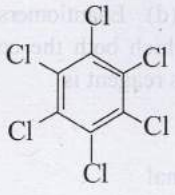
Chapter - Biomolecules

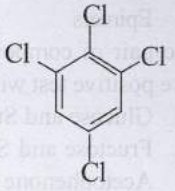
Topic-1: Carbohydrates and Lipids

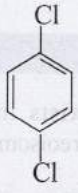
1 MCQs with One Correct Answer

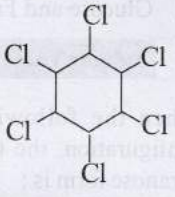
1. In the following reaction sequences, the major product Q is **[Adv. 2024]**

L-Glucose $\xrightarrow[\text{(ii) } Cr_2O_3, 775\,K, \text{ 10-20 atm}]{\text{(i) HI, } \Delta}$ P $\xrightarrow[UV]{Cl_2 \text{ (excess)}}$ Q

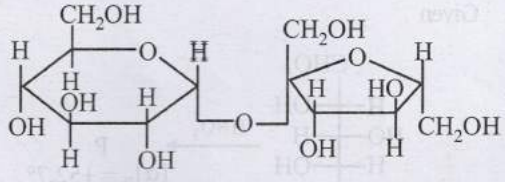
(a) 

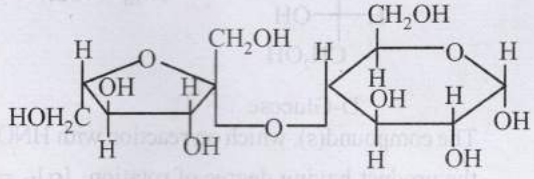
(b) 

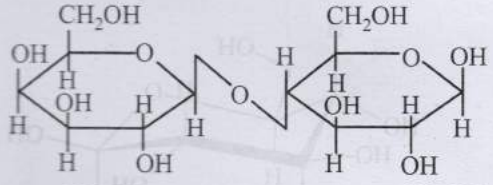
(c) 

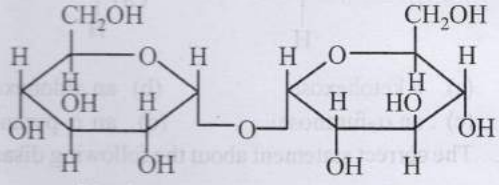
(d) 

2. A disaccharide X cannot be oxidised by bromine water. The acid hydrolysis of X leads to a laevorotatory solution. The disaccharide X is **[Adv. 2023]**

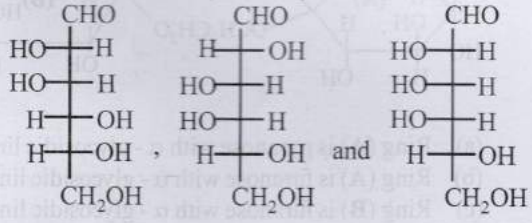
(a) 

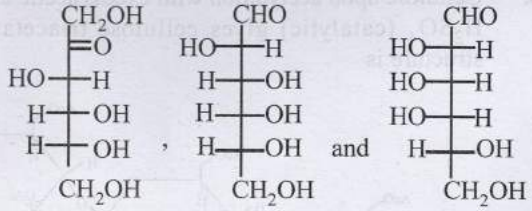
(b) 

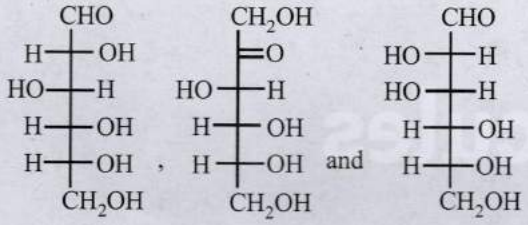
(c) 

