(d) Proteins with specific structure

79. Chlorophyll contains **[RPMT 2002]**

(a) Fe (b) Na

(c) Mg (d) Zn

80. Which one of the following biomolecules is insoluble in water **[AIIMS 2005]**

(a) α- Keratin (b) Haemoglobin

(c) Ribonuclease (d) Adenine

81. A nanopeptide contains ..... peptide linkages **[KCET 2005]**

(a) 10 (b) 8

(c) 9 (d) 18

82. Identify the incorrect statement **[Kerala (Med.) 2003]**

(a) An octa deca peptide contains 18 amino acid residues and 17 peptide bonds

(b) Addition of an inert gas into a system in thermodynamic equilibrium for the dissociation of PCl_5 shifts the equilibrium to the left.

(c) When gold dissolves in aquaregia the complex formed is chloroauric acid

(d) In the extraction of aluminium purified bauxite is dissolved in molten fluorospar

(e) If the pH value of a solution is to be decreased from 5 to 3, the hydrogen ion concentration must be increased twice the initial value.

83. α-helix is found in **[Kerala (Engg.) 2002]**

(a) DNA (b) RNA

(c) Lipid (d) Protein

84. The main structural of protein is **[UPSEAT 2000, 02]**

(a) The ester linkage (b) The ether linkage

(c) The peptide linkage (d) All of these

85. Among the following, the achiral amino acid is **[AIIMS 2003]**

(a) 2-Ethylalanine

(b) 2-Methylglycine

(c) 2-Hydroxymethyl serine

(d) Tryptophan

86. Which of the following could act as a propellant or rockets **[CBSE PMT 2003]**

(a) Liquid hydrogen + liquid nitrogen

(b) Liquid oxygen + liquid argon

(c) Liquid hydrogen + liquid oxygen

(d) Liquid nitrogen +liquid oxygen

87. Which amino acid has aromatic ring **[CPMT 2003]**

(a) Alamine (b) Glycine

(c) Tyrosine (d) Lysine

88. The *pH* value of the solution in which a particular amino acid does not migrate under the influence of an electric field in called the **[Kerala (Med.) 2003]**

(a) Eutectic point (b) Yielding point

(c) Neutralisation point (d) Effusion

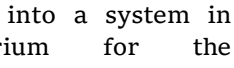
(e) Isoelectric point

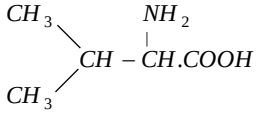
89. Which part of the protein molecule is responsible for function and activity of the proteins **[AMU 2002]**

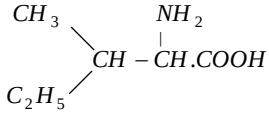
(a) Secondary structure (b) Peptide bond

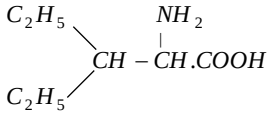
(c) Primary structure (d) Binding sites

90. The Structural formula of an amino acid, isoleucine is **[MP PMT 2003]**

(a) 

(b) 

(c) 

(d) 

91. The process by which synthesis of protein takes place based on the genetic information present in *m*-RNA is called **[KCET 2003; Kerala CET 2005]**

(a) Translation (b) Transcription

(c) Replication (d) Messenger hypothesis

92. Which of the following is used in our body as a fuel for muscles and nerves and to build and repair body tissues? **[DCE 2003]**

(a) Cane sugar (b) Fructose

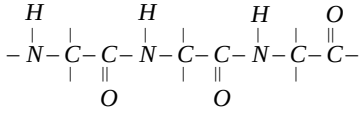
(c) Proteins (d) Glucose

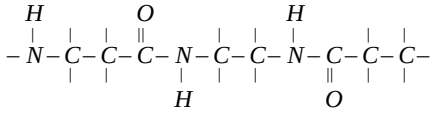
93. Which enzyme convert glucose into alcohol **[Pb. CET 2003]**

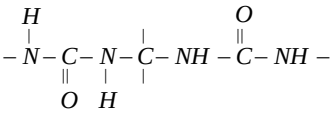
(a) Invertase (b) Zymase

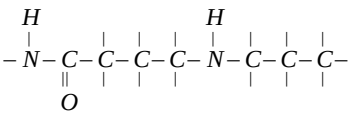
(c) Maltase (d) Diastase

94. Which one of the following structures represents the peptide chain **[CBSE PMT 2004; CPMT 2003; DCE 2002; MP PET 1994; Bihar MEE 1997; Orissa JEE 1997]**

(a) 

(b) 

(c) 

(d) 

95. The correct statement in respect of protein haemoglobin is that it **[CBSE PMT 2004]**

(a) Acts as an oxygen carrier in the blood

(b) Forms antibodies and offers resistance to diseases

(c) Functions as a catalyst for biological reactions

(d) Maintains blood sugar level

96. Identify the correct statement regarding enzymes **[AIEEE 2004]**

(a) Enzymes are specific biological catalysts that cannot be poisoned

(b) Enzymes are normally heterogeneous catalysts that are very specific in their action

(c) Enzymes are specific biological catalysts that can normally function at very high temperature ($T \sim 1000K$)

(d) Enzymes are specific biological catalysts that possess well-defined active sites

97. A biological catalyst is essentially

(a) An enzyme

(b) A carbohydrate

(c) An amino acid

(d) A nitrogen compound

98. Which synthesis was done by Stainley Millar **[CPMT 1979]**

(a) Amino acid (b) Protein

(c) Virus (d) Vitamin

99. The bond that determines the secondary structure of proteins is or secondary structure of protein is due to **[NCERT 1984; MP PET 1996; MP PMT 1997]**

(a) Coordinate bond

(b) Covalent bond

(c) Hydrogen bond

(d) Peptide bond

Fats and Lipids

1. Tripalmitin is

(a) A protein (b) An enzyme

(c) A lipid (d) A carbohydrate

2. On hydrolysis, all lipids yield

(a) Monocarboxylic acids (b)Monohydric alcohols

(c) Monohaloalkanes (d) Enzymes

3. Which of the following is not a lipid

(a) Oils (b) Fats

(c) Waxes (d) Proteins

4. The '*acid value*' of an oil or fat is measured in terms of weight of

(a) NH_4OH (b) $NaOH$

(c) KOH (d) CH_3COOH

5. The '*saponification value*' of an oil or fat is measured in terms of

(a) NH_4OH (b) $NaOH$

(c) KOH (d) C_6H_5OH

6. The '*iodine value*' of an oil indicates

(a) Its boiling point

(b) Inflammability

(c) Unsaturation present in acid contents

(d) Solubility of salt in oils

7. Hardening of oils is caused by

(a) H_2 (b) N_2

(c) O_2 (d) CO_2

8. Which of the following is obtained when an oil is hydrolysed with alkali

(a) Fat (b) Wax

[BHU 2004] (c) Soap (d) Vitamin

9. Which of the following indicates the number of free $-OH$ groups in an oil or fat

(a) Iodine value

(b) Acid value

(c) Acetyl value

(d) Saponification value

10. Which of the following is not glyceride

(a) Lipids (simple) (b) Phospholipids

(c) Sphingolipids (d) All

11. The most important food reserves of animals and plants are **[MP PET 1993]**

(a) Carbohydrates (b) Proteins

(c) Vitamins (d) Fats

12. Which of the following gives maximum energy in metabolic processes **[CPMT 1991; MP PET 1999]**

(a) Proteins (b) Carbohydrates

(c) Lipids (d) Vitamins

13. The energy change produced by the combustion of food is called the '*calorific value*'. The highest calorific value is given by **[NCERT 1984; AFMC 1988]**

(a) Proteins (b) Fats
(c) Carbohydrates (d) Vitamins

14. Cell membrane contains
(a) Alternate layers of phospholipid and coline
(b) Double layers of phospholipid
(c) Double layers of phospholipid with polar ends projected outside
(d) Double layers of phospholipid with polar ends projected inside

15. Which of the following compounds do not belong to lipids **[AFMC 1998]**
(a) Fats (b) Amino acids
(c) Phospholipids (d) Carbohydrates