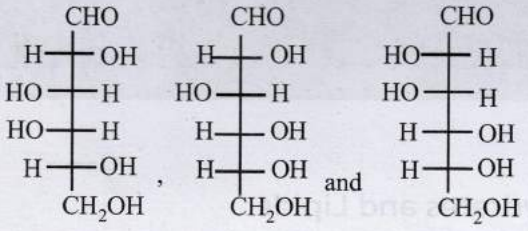
(d) 

3. Treatment of D-glucose with aqueous NaOH results in a mixture of monosaccharides, which are **[Adv. 2022]**

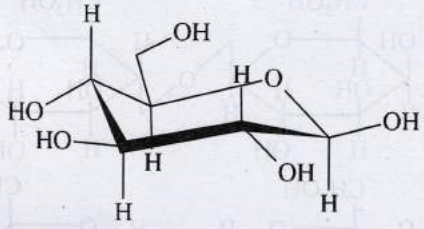
(a) 

(b) 

(c)  and

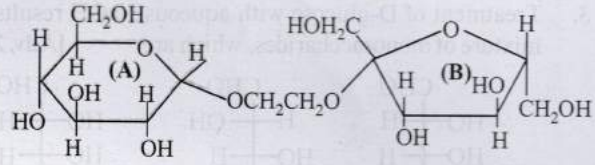
(d)  and

4. The following carbohydrate is **[2011 - II]**



(a) a ketohexose (b) an aldohexose
(c) an α-furanose (d) an α-pyranose

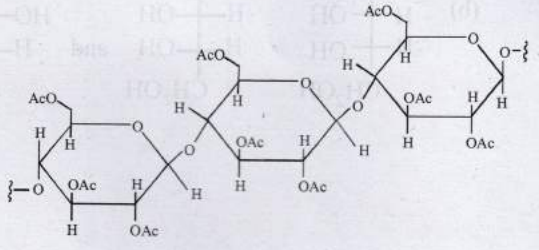
5. The correct statement about the following disaccharide is

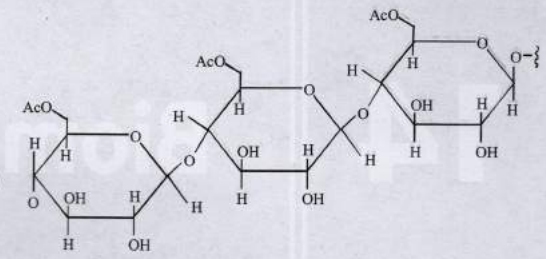


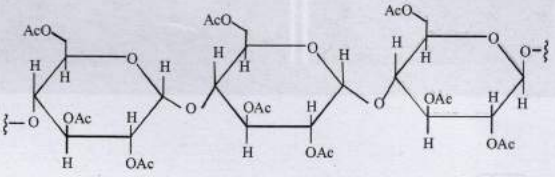
[2010]

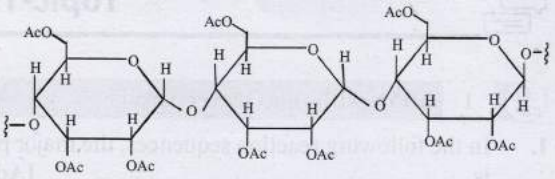
(a) Ring (**A**) is pyranose with α - glycosidic link
(b) Ring (**A**) is furanose with α - glycosidic link
(c) Ring (**B**) is furanose with α - glycosidic link
(d) Ring (**B**) is pyranose with β - glycosidic link

6. Cellulose upon acetylation with excess acetic anhydride/ H_2SO_4 (catalytic) gives cellulose triacetate whose structure is **[2008S]**

(a) 

(b) 

(c) 

(d) 

7. The two forms of D–glucopyranose obtained from the solution of D–glucose are called **[2005S]**

(a) Isomers (b) Anomers
(c) Epimers (d) Enantiomers

8. The pair of compounds in which both the compounds give positive test with Tollen's reagent is **[2004S]**

(a) Glucose and Sucrose
(b) Fructose and Sucrose
(c) Acetophenone and Hexanal
(d) Glucose and Fructose

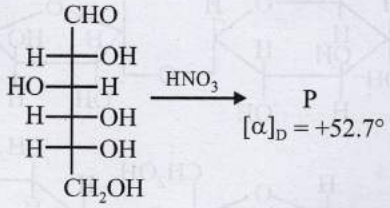
2 Integer Value Answer

9. When the following aldohexose exists in its D-configuration, the total number of stereoisomers in its pyranose form is : **[2012]**

$CHO-CH_2-CHOH-CHOH-CHOH-CH_2OH$

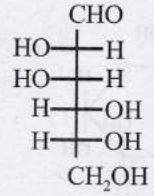
6 MCQs with One or More than One Correct Answer

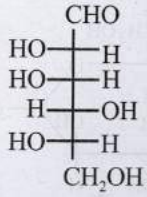
10. Given

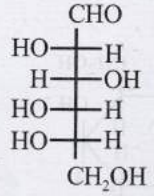


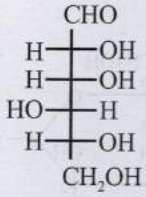
D-Glucose

The compound(s), which on reaction with HNO_3 will give the product having degree of rotation, $[\alpha]_D = -52.7°$ is (are) **[Adv. 2021]**

(a) 

(b) 

(c) 

(d) 

11. Which of the following statement(s) is (are) true? **[Adv. 2019]**

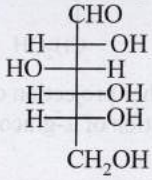
(a) Oxidation of glucose with bromine water gives glutamic acid.

(b) Hydrolysis of sucrose gives dextrorotatory glucose and laevorotatory fructose.

(c) The two six-membered cyclic hemiacetal forms of D-(+)- glucose are called anomers.

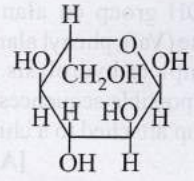
(d) Monosaccharides cannot be hydrolysed to give poly-hydroxy aldehydes and ketones

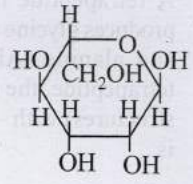
12. The Fischer presentation of D-glucose is given below. **[Adv. 2018]**

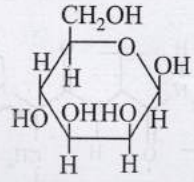


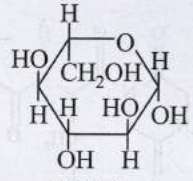
D-glucose

The correct structure(s) of β-L-glucopyranose is (are)

(a) 

(b) 

(c) 

(d) 

13. For 'invert sugar', the correct statement(s) is(are) (Given : specific rotations of (+) -sucrose, (+)-maltose, L-(-)-glucose and L-(+) fructose in aqueous solution are +66°, +140°, –52° and +92°, respectively) **[Adv. 2016]**

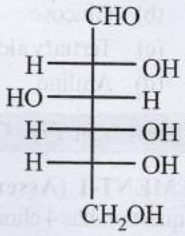
(a) 'invert sugar' is prepared by acid catalyzed hydrolysis of maltose

(b) 'invert sugar' is an equimolar mixture of D-(+)-glucose and D-(-)-fructose

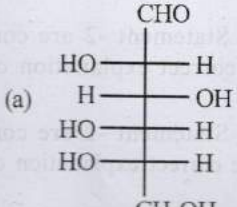
(c) specific rotation of 'invert sugar' is –20°

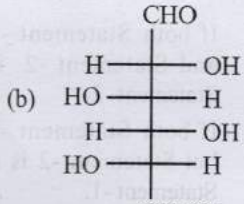
(d) on reaction with Br_2 water, 'invert sugar' forms saccharic acid as one of the products

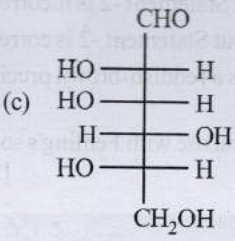
14. The structure of D-(+)-glucose is **[Adv. 2015]**