16. Which is not a macromolecule **[BHU 1998]**
(a) *DNA* (b) Starch
(c) Palmitate (d) Insulin

17. A distinctive and characteristic functional group of fats is **[Kerala (Med.) 1999; AFMC 2005]**
(a) An ester group
(b) A peptide group
(c) A ketonic group
(d) An alcoholic group

18. The waxes are long chain compounds of fatty acids, which belong to the class of **[BHU 1999; AFMC 2005]**
(a) Esters (b) Ethers
(c) Alcohols (d) Acetic acid

19. Hydrolytic reaction of fats, with caustic soda, is known as **[Kerala (Med.) 2000; Pb. PMT 2004; MNR 1988]**
(a) Acetylation (b) Carboxylation
(c) Saponification (d) Esterification

20. Fat consists of **[MH CET 2002]**
(a) Monohydroxy carboxylic acid
(b) Monohydroxy aliphatic carboxylic acid
(c) Monohydroxy aliphatic, saturated carboxylic acid
(d) Dihydroxy aliphatic carboxylic acid

21. The alcohol obtained by the hydrolysis of oils and fats is **[KCET 2001]**
(a) Glycol (b) Glycerol
(c) Propanol (d) Pentanol

22. Iodine value is related to **[MP PET 2002]**
(a) Fats and oils (b) Alcohols
(c) Esters (d) Hydrocarbons

23. Phospholipids are esters of glycerol with **[CBSE PMT 2003]**
(a) Three phosphate groups
(b) Three carboxylic acid residues
(c) Two carboxylic acid residues and one phosphate group
(d) One carboxylic acid residue and two phosphate groups

24. Oils and fats are jointly called **[MP PET 2003]**
(a) Lipids (b) Soaps
(c) Proteins (d) Polymer

25. $\begin{matrix} CH_2OOCR' \\ | \\ CHOOCR'' \\ | \\ CH_2OOCR''' \end{matrix} \xrightarrow[\text{Hydrolysis}]{\text{Enzyme}} \begin{matrix} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{matrix} + \begin{matrix} R'COOH \\ + \\ R''COOH \\ + \\ R'''COOH \end{matrix}$

The enzyme used in the above reaction is **[AMU 2003]**
(a) Amylase (b) Lactase
(c) Lipase (d) Invertase

26. Oleic, stearic and palmitic acids are **[Pb. CET 2002]**
(a) Fatty acid (b) Amino acid
(c) Nucleic acid (d) Essential acid

27. An example for a saturated fatty acid, present in nature is **[KCET 2005]**
(a) Oleic acid (b) linoleic acid
(c) Linolenic acid (d) Palmitic acid

Vitamin, Harmone and Nucleic acid

1. A nucleotide consists of
(a) Base and sugar (b) Base and phosphate
(c) Sugar and phosphate (d) Base, sugar and phosphate

2. Which of the following is responsible for heredity character
(a) DNA (b) RNA
(c) Proteins (d) Hormones

3. The base adenine occurs in **[MP PMT 1995]**
(a) DNA only (b) RNA only
(c) DNA and RNA both (d) Protein

4. The protein which maintains blood sugar level in the human body **[KCET 1993; MP PMT 1995]**
(a) Haemoglobin (b) Oxytocin
(c) Insulin (d) Ptyalin

5. Which of the following statements about the assembly of nucleotides in a molecule of deoxyribose nucleic acid (DNA) is correct
(a) A pentose of one unit connects to a pentose of another
(b) A pentose of one unit connects to the base of another
(c) A phosphate of one unit connects to a pentose of another

(d) A phosphate of one unit connects to the base of another

6. Vitamin *A* is present in **[MP PET 1995, 2000]**
(a) Cod liver oil (b) Carrot
(c) Milk (d) In all of these

7. Ascorbic acid is a **[Bihar CEE 1995; MP PET 1995]**
(a) Vitamin (b) Enzyme
(c) Protein (d) Carbohydrate

8. The chemical name of vitamin *C* is **[J & K 2005]**
(a) Ascorbic acid (b) Folic acid
(c) Nicotinic acid (d) Tartaric acid

9. Which of the following is not a constituent of *RNA* **[MP PET 1996]**
(a) Ribose (b) Phosphate
(c) Adenine (d) Pyridine

10. Which one is found in ATP ribonucleotide
(a) Guanine (b) Uracil
(c) Adenine (d) None of these

11. Which of the following proteins acts as a messenger in living system
(a) Harmone (b) Enzyme
(c) Protective protein (d) Transport protein

12. Which substance is not present in nucleic acid **[MP PET/PMT 1998]**
(a) Cytosine (b) Adenine
(c) Thymine (d) Guanidine

13. The deficiency of vitamin B_1 causes **[CPMT 1994; MP PMT 1999; BHU 2000]**
(a) Beri-beri (b) Scurvy
(c) Rickets (d) Anaemia

14. Which of the following is not present in nucleic acids **[MP PMT 1999]**
(a) Uracil (b) 2-aminopyridine
(c) Thymine (d) Adenine

15. In nucleic acids, the sequence is **[AIIMS 1996]**
(a) Base-phosphate-sugar (b)Phosphate-base-sugar
(c) Sugar-base-phosphate (d)Base-sugar-phosphate

16. The segment of DNA which acts as the instructional manual for the synthesis of the protein is **[Pb. PMT 1998]**
(a) Nucleoside (b) Nucleotide
(c) Ribose (d) Gene

17. The double helical structure of DNA was proposed by **[KCET 1998]**
(a) Watson and Crick (b) Meicher
(c) Emil Fischer (d) Khorana

18. A segment of DNA molecule which codes or specifies for one polypeptide chain is called **[KCET 1998]**
(a) Phosphate group (b) Adenine
(c) Gene (d) Amino acid

19. In DNA, the complementary bases are **[CBSE PMT 1998]**
(a) Uracil and adenine; cytosine and guanine
(b) Adenine and thymine; guanine and cytosine
(c) Adenine and thymine; guanine and uracil
(d) Adenine and guanine; thymine and cytosine

20. The structure of DNA is **[AFMC 1999]**
(a) Linear (b) Single helix
(c) Double helix (d) Triple helix

21. Vitamin B_1 is **[MP PMT 2000]**
(a) Riboflavin (b) Cobalamin
(c) Thiamine (d) Pyridoxine

22. A gene is a segment of a molecule of **[AIIMS 1999]**
(a) DNA (b) *m*-RNA
(c) *t*-RNA (d) Protein

23. The deficiency of vitamin-*C* causes **[MP PMT 2000; CPMT 2000]**
(a) Scurvy (b) Rickets
(c) Pyrrohea (d) Pernicious Anaemia

24. DNA contains the sugar **[MP PMT 2000]**
(a) Deoxyribose (b) Ribose
(c) *D*-Fructose (d) *D*-glucose

25. Which of the following is not a sex hormone **[MP PMT 2000]**
(a) Testosterone (b) Estrone
(c) Estradiol (d) Cortisone

26. Acquired immune deficiency syndroms (AIDS) is characterised **[AIIMS 2000]**
(a) Killer T-cells
(b) Reduction in number of helper T-cells
(c) An autoimmune disease
(d) Inability of body to produce interferons

27. The base present in DNA, but not in RNA is **[KCET (Engg.) 2001; NCERT 1978; Manipal MEE 1985; MP PMT 1994, MP PET 1995; DCE 2004]**
(a) Guanine (b) Adenine
(c) Uracil (d) Thymine

28. Mutation of DNA occurs due to changes in the sequence of one of the following **[MP PMT 2001]**
(a) Bases (b) Ribose units
(c) Phosphate units (d) Sugar units

29. Which of the following is not true about vitamins **[AFMC 2001]**
(a) They are vital for life
(b) They help in digestion
(c) They were named by "Funic"
(d) Their deficiency causes diseases

30. Blood calcium level can be increased by the administration of **[AFMC 2001]**
(a) Glucogon (b) Calcitonin
(c) Thyroxine (d) Paratharmone

31. The first harmone chemically synthesised in the laboratory is **[BHU 2002]**
(a) Cortisone (b) Insuline
(c) Adrenaline (d) Estrone

32. Purine derivative among the following bases is **[KCET (Med./Engg.) 2002; MPPET 2004]**
(a) Guanine (b) Cytosine
(c) Thymine (d) Uracil