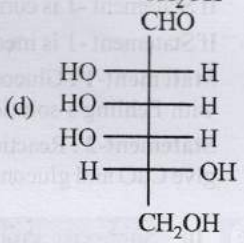


The structure of L-(–)-glucose is

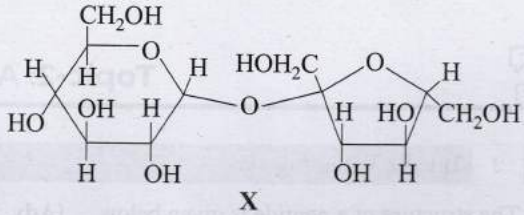
(a) 

(b) 

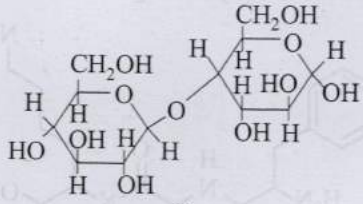
(c) 

(d) 

15. The correct statement(s) about the following sugars **X** and **Y** is (are) **[2009S]**



X



Y

(a) **X** is a reducing sugar and **Y** is a non-reducing sugar

(b) **X** is a non-reducing sugar and **Y** is a reducing sugar

(c) The glucosidic linkages in **X** and **Y** are α and β, respectively

(d) The glucosidic linkages in **X** and **Y** are β and α, respectively

7 Match the Following

16. Match the following, choosing one item from column **X** and the appropriate item from column **Y**. **[1983 - 2 Marks]**

(*i*)	Lucas test	(a)	Phenol
(*ii*)	Neutral $FeCl_3$ test	(b)	Glucose
(*iii*)	Dye test	(c)	Tertiary alcohol
(*iv*)	Tollen's test	(d)	Aniline

9 Assertion and Reason Statement Type Questions

Each question contains **STATEMENT-1 (Assertion)** and **STATEMENT-2 (Reason)**. Each question has 4 choices (a), (b), (c) and (d) out of which ONLY ONE is correct. Mark your answer as

(a) If both Statement -1 and Statement -2 are correct, and Statement -2 is the correct explanation of the Statement -2.

(b) If both Statement -1 and Statement -2 are correct, but Statement -2 is not the correct explanation of the Statement -1.

(c) If Statement -1 is correct but Statement -2 is incorrect.

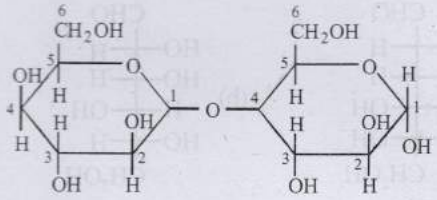
(d) If Statement -1 is incorrect but Statement -2 is correct.

17. **Statement-1 :** Glucose gives a reddish-brown precipitate with Fehling's solution.

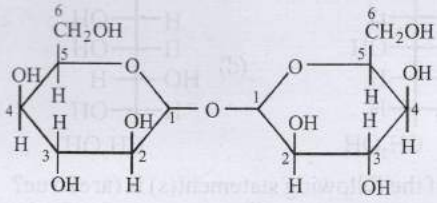
Statement-2 : Reaction of glucose with Fehling's solution give CuO and gluconic acid. **[2007]**

10 Subjective Problems

18. Which of the following will reduce Tollen's reagent? Explain. **[2005 - 2 Marks]**

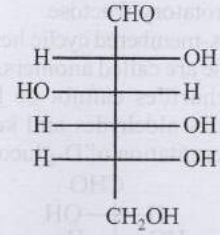


A



B

19. The Fisher projection of D-glucose is drawn below. **[2004 - 2 Marks]**



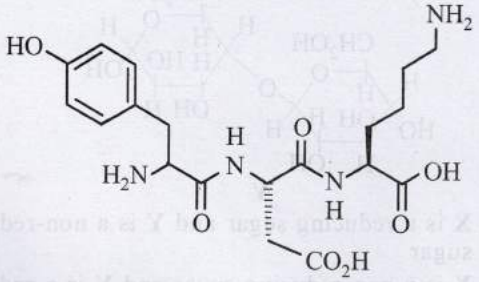
(i) Draw the Fisher projection of L-glucose.