33. RNA is different from DNA because RNA contains **[AIEEE 2002, 04]**
(a) Ribose sugar and thymine
(b) Ribose sugar and uracil
(c) Deoxyribose sugar and thymine
(d) Deoxyribose sugar and uracil

34. Deficiency of which vitamin causes rickets **[MP PET 2002]**
(a) Vitamin-*D* (b) Vitamin-*B*
(c) Vitamin-*A* (d) Vitamin-*K*

35. Which do the following vitamins has isoprene units in its structure **[JIPMER 2002]**
(a) Vitamin *A* (b) Vitamin C
(c) Vitamin B_2 (d) Vitamin *D*

36. The reason for double helical structure of DNA is operation of **[CBSE PMT 2003; DPMT 2004]**
(a) Vander Waal's forces
(b) Dipole-dipole interaction
(c) Hydrogen bonding
(d) Electrostatic attractions

37. The tripeptide harmone present in most living cells is... **[KCET 2003]**
(a) Glutathione (b) Glutamine
(c) Oxytocin (d) Ptyalin

38. The function of DNA in an organism is **[DCE 2003]**
(a) To assist in the synthesis of RNA molecule
(b) To store information of heredity characteristics
(c) To assist in the synthesis of proteins and polypeptides
(d) All of these

39. The harmone that helps in the conversion of glucose to glycogen in **[CBSE PMT 2004]**
(a) Adrenaline (b) Insulin
(c) Cortisone (d) Bile acids

40. Insulin production and its action in human body are responsible for the level of diabetes. This compound belongs to which of the following categories **[AIEEE 2004]**
(a) An enzyme (b) A harmone
(c) A co-enzyme (d) An antibiotic

41. Codon is present in **[Pb. PMT 2004]**
(a) *t*-RNA (b) *m*-RNA
(c) *r*-RNA (c) All of these

42. Energy is stored in our body in the form of **[CBSE PMT 2001; KCET 2003]**
(a) ATP (b) ADP
(c) Fats (d) Carbohydrates

43. Nucleic acid is a polymer of
(a) Nucleosides (b) α – amino acids
(c) Nucleotides (d) Glucose

44. A nucleoside on hydrolysis gives
(a) A heterocyclic base and orthophosphoric acid
(b) An aldopentose, a heterocyclic base and orthophosphoric acid
(c) An aldopentose and a heterocyclic base
(d) An aldopentose and orthophosphoric acid

45. An alternation in the base sequence of nucleic acid molecule is called **[Kerala PMT 2004]**
(a) Replication (b) Mutation
(c) Duplication (d) Dislocation
(e) Flocculation

46. Vitamin B_6 is known as **[DCE 2004]**
(a) Pyridoxin (b) Thiamine
(c) Tocopherol (d) Riboflavin

Critical Thinking

Objective Questions

1. Number of chiral carbons in $\beta - D - (+)$-glucose is **[CBSE PMT 2004; MHCET 2004]**
(a) Three (b) Four
(c) Five (d) Six

2. The nucleic acid base having two possible binding sites is **[AIIMS 2004]**
(a) Thymine (b) Cytosine
(c) Guanine (d) Adenine

3. Subunits present in haemoglobin are **[AIIMS 2003]**
(a) 2 (b) 3
(c) 4 (d) 5

4. A sequence of how many nucleotides in messenger RNA makes a codon for an amino acid
(a) One (b) Two
(c) Three (d) Four

5. Chargaff's rule states that in an organism **[CBSE PMT 2003]**
(a) Amounts of all bases are equal

(b) Amount of adenine (A) is equal to that of thymine (T) and the amount of guanine (G) is equal to that of cytosine (C)

(c) Amount of adenine (A) is equal to that of guanine (G) and the amount of thymine (T) is equal to that of cytosine (C)

(d) Amount of adenine (A) is equal to that of cytosine (C) and the amount of thymine (T) is equal to guanine (G)

6. DNA multiplication is called **[Kerala (Med.) 2000]**

(a) Translation (b) Transduction

(c) Transcription (d) Replication

7. Insulin is a protein which plays the role of **[KCET 1986]**

(a) An antibody (b) A harmone

(c) An enzyme (d) A transport agent

8. Proteins fulfil several functions in living systems. An example of a protein which acts as a hormone is **[KCET 1985]**

(a) Casein (b) Oxytocin

(c) Trypsin (d) Keratin

9. Pick out the unsaturated fatty acid from the following **[KCET 2004; MHCET 2002]**

(a) Stearic acid (b) Lauric acid

(c) Oleic acid (d) Palmitic acid

10. Vitamin B_{12} contains metal **[Bihar MEE 1997; RPET 1999; Pb. PMT 1999; AFMC 2002; CBSE PMT 2003; CPMT 2003; MP PMT 2003]**

(a) *Ca* (II) (b) *Zn* (II)

(c) *Fe* (II) (d) *Co* (III)

11. The number of molecules of ATP produced in the lipid metabolism of a molecule of palmitic acid is **[CBSE PMT 1998]**

(a) 130 (b) 36

(c) 56 (d) 86

12. Protein can be most easily removed from **[UPSEAT 2000, 02]**

(a) Alkanes (b) Alkenes

(c) Alkynes (d) Benzene

13. The enzyme which hydrolyses triglycerides to fatty acids and glycerol is called

(a) Zymase (b) Pepsin

(c) Maltase (d) Lipase

14. The helical structure of protein is stabilized by **[CBSE PMT 2004]**

(a) Ether bonds (b) Peptide bonds

(c) Dipeptide bonds (d) Hydrogen bonds

15. The cell membranes are mainly composed of **[CBSE PMT 2005]**

(a) Carbohydrates (b) Proteins

(c) Phospholipids (d) Fats

16. A compound of mol. wt. 180 is acetylated to give a compound of mol. wt. 390. The number of amino groups in the initial compound is

(a) 2 (b) 4

(c) 5 (d) 6

17. Starting with three different amino acid molecules, how many different tripeptide molecules are formed **[Kerala PMT 1999; KCET 1999]**

(a) 12 (b) 9

(c) 8 (d) 6

18. Which one of the following is a polysaccharide **[NDA 1999]**

(a) Nylon (b) Amylose

(c) Ribose (d) Polyethylene

19. Which of the following is not an acidic amino acid

(a) Lysine (b) Arginine

(c) Aspartic acid (d) Histidine

20. Proteins do not respond to

(a) Biuret test (b) Heller's ring test

(c) Ninhydrin test (d) Lucas test

21. Alkyl benzene sulphonates can be conductivity used as detergents in hard water, unlike soaps, as **[AMU 2002]**

(a) They are highly soluble in water

(b) Their Ca^{++}/Mg^{++} salts are water soluble

(c) They are non-ionic

(d) Their Ca^{++}/Mg^{++} salts are insoluble in water

22. When glucose reacts with bromine water, the main product is **[Pb. CET 2003; BHU 2004]**

(a) Acetic acid (b) Saccharic acid

(c) Glyceraldyhyde (d) Gluconic acid

23. A zwitter ion is **[KCET 1989]**

(a) A positively charged ion without a metal atom in it

(b) A negatively charged ion without metal atom in it

(c) An ion with positive and negative charges at different points on it

(d) A heavy ion with a small charge on it

24. Ribose is an example of **[KCET 1998]**

(a) Ketohexose (b) Aldopentose

(c) Disaccharide (d) Aldohexose

25. The two forms of *D*-glucopyranose obtained from the solution of *D*-glucose are called

(a) Isomer (b) Anomer

(c) Epimer (d) Enantiomer

26. Sucrose molecule is made up of **[KCET 2005]**

(a) A gluco pyranose and a fructo pyranose
(b) A gluco pyranose and a fructo furanose
(c) A gluco furanose and a fructo pyranose
(d) A gluco furanose and a fructo furanose

AR Assertion & Reason

For AIIMS Aspirants

Read the assertion and reason carefully to mark the correct option out of the options given below :

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.
(c) If assertion is true but reason is false.
(d) If the assertion and reason both are false.
(e) If assertion is false but reason is true.