(ii) Give the reaction of L-glucose with Tollen's reagent

Topic-2: Amino Acids and Proteins

2 Integer Value Answer

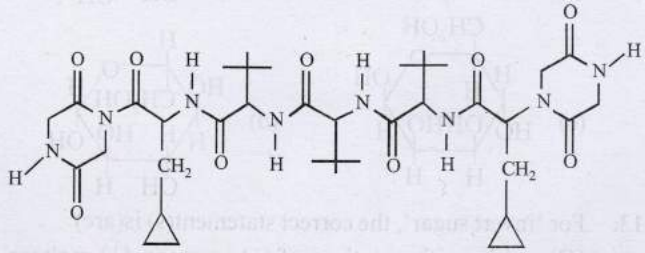
1. The structure of a peptide is given below. **[Adv. 2020]**



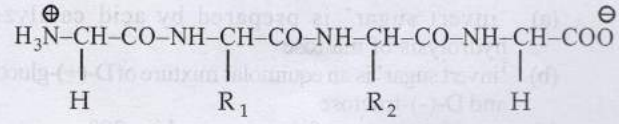
If the absolute values of the net charge of the peptide at pH = 2, pH = 6, and pH = 11 are $|z_1|$, $|z_2|$, and $|z_3|$, respectively, then what is $|z_1| + |z_2| + |z_3|$?

2. The total number of ***distinct naturally occurring amino acids*** obtained by complete acidic hydrolysis of the peptide shown below is **[Adv. 2014]**

3. A tetrapeptide has —COOH group on alanine. This produces glycine (Gly), valine (Val), phenyl alanine (Phe) and alanine (Ala), on complete hydrolysis. For this tetrapeptide, the number of possible sequences (primary structures) with $-NH_2$ group attached to a chiral center is **[Adv. 2013]**



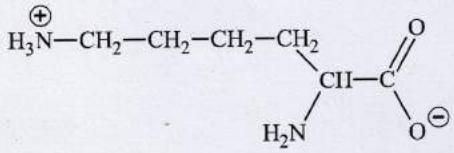
4. The substituents R_1 and R_2 for nine peptides are listed in the table given below. How many of these peptides are positively charged at pH = 7.0 ? **[2012]**



Peptide	R_1	R_2
I	H	H
II	H	CH_3
III	CH_2COOH	H
IV	CH_2CONH_2	$(CH_2)_4NH_2$
V	CH_2CONH_2	CH_2CONH_2
VI	$(CH_2)_4NH_2$	$(CH_2)_4NH_2$
VII	CH_2COOH	CH_2CONH_2
VIII	CH_2OH	$(CH_2)_4NH_2$
IX	$(CH_2)_4NH_2$	CH_3

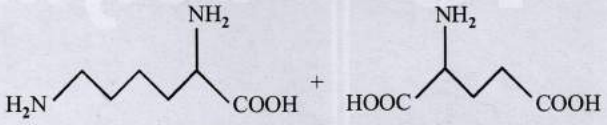
5. A decapeptide (Mol. wt. 796) on complete hydrolysis gives glycine (Mol. wt. 75), alanine and phenylalanine. Glycine contributes 47.0% to the total weight of the hydrolysed products. The number of glycine units present in the decapeptide is **[2011]**

6. The total number of basic groups in the following form of lysine is **[2010]**

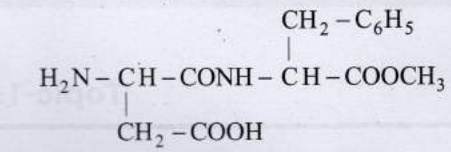


10 Subjective Problems

7. Following two amino acids lysine and glutamine form dipeptide linkage. What are two possible dipeptides? **[2003 - 2 Marks]**



8. Aspartame, an artificial sweetener, is a peptide and has the following structure : **[2001 - 5 Marks]**



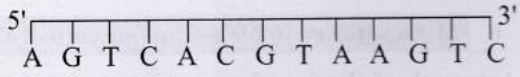
(i) Identify the four functional groups.
(ii) Write the zwitterionic structure.
(iii) Write the structures of the amino acids obtained from the hydrolysis of aspartame.
(iv) Which of the two amino acids is more hydrophobic?