1. Assertion : Glycine is amphoteric in nature.
Reason : Glycine contains both acid and basic groups. **[AIIMS 1996]**

2. Assertion : Hydrolysis of sucrose is known as inversion of cane sugar.
Reason : Sucrose is a disaccharide. **[AIIMS 1997]**

3. Assertion : Proteins on hydrolysis produce amino acids.
Reason : Amino acids contain $-NH_2$ and $-COOH$ groups. **[AIIMS 1998]**

4. Assertion : Sucrose undergo mutarotation.
Reason : Sucrose is a disaccharide. **[AIIMS 2000]**

5. Assertion : DNA molecules and RNA molecules are found in the nucleus of a cell.
Reason : On heating the enzyme do not lose their specific activity. **[AIIMS 2002]**

6. Assertion : All Amino acids exist as Zwitter ions.
Reason : Amino acids have both $-NH_2$ and $-COOH$ group. **[AIIMS 2002]**

7. Assertion : Activity of an enzyme is *pH*-dependent.
Reason : Change in *pH* affects the solubility of the enzyme in water. **[AIIMS 2003]**

8. Assertion : Glycosides are hydrolyzed in acidic conditions.
Reason : Glycosides are acetals. **[AIIMS 2003]**

9. Assertion : Haemoglobin is an oxygen carrier.
Reason : Oxygen binds as O_2^- to *Fe* of haemoglobin. **[AIIMS 2003]**

10. Assertion : Carboxypeptidase is an exopeptidase.
Reason : It cleaves the *N*-terminal bond. **[AIIMS 2004]**

11. Assertion : Sucrose is a non-reducing sugar.
Reason : It has glycosidic linkage. **[AIIMS 2004]**

12. Assertion : Sucrose is a disaccharide.
Reason : Sucrose is dextro rotatory.

13. Assertion : Fructose reduces Fehling's solution and Tollen's reagent.
Reason : Fructose does not contain any aldehyde group.

14. Assertion : The specific rotation of a freshly prepared solution of α – glucose decreases from + 112° to 52.7° while that of β glucose increase from + 19° to 52.7°.
Reason : The change in specific rotation of an optically active compound with time to an equilibrium value is called mutarotation.

15. Assertion : α – amino acids exist as dipolar ions or zwitter ions.
Reason : α – amino acids are the building blocks of proteins.

16. Assertion : Valine is an essential amino acid.
Reason : The lack of essential amino acids in the diet causes Kwashiorkor.

17. Assertion : Sequence of bases in DNA is TGAACCCTT and sequence of bases in *m*-RNA is CATTAAACC.
Reason : In DNA nitrogenous bases have hydrogen bonds.

18. Assertion : Millon's test is a test to identify carbohydrates.
Reason : Millon's reagent is solution of mercurous nitrate and mercuric nitrate in nitric acid containing little nitrous acid.

19. Assertion : ATP molecules are energy rich molecules.
Reason : ATP consists of a purine base adenine, pentose sugar ribose and a string of three phosphate groups.

20. Assertion : Solubilities of protein is minimum at the isoelectric point.
Reason : At isoelectric point, protein molecule behaves as a zwitter ion.

21. Assertion : Amino acids are soluble in benzene and ether.
Reason : Amino acids exist as zwitter ions.

22. Assertion : A solution of sucrose in water is dextrorotatory but on hydrolysis in presence of little hydrochloric acid, It becomes laevorotatory.
Reason : Sucrose on hydrolysis gives unequal amounts of glucose and fructose as.

23. Assertion : Treatment of *D*-glucose with alkali affords an equilibrium mixture consisting of *D*-mannose, *D*-fructose and starting substance *D*-glucose.

Reason : The reaction involves an intermediate in which hybridization of C_2 changes from sp^3 to sp^2.

Answers

Carbohydrates

1	d	2	b	3	d	4	d	5	c
6	c	7	c	8	d	9	b	10	d
11	c	12	d	13	c	14	c	15	c
16	a	17	a	18	b	19	b	20	d
21	a	22	a	23	b	24	d	25	a
26	d	27	d	28	a	29	c	30	b
31	c	32	a	33	d	34	d	35	c
36	cd	37	d	38	a	39	c	40	c
41	b	42	c	43	c	44	a	45	b
46	a	47	b	48	d	49	a	50	c
51	a	52	c	53	c	54	a	55	c
56	b	57	d	58	c	59	a	60	c
61	b	62	d	63	a	64	d	65	d
66	d	67	d	68	c	69	b	70	c
71	e	72	b	73	b	74	a	75	b
76	c	77	c	78	a	79	b	80	d
81	a	82	c	83	c	84	b	85	a
86	c	87	b	88	c	89	a	90	a
91	a	92	c	93	a	94	c	95	c
96	a	97	a	98	d	99	b	100	b
101	c	102	a	103	a	104	a	105	b
106	c	107	d	108	c	109	c	110	a
111	c	112	c	113	b	114	a	115	b
116	c	117	c	118	b	119	d	120	d
121	c	122	c	123	c	124	a	125	a
126	b	127	b	128	b	129	a	130	d
131	b	132	b	133	a				

Proteins, Amino Acids and Enzymes

1	b	2	c	3	a	4	a	5	c
6	b	7	c	8	d	9	c	10	c
11	c	12	b	13	a	14	b	15	c
16	a	17	d	18	c	19	d	20	d
21	c	22	b	23	c	24	b	25	a
26	a	27	d	28	a	29	a	30	d
31	c	32	a	33	b	34	c	35	d
36	b	37	a	38	d	39	c	40	a
41	d	42	d	43	b	44	d	45	d
46	d	47	b	48	b	49	d	50	b
51	a	52	d	53	b	54	c	55	d
56	d	57	a	58	b	59	c	60	b
61	c	62	d	63	b	64	c	65	c
66	b	67	d	68	d	69	c	70	b
71	b	72	c	73	a	74	c	75	c
76	a	77	d	78	d	79	c	80	a
81	b	82	e	83	d	84	c	85	c
86	c	87	c	88	e	89	b	90	c
91	a	92	c	93	b	94	a	95	a
96	d	97	a	98	a	99	c		

Fats and Lipids

1	c	2	a	3	d	4	c	5	c
6	c	7	a	8	c	9	b	10	c
11	d	12	c	13	d	14	c	15	bd
16	c	17	a	18	a	19	c	20	c
21	b	22	a	23	d	24	a	25	c
26	a	27	d						

Vitamins, Hormone and Nucleic Acid

1	d	2	a	3	c	4	c	5	c
6	d	7	a	8	a	9	d	10	c
11	a	12	d	13	a	14	b	15	d
16	b	17	a	18	c	19	b	20	c
21	c	22	a	23	a	24	a	25	d
26	b	27	d	28	a	29	b	30	d
31	b	32	a	33	b	34	a	35	a
36	c	37	a	38	d	39	b	40	b
41	b	42	a	43	c	44	c	45	b
46	a								

Critical Thinking Questions

1	b	2	c	3	c	4	c	5	b
6	d	7	b	8	b	9	c	10	d
11	a	12	d	13	d	14	d	15	b
16	a	17	d	18	b	19	c	20	d
21	d	22	d	23	c	24	b	25	b
26	b								

Assertion and Reason

1	a	2	b	3	b	4	e	5	d
6	a	7	b	8	d	9	c	10	c
11	a	12	b	13	b	14	b	15	b
16	b	17	e	18	e	19	b	20	e
21	e	22	c	23	a				

AS Answers and Solutions

Carbohydrates

1. (d) $\alpha - D - \text{Glucose} \underset{[\alpha]=+112^o}{\underset{(36\%)}{}} \rightleftharpoons \underset{[\alpha]_D=+52^o}{\underset{(0.02\%)}{\text{Equilibrium mixture}}} \rightleftharpoons \beta - D - \text{Glucose} \underset{[\alpha]_D=+19^o}{\underset{(64\%)}{}}$

Glucose has two forms α and β. When either of these two is dissolved in water and allowed to stand, it gets converted to an equilibrium mixture of α and β forms.

2. (b) Gun-cotton is a nitrocellulose or cellulose trinitrate which is used in explosive and as a binder for solid rocket propellant.

3. (d) Arabinose is an aldopentose $HOCH_2-(CHOH)_3-CHO$

4. (d) In proteins amide group is present

$$(-NH-\underset{\underset{R}{|}}{CH}-\underbrace{\overset{\overset{O}{\|}}{C}-NH}_{\text{Amino or peptide bond}}-\underset{\underset{R}{|}}{CH}-\overset{\overset{O}{\|}}{C}-)_n$$

5. (c) Inulin is a carbohydrate which is stored in "Roots of Dahliya".

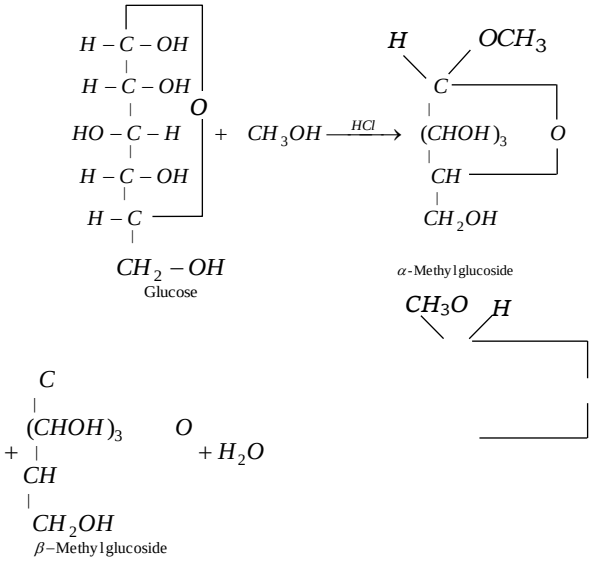
6. (c) Carbohydrates are hydrates of carbon. Their general formula is $C_x(H_2O)_y$.

8. (d) Glucose + Tollen's reagent $\rightarrow$ Gluconic acid + *Ag*-mirror.

9. (b) Protein gives blue-violet colour with ninhydrin

(2, 2-dihydroxyindane-1, 3-diene)
Carbohydrates gives brown red ppt. with benedict's solution (Alk. $CuSO_4$ + Citrate ions)

11. (c) A ring structure



39. (c) Glucose + Benedict's solution → Red colour (Cu_2O).

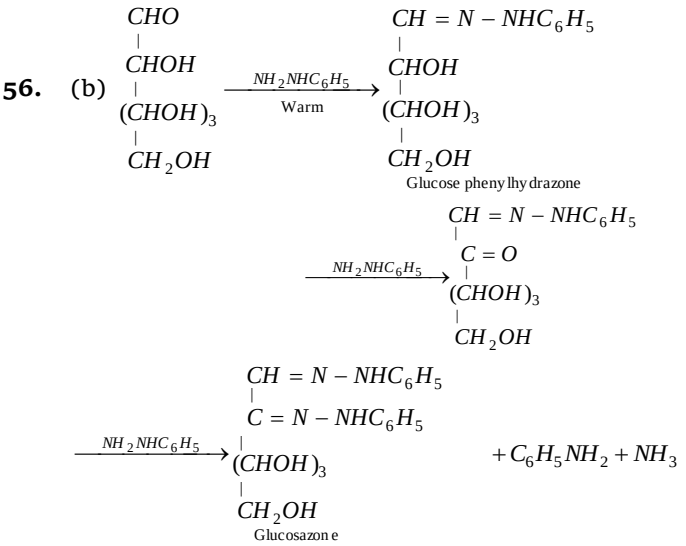
40. (c) Sucrose $\xrightarrow{\text{conc.}HNO_3}$ Oxalic acid.

41. (b) Amylopectin is not soluble in water.

43. (c) $\underset{\text{Maltose}}{C_{12}H_{22}O_{11}}$

47. (b) Sucrose is not a reducing sugar.

56. (b)



57. (d) Starch $\xrightarrow{\text{Diastase}}$ Maltose.

58. (c) $\underset{\text{Cane sugar}}{C_{12}H_{22}O_{11}} + H_2O \rightarrow \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$

61. (b) Monosaccharide cannot be hydrolysed to simple forms.

64. (d) Starch + I_2 → Blue colour.

66. (d) Glucose and sucrose are dextrorotatory Fructose is leavorotatory

68. (c) $\underset{(C \text{ and } H)}{\text{Food shift}} + O_2 \rightarrow CO_2 + H_2O$

70. (c) In neutral solvent, glucose shows mutarotation.

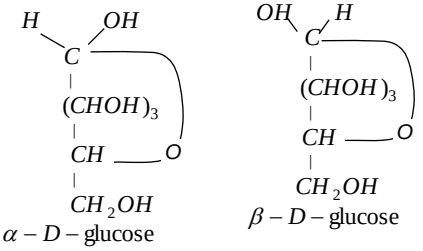
73. (b) Maltose $\xrightarrow[\text{Maltase}]{\text{Hydrolysis}}$ glucose + glucose.

79. (b) 3 carbons e.g. Glyceraldehyde $\begin{matrix} CH_2-CH-CHO \\ | \quad\quad | \\ OH \quad OH \end{matrix}$

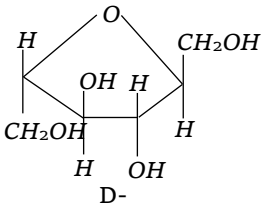
83. (c) Starch $\xrightarrow{\text{Diastage}}$ Maltose $\xrightarrow{\text{Maltase}}$ glucose.

85. (a) All are optically active.

86. (c)



90. (a)



5 atoms in the ring

93. (a) In sucrose the two monosaccharide units joined by α-1, 2 glycoside bond. Since sucrose does not have hemiacetal carbon. Therefore it is non- reducing sugar.

94. (c) Starch $\xrightarrow{\text{Amylase}}$ Maltose.

96. (a) Glucose is the simplest carbohydrate i.e. mono saccharide rest are polysaccharide.

97. (a) We can't digest cellulose which is a polysaccharide.

98. (d) Diastase enzyme converts starch into maltose.

99. (b) Lactose is present in milk (Glucose + Galactose).

100. (b) Carbohydrates are rich source of energy.

102. (a) Sucrose is a non reducing sugar it does not give any test with Benedict's solution.

103. (a) That is called glycosidic linkage.

108. (c) Invert sugar is laevo rotatory.

111. (c) Starch is polymer of alpha glucose.

114. (a) Raffinose ($C_{18}H_{32}O_{16}$) is a trisaccharide

$$C_{18}H_{32}O_{16} + H_2O \rightarrow \underset{\text{D glucose}}{C_6H_{12}O_6} + \underset{\text{D fructose}}{C_6H_{12}O_6} + \underset{\text{D mannose}}{C_6H_{12}O_6}$$

118. (b) Glucose + Fehling solution → Gluconic acid + $\underset{\text{(Red ppt)}}{Cu_2O}$

123. (c) Charring of sugar, when it is treated with sulphuric acid (H_2SO_4) is due to dehydration.

In this reaction water is removed from the sugar.

124. (a) Glucose is a monosaccharide while others are polysaccharide. So glucose is the simplest sugar.

125. (a) Glucose and mannose are epimers because they both differ in configuration at *C*–2 and the Isomer which differ at C_2 position known as epimers of each other.

126. (b) $\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{Hydrolysis}]{} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Glucose}}{C_6H_{12}O_6}$

127. (b) Pepsin, ptyalin and lipase are enzyme while cellulose is not the enzyme.

128. (b)

Sugar	Relative sweetness
Sucrose	100
Glucose	74
Lactose	16
Fructose	173

129. (a) $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 38\,\text{ATP}$

131. (b) Fructose has three chiral centres and hence 23 = 8 optical isomers are possible.

132. (b) Freezing point is the temperature at which the liquid and the solid form of the same substance are in equilibrium and hence have the same vapour pressure. Due to lower vapour pressure of the solution, solid form of a solution separates out at a lower temperature. The decrease is called depression in freezing point.

When solid is the solute, it is solvent that freezes. Hence in the given question water will be separated out first.

133. (a) Glucose is a monosaccharide having chemical composition $C_6H_{12}O_6$.

Proteins, Amino Acids and Enzymes

1. (b) Insulin is a protein consists of 51 amino acids in two chains. α and β

α - 21 amino acids, β - 30 amino acids

It is secreted by pancreas for controlling the sugar level in blood.

3. (a) Fibrous proteins are insoluble in water.