9. Write the structures of alanine at pH = 2 and pH = 10. **[2000 - 2 Marks]**

Topic-3: Nucleic Acids, Enzymes, Vitamins and Hormones

2 Integer Value Answer

1. F or a double strand DNA, one strand is given below: **[Adv. 2024]**



The amount of energy required to split the double strand DNA into two single strands is _____ kcal mol^{-1}.
[**Given:** Average energy per H-bond for A-T base pair = 1.0 kcal mol^{-1}, G-C base pair = 1.5 kcal mol^{-1}, and A-U base pair = 1.25 kcal mol^{-1}. Ignore electrostatic repulsion between the phosphate groups.]

Answer Key

Topic-1 : Carbohydrates and Lipids

1. (d) **2.** (a) **3.** (c) **4.** (b) **5.** (a) **6.** (a) **7.** (b) **8.** (d) **9.** (8) **10.** (c, d)
11. (b,c,d) **12.** (d) **13.** (b,c) **14.** (a) **15.** (b,c) **16.** (i) – (c), (ii) – (a), (iii) – (d), (iv) – (b) **17.** (c)

Topic-2 : Amino Acids and Proteins

1. (5) **2.** (1) **3.** (4) **4.** (4) **5.** (6) **6.** (2)

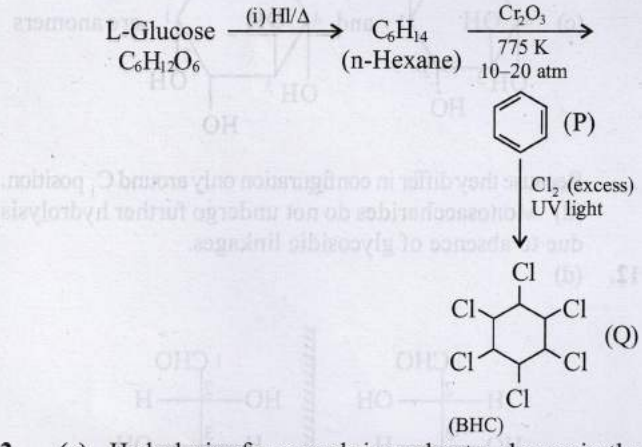
Topic-3 : Nucleic Acids, Enzymes, Vitamins and Hormones

1. (41)

Hints & Solutions

Topic-1 : Carbohydrates and Lipids

1. (d)



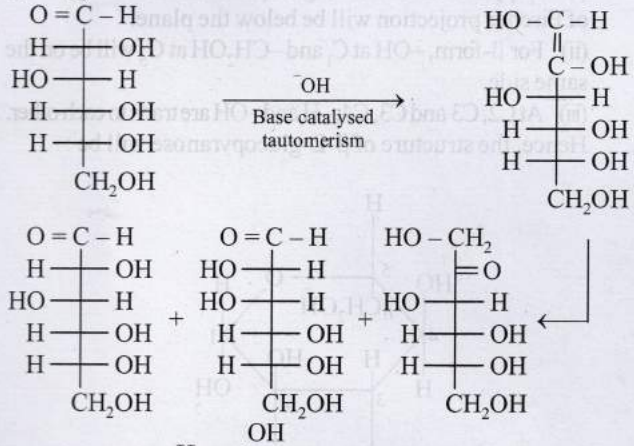
2. (a) Hydrolysis of sucrose brings about a change in the sign of rotation from dextro to laevo.

$$\text{Sucrose} \xrightarrow{H_3O^+} \alpha - D(+)\text{Glucopyranose} + \beta\text{- } D(+)\text{Fructofuranose}$$

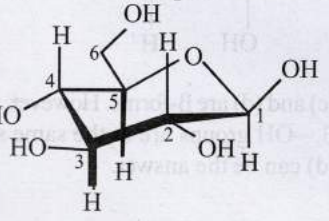
$$\text{Sucrose} \xrightarrow{Br_2+H_2O} \text{No reaction}$$

Opton (b), (c), (d) are reducing sugars, will get oxidized by bromine water.