4. (a) $\text{Protein} \xrightarrow[\text{or change in pH}]{\text{Heated}} \text{Denatured protein}$

5. (c) $\underset{\text{(Prosthetic group or co-factor)}}{\text{Simple protein} + \text{non - protein material}} \rightarrow$ Conjugated protein

6. (b) Heam $\rightarrow Fe^{+2}$ to which the porphyrine ring is attached to central atom by co-ordinate linkage.

7. (c) It is insoluble in water and used in food products capsules and photographic plates.

9. (c) Amino acids are non volatile crystalline compound.

10. (c) Isoelectric point is a pH at which zwitter ions do not migrate towards any of the electrode.

11. (c) $\text{Protein} \xrightarrow{\text{Enzyme}} \underset{\text{(Acidic medium in stomach)}}{\text{Amino acid}}$

12. (b) Protein + conc. $HNO_3 \rightarrow$ Yellow colour

[This test is given by a protein which consists of α-amino acids containing a benzene ring such as tyrosine, phenylalanine etc. The yellow colour is due to nitration of benzene ring.]

14. (b) Proteins are polymers of amino acids.

Amino acid → Dipeptide → Polypeptide → Protein.

21. (c) Proteins are nitrogenous compounds.

22. (b) In stomach medium is strongly acidic. Hence, $pH = 2$.

30. (d) Glycine $\rightarrow NH_2 - CH_2 - COOH$.

34. (c) Antigens are polysaccharides present on RBC's surface.

37. (a) $Hb + CO \rightarrow HbCO$

carboxy haemoglobin it is 20 times more stable then oxyhaemoglobin.

40. (a) Peptides are formed by condensation of α-amino acids.

$$H_2N - CH_2COOH + H_2N - CH_2 - COOH$$

$$\xrightarrow{-H_2O} \underset{\text{peptide bond}}{H_2N - CH_2 - CONH - CH_2COOH}$$

$$\xrightarrow{H_2N-CH_2COOH}$$ and so on.

41. (d) Muscles contain myoglobin $CH_3 - \underset{COOH}{\overset{NH_2}{\overset{|}{\underset{|}{CH}}}}$

alanine contain side chain of methyl group.

43. (b) It is the general formula for polysaccharides.

50. (b) $(CH_3)_2.\underset{NH_2}{\underset{|}{CH}}.CH - COOH \rightleftharpoons (CH_3)_2 - CH.\underset{NH_3^+}{\underset{|}{CH}} - COO^-$

52. (d) Lipase is used in lipid metabolism.

$$\text{Lipid} \xrightarrow{\text{Lipase}} \text{Fatty acid} + \text{Glycerol}$$

53. (b) Haemoglobin is a globular protein.

59. (c) Zwitter ion is a dipolar ion containing both a positive and negative charge in the following form $R-\underset{\text{Zwitter ion}}{\overset{NH_3^+}{\overset{|}{CH}}}-COO^-$

The basic group CO_2^- and acidic group NH_3^+.

63. (b) The amino acids which can't be synthesised by human body so they are essential to take from diet. They are 10 in number.

66. (b) Biological catalysts are enzymes and all enzymes are nucleic acid.

68. (d) Protein is a body building substance not energy giving substance.

76. (a) Na^+ and K^+ controls blood pressure and heart beat so excess of Na^+ ion increases B.P.

80. (a) This protein is found in hair, nail, muscle etc.

81. (b) The peptide bond is formed between two amino acids by the elimination of a water molecule. A dipeptide contains one peptide linkage. A tripeptide contains two peptide linkages. Similarly, a nanopeptide contains 8 peptide linkages.

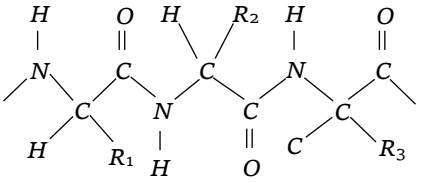
91. (a) Synthesis of polypeptide known as translation. For this process three type of RNA essential.

92. (c) Protein is used in our body as a fuel for muscles and nerves and to build and repair body tissues.

93. (b) Zymase enzyme convert glucose into alcohol. It is found in the yeast.

$$\underset{\text{glucose}}{C_6H_{12}O_6} \xrightarrow{\text{zymase}} 2\underset{\text{ethyl alcohol}}{C_2H_5OH} + 2CO_2$$

94. (a) In peptide linkage *i.e.*, $-CONH-$ group, the carboxyl group of one amino acid molecules forms an amide by combination with the amino group of the next amino acid molecule with the liberation of water molecule.



95. (a) Four Fe^{2+} ions of each haemoglobin can bind with 4 molecules of O_2 and it is carried as oxyhaemoglobin.

$Hb_4 + 4O_2 \rightarrow Hb_4O_8$

96. (d) Enzyme are shape selective specific biological catalyst which normally functions effectively at body temperature.

97. (a) An enzyme (protein) is a biological catalyst.

98. (a) Amino acid synthesis was done by stainley millar.

Fats and Lipids

4. (c) Acid value is the number of 1 mg of *KOH* required to neutralise 1 *gm* of the fat or oil.

5. (c) Saponification value is the number of mg of *KOH* required to neutralize the fatty acid resulting from the complete hydrolysis of 1gm. of oil or fat.

6. (c) Iodine number is the number of *gms* of I_2 which combine with 100 *gm* of oil or fat. It shows the degree of unsaturation of acids in fat or oil.

7. (a) $\text{Oil(unsaturated)} + H_2 \xrightarrow{Ni} \text{Fat (saturated)}$

8. (c) $\text{Oil} + NaOH\ \text{(alkali)} \xrightarrow{\text{Saponification}} \text{Glycerol} + \text{Soap}$

11. (d) Fats are called energy bank of the body. Stored below the dermis as subcutaneous fats.

12. (c)

13. (b) 1*gm* carbohydrate on oxidation gives 17 *kJ* of energy while 1 gm fat provide 37 *kJ* of energy.

18. (a) Waxes are esters of higher fatty acids.

19. (c) Oil/fat + Alkali $\xrightarrow{\text{Saponification}}$ Soap + Glycerol.

21. (b) $\underset{\substack{\text{Lipid or}\\ \text{Triglyceride}}}{\begin{matrix}CH_2OOCR\\ |\\ CHOOCR\\ |\\ CH_2OOCR\end{matrix}} + H_2O \rightarrow \underset{\substack{\text{Glycerolor}\\ \text{Trihydric alcohol}}}{\begin{matrix}CH_2OH\\ |\\ CHOH\\ |\\ CH_2OH\end{matrix}} + \underset{\text{Monocarboxylic acid}}{3R-COOH}$

26. (a) Oleic acid, stearic acid and palmitic acids are produced by the hydrolysis of fats and the acid produced by hydrolysis of fats are called fatty acid.

27. (d) Oleic acid - $C_{17}H_{33}COOH$, linoleic acid- $C_{17}H_{31}COOH$, linolenic acid - $C_{17}H_{29}COOH$, palmitic acid - $C_{15}H_{31}COOH$.

Saturated monocarboxylic acids form a homologous series which has a general formula $C_nH_{2n+1}COOH$ or $C_nH_{2n}O_2$. Only palmitic acid follows this.

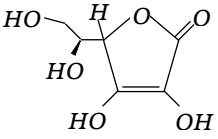
Vitamin, Hormone and Nucleic acid

1. (d) $\underbrace{\text{Nitrogenbase} + \text{Sugar}}_{\text{Nucleoside}} + \text{Phosphate}$

3. (c) Adenine is a purine base common in both RNA and DNA.

4. (c) Insulin hormone is secreted by pancreas.

8. (a)



Ascorbic acid

19. (b) $\underset{\text{2 hydrogen bonds}}{\text{Adenine}} = \text{Thymine}, \underset{\text{3 hydrogen bonds}}{\text{Guanine}} \equiv \text{Cytosine}$

21. (c) Vitamin B_1 is thiamine. Its main source is cereals.

22. (a) Gene is a part of the DNA molecule that codes for a specific protein.

25. (d) Cortisone is not a sex harmone, it regulates metabolism of fats, carbohydrates, proteins etc.

27. (d) Thymine is present in DNA while in RNA there is Uracil.

28. (a) Mutation is a chemical change in the sequence of Nitrogenous bases along the DNA strained which can lead to the synthesis of protein with altered amino acid sequence.