3. (c)

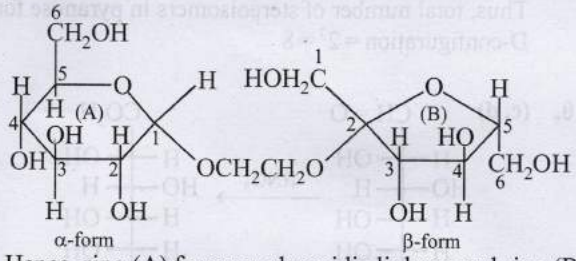


4. (b)



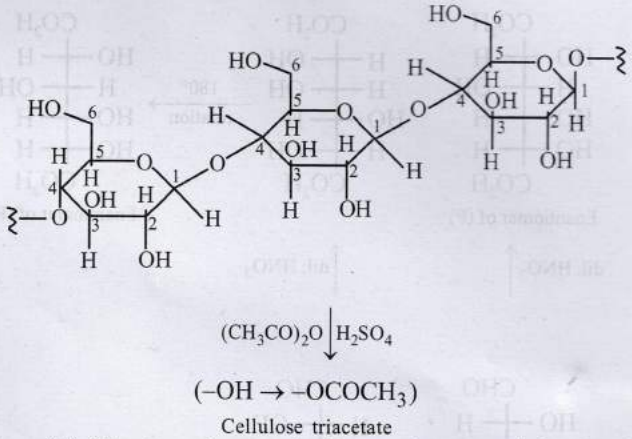
At C_1, –OH group is above the plane, thus, it is β-pyranose. If hydrogen is present at the anomeric carbon (i.e. C_1), then it is an aldose.
Hence, the given compound is an aldohexose.

5. (a) Ring (A) is pyranose (analogous to pyran) and ring (B) is furanose (analogous to furan). Before forming the disaccharide the monosaccharide (A) has –OH group at C_1, below the plane. The monosaccharide (B) has –OH group at C_1, above the plane.



Hence, ring (A) forms α-glycosidic linkage and ring (B) forms β-glycosidic linkage.

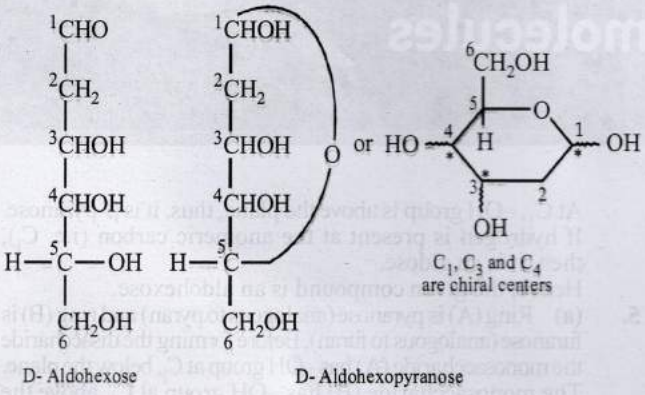
6. (a) Cellulose is a polysaccharide composed of only D-glucose units. Every adjacent glucose units are joined by β-glycosidic linkage between C_1 of one glucose and C_4 of the next.
Thus in every glucose units only three –OH groups are free to form triacetate.



7. (b) The two isomeric forms (α – and β –) of D-glucopyranose differ in configuration only at C–1; hence these are called anomers.