39. (b) Insulin is a hormones secreted by the pancreas that lower blood glucose level by promoting the uptake of glucose by cells and the conversion of glucose to glycogen by the liver and skeletal muscle.

40. (b) Insulin is a proteinaceous harmone secreted by β cells by islet of langerhans of pancreas in our body.

41. (b) Codon is present in *m*-RNA, which is responsible for translation.

42. (a) Energy is stored in our body in the form of A.T.P

43. (c) Nucleic acid is a polymer of nucleotides.

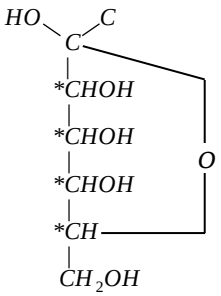
44. (c) Nucleoside on hydrolysis gives an aldopentose and a heterocyclic base purine and pyrimidine.

45. (b) An alternation in the base sequence of nucleic acid molecule is called mutation which can be by radioactive ray, by adaptation etc.

46. (a) Vitamin B_6 is called pyridoxin. It is found in fruits, green-vegetables, milk, etc. Due to its deficiency, anaemia disease is caused.

Critical Thinking Questions

1. (b)



This structure of β-D glucose has four asymmetric carbon atom

2. (c) It is Guanine having two possible binding site.

3. (c) Four sub units are present in haemoglobin.

4. (c) The four bases in *m*-RNA : adenine, cytosine, guanine and Uracil have been shown to act in the form of triplet; each triplet behaving as a code for the synthesis of a particular amino acid.

5. (b) According to Chargaff's rule amount of adenine(*A*) is equal to that of thymin(*T*) and the amount of guanine(*G*) is equal to that of cytosine(*C*).

6. (d) Multiplication of DNA is called replication.

7. (b) Insulin is a harmone which decreases sugar level in the blood.

8. (b) Oxytocin hormone secreted by posterior pituitary gland plays an important role in child birth and milk ejection for feeding baby.

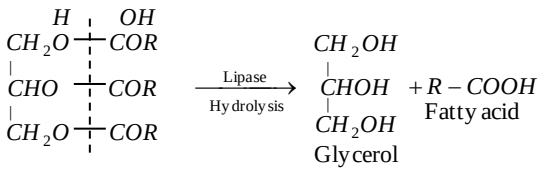
9. (c) Except oleic acid stearic acid, Lauric acid and Palmitic acid are saturated fatty acid. Oleic acid is unsaturated fatty acid.

10. (d) CO (III) Transition metal is present in vitamin B_{12} .

11. (a) 130 molecules of ATP produced in the lipid metabolism of a molecule of palmitic acid.

12. (d) Protein is insoluble in benzene.

13. (d)



14. (d) α–helix structure is formed when the chain of α–amino acid coil as a right handed screw because of the formation of hydrogen bonds between amide groups of the same peptide chain *i.e., NH* group in one unit is linked to carbonyl oxygen of the third unit by hydrogen bonding. This *H*–bonding is responsible for holding helix in a position.

15. (b) Three types of chemicals enter the composition of all membranes proteins, lipids and carbohydrates, proteins content varies from 46–76% lipids 20–53%, while Carbohydrate content is 1–8%

16. (c) Difference in mass of compound

= 390 – 180 = 210

wt. of CH_3CO – group is = 43

Therefore no. of $-NH_2$ group = $\frac{210}{43} = 4.88 = 5$.

17. (d) Six type of tripeptide molecules are formed.

18. (b) Amylose is a polysaccharide.

19. (c) Aspartic acid is an amino acid with acidic side chain.

$$HOOC - CH_2 - CH \begin{matrix} NH_2 \\ COOH \end{matrix}$$

Lysine, Arginine and Histidine all are basic amino acids.

20. (d) Lucas test is used for the distinction of alcohols.

21. (d) Because their Ca^{++}/Mg^{++} salts are insoluble in water.

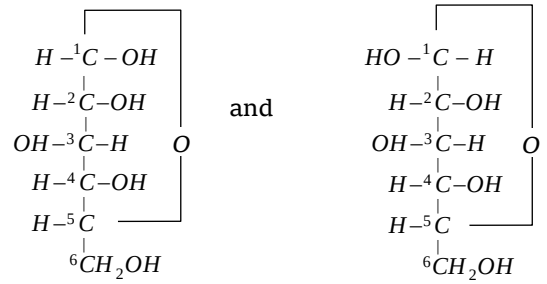
22. (d) Glucose on reaction with bromine water followed by oxidation gives gluconic acid

$$\underset{\text{Glucose}}{C_6H_{12}O_6}+(O)\xrightarrow{Br_2/H_2O}\underset{\text{Gluconic acid}}{CH_2OH(CHOH)_4COOH}$$

23. (c) $\underset{\substack{\text{dipolar ion}\\(\text{Zwitter ion or internal salt})}}{NH_3^+-CH_2-COO^-}$

24. (b) Ribose is an example of aldopentose.

25. (b)



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

Two form of *D*–Glucopyranose are α–D(+)–Glucopyranose and β–D(+)–Glucopyranose. These are anomers (a pair of stereoisomers which differ in configuration only around C_1 are called anomers).

26. (b) Surcrose is composed of α -*D*-glucopyranose unit and a β –D-fructofuranose unit. These units are joined by $\alpha-\beta$ -glycosidic linkage between *C*–1 of the glucose unit and *C*–2 of the fructose unit.

Assertion and Reason

1. (a) Glycine is an amino acid, it contains both NH_2 as well as –*COOH* groups and therefore, its aqueous solution form Zwitter ion which is amphoteric in nature.

$$\underset{\text{Glycine}}{NH_2CH_2COOH} \qquad \underset{\text{Zwitter ion}}{NH_3^+CH_2COO^-}$$

Therefore, both assertion and reason are true.

2. (b) Hydrolysis of sucrose is known as inversion of canesugar because sucrose produce equimolecular mixture of glucose and fructose. Sucrose is dextro-rotatory which glucose and fructose mixture is laevorotatory. Sucrose is disaccharide.

3. (b) Proteins on hydrolysis gives α–amino acid because amino acids are the building block of proteins. It is also fact that amino acids contain both $-NH_2$ and $-COOH$ group.

Here assertion and reason both are correct but reason is not a correct explanation of assertion.

4. (e) Sucrose does not undergo mutarotation. Glucose and fructose shows mutarotation because they have two forms α and β. It is fact that sucrose is a disaccharide. Therefore, assertion is false but reason is true.

5. (d) Here, both the reason and assertion are false, DNA occurs in nucleus of the cell while RNA is found mainly in cytoplasm of the cell. On heating, enzymes lose their specific activity.

6. (a) All amino acid posses amino as well as carboxylic group. $-NH_2$ group is basic while $-COOH$ group is acidic. Therefore, they behave as zwitter ion (dipolar ion). Here, both assertion and reason are true and reason is a correct explanation.

7. (b) The assertion that activity of an enzyme is *pH* dependent is correct. The reason that change in *pH* affects the solubility of enzyme in water is also true but the reason is not the correct explanation of assertion. Change in *pH* cause denaturation of enzyme.

8. (d) Glycosides are formed by treating glucose with methanol in presence of dry *HCl* gas. They cannot be hydrolysed in acidic conditions. They are not acetals but they are hemiacetals.

9. (c) The assertion is correct that haemoglobin is an oxygen carrier and the reason that oxygen binds as O_2^- to *Fe* of haemoglobin is incorrect, because oxygen binds as O_2 to *Fe* of haeme part.

10. (c) Carboxypeptidase is an exopeptidase because it breaks the peptide chain at terminal ends.

Carboxypeptidase cleaves carboxy-terminal amino acids that have aromatic or branched aliphatic side chains.

11. (a) Sucrose is a non reducing sugar as it does not reduce Tollen's or Fehling's reagent, due to absence of free aldehyde of ketone group. It contains stable acetal or ketal structure which cannot be opened into a free carboxyl group.

Sugar is composed of α-D-glucopyranose unit and β-D-fructo furanose unit. These units are joined by α-β-glycosidic linkage between *C*- 1 of the glucose unit and *C*- 2 of the fructose unit.

12. (b) Carbohydrates which upon hydrolysis yield two molecules of the same or different monosaccharides are called disaccharides. For example, sucrose on acid hydrolysis give one molecule of glucose and fructose.

13. (b) Fructose on warming with dilute alkali, gives rise to an equilibrium mixture of glucose, fructose and mannose. The ability of fructose to reduce Fehling solution and Tollen's reagent is probably due to the isomerisation of fructose to glucose and mannose (this is called Lobry de Bruyn and Elkenstein rearrangement).

14. (b) Glucose exists in two forms, *i.e.,* α-D-glucose with a specific rotation of +112° and β-D-glucose with a specific rotation of +19°. However, when either of these two forms is dissolved in water and allowed to stand. it gets converted into the same equilibrium mixture of both the α- and β-forms with a small amount of open chain form. As a result of this equilibrium, the specific rotation of a freshly prepared solution of α-glucose decreases from +112° to 52.7° while that of β glucose increases from +19° to 52.7°.

15. (b) In acidic medium $-COOH$ group acts as the base and accepts a proton. As a result, α-amino acids exist as cations in acidic medium and migrate towards cathode under the influence of an electric field. In alkaline medium $\overset{+}{N}H_3$ group acts as the acid and thus loses a proton. As a result, α-amino acids exist as anion and migrate towards anode under the influence of an electric field. However at some intermediate value of *pH*, the concentration of cationic form and anionic form will become equal and hence there is no net migration of α-amino acid under the influence of an electric field.

16. (b) Valine is an essential amino acid. The amino acids which the body cannot synthesize are called essential amino acid.

17. (e) Sequence of bases in DNA is TGAACCCTT. Since according to base-pairing principle, *T* in DNA faces *A* in *m*-RNA, while *G* faces *C* and *A* faces *U*. Therefore, sequence of bases in *m*-RNA is ACUUGGGAA.

18. (e) Millons test is a test for proteins. When Millon's reagent is added to the aqueous solution of a protein, a white precipitate is formed.

19. (b) ATP has four negatively charged oxygen atoms very close to each other. So the repulsive forces between them is high. On hydrolysis of ATP, a $H_2PO_4^-$ ion is eliminated and the number of negatively charged oxygen atoms decreases. Thus, repulsive forces decreases and a large amount of energy is set free. When ATP changes to ADP, which in turn changes into AMP, energy is released at each step. This is how ATP can act as a source of energy.

20. (e) Solubility of protein is maximum at the isoelectric point.

21. (e) Amino acids are soluble in polar solvents like H_2O, $NaOH$ and HCl and insoluble in non-polar solvents like benzene, ether etc.

22. (c) Sucrose on hydrolysis gives equal amounts of glucose and fructose. Since glucose has less positive and fructose has more negative magnitude of rotation, therefore, change in the sign of rotation is observed.

Biomolecules

SET Self Evaluation Test - 31

1. Which does not show mutarotation

(a) Sucrose (b) Maltose

(c) Glucose (d) Fructose

2. Artificial silk is

(a) Polyamides (b) Polyesters

(c) Polyacids (d) Polysaccharides

3. Which of the following is a protein

(a) Pepsin (b) Adrenaline

(c) ATP (d) Glutamin

4. Glucose gives many reactions of aldehyde, because **[CPMT 1977]**

(a) It is hydrolysed to acetaldehyde

(b) It is a polyhydroxy ketone

(c) It is a cyclic aldehyde

(d) It is a hemiacetal in equilibrium with its aldehyde form in solution

5. Glucose in blood can be quantitatively determined with **[JIPMER 2002]**

(a) Tollen's reagent

(b) Benedict's solution

(c) Alkaline iodine solution

(d) Bromine water

6. Which of the following ions can cause coagulation of proteins **[Kerala (Med.) 1999]**

(a) Na^+ (b) Ag^+

(c) Ca^{++} (d) Mg^{++}

7. Glucose reacts with methyl alcohol to give **[CPMT 1985]**

(a) α – methyl glucoside

(b) β – methyl glucoside

(c) Both (a) and (b)

(d) None of these

8. Molisch's test is done for the detection of **[BHU 1987]**

(a) Alkyl halide (b) Carbohydrate

(c) Alkaloid (d) Fat

9. Which of the following is not an amino acid **[MP PET/PMT 1998]**

(a) Glycine (b) Alanine

(c) Histidine (d) Benzidine

10. A substance forms zwitter ion. It can have functional groups **[DCE 2002]**

(a) $-NH_2, -COOH$ (b) $-NH_2, -SO_3H$

(c) Both **[PB. CET 2003]** (d) None of these

11. Which functional group participates in disulphide bond formation in proteins

(a) Thiolactone (b) Thiol

(c) Thioether (d) Thioester

12. Schweitzer's reagent used for dissolving cellulose in the manufacture of artificial silk is **[Roorkee 1999]**

(a) $CuSO_4 . 5H_2O$

(b) CuI

(c) $[Cu(NH_3)_4]SO_4$

(d) $Cu(CH_3COO)_2 . Cu(OH)_2$

13. Which one of the following statements is true for protein synthesis (translation) **[AIIMS 2005]**

(a) Amino acid are directly recognized by *m*-RNA

(b) The third base of the codon is less specific

(c) Only one codon codes for an amino acid

(d) Every *t*-RNA molecule has more than one amino acid attachment site.

14. In both DNA and RNA, heterocyclic base and phosphate ester linkages are at **[AIEEE 2005]**

(a) C_5' and C_2' respectively of the sugar molecule

(b) C_2' and C_5' respectively of the sugar molecule

(c) C_1' and C_5' respectively of the sugar molecule

(d) C_5' and C_1' respectively of the sugar molecule

15. Which of the following biomolecules contain non-transition metal ion **[KCET 2005]**

(a) Vitamin B_{12} (b) Chlorophyll

(c) Haemoglobin (d) Insulin

16. An example of a sulphur containing amino acid is **[KCET 2005]**

(a) Lysine (b) Serine

(c) Cysteine (d) Tyrosine

17. Which of the following is not present in a nucleotide

[KCET 2005]

(a) Cytosine (b) Guanine (c) Adenine (d) Tyrosine

Answers and Solutions

(SET -31)

1. (a) Sucrose does not show mutarotation due to non reducing nature.

2. (d) It is a polysaccharide.

3. (a) Pepsin is a protein.

4. (d) It is a hemiacetal in equilibrium with its aldehyde form in solution.

5. (a) In glucose aldehydic group is present and Tollen's reagent is the test for aldehydes.

6. (b) Ag^+ can cause coagulation of proteins.

7. (c) Alpha methyl glucoside and beta methyl glucoside.

8. (b) Molisch's test is done for the detection of carbohydrate bond formation.

9. (d) Benzidine is not an amino acid. It is an amine.

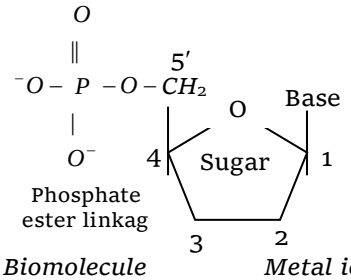
10. (c) A substance forms Zwitter ion. It can have functional groups $-NH_2COOH$ and $-NH_2$, $-SO_3H$.

11. (b) Thiol functional group particpitates in disulphide in proteins.

12. (c) $[Cu(NH_3)_4]SO_4$ is schweitzer's reagent used for manufacture of artificial silk.

13. (a) In the process of translation amino acids are directly recognized by *m*-RNA.

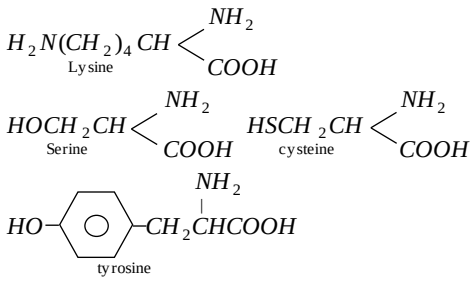
14. (c)



15. (b)

Biomolecule	*Metal ion*
Vitamin B_{12}	*Co* (transition metal)
Chlorophyll	*Mg* (non-transition metal ion)
Haemoglobin	*Fe* (transition metal)
Insulin	*S* (non-Metal)

16. (c)



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17. (d) Nucleotide contains nitrogenous bases like adenine, guanine, thymin, cytosine and uracil.