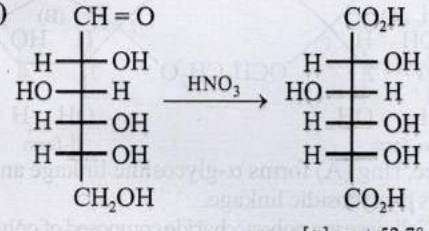
8. (d) Glucose being an aldose responds to Tollen's test while fructose (an α-hydroxy ketone), although a ketose, undergoes rearrangement in presence of basic medium (provided by Tollen's reagent) to form glucose, which then responds to Tollen's test.

9. (8)

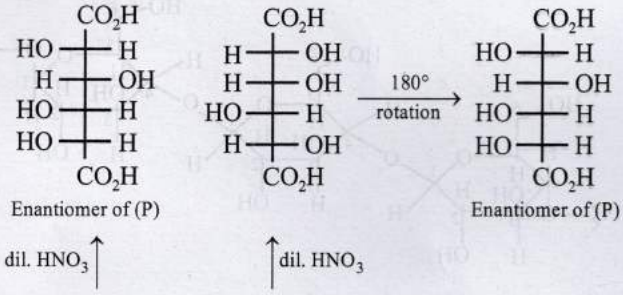


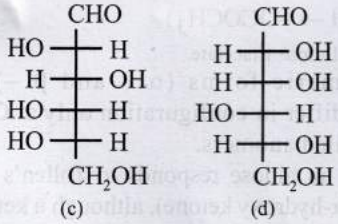
Thus, total number of stereoisomers in pyranose form of D-configuration = $2^3 = 8$

10. (c, d)



The enantiomer of P has rotation – 52.7° is as follow





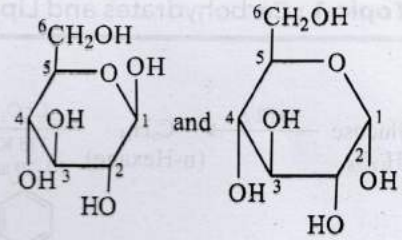
11. (b, c, d)

(a) Glucose $\xrightarrow[H_2O]{Br_2}$ Gluconic acid.

Bromine water oxidises only aldehyde group to carboxylic group. It neither oxidises –OH group nor –CO group.

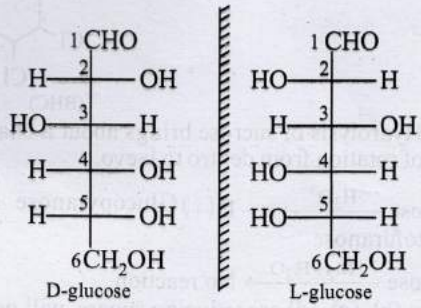
(b) Sucrose $\xrightarrow{H_2O}$ Glucose + Fructose
(+) (+) (–)

Sucrose is dextrorotatory (+ 66.6°) in nature but on hydrolysis it gives dextrorotatory glucose (+52.5°) and laevorotatory fructose (–92.4°). Overall solution is laevorotatory since laevorotation is more than dextrorotation.

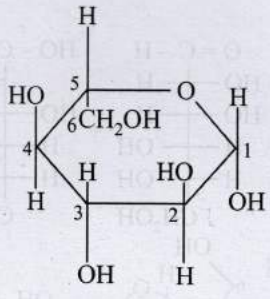
(c)  are anomers

Because they differ in configuration only around C_1 position.
(d) Monosaccharides do not undergo further hydrolysis due to absence of glycosidic linkages.

12. (d)



(i) In pyranose form, the groups which are in right side of Fischer projection will be below the plane.
(ii) For β-form, –OH at C_1 and –CH_2OH at C_5 will be on the same side.
(iii) At C2, C3 and C3, C4; –H and –OH are trans to each other.
Hence, the structure of β-L-glucopyranose will be :



Only option (c) and (d) are β-forms. However, in option (c) at C2 and C3, –OH groups are at the same side. Hence, only option (d) can be the answer.

13. **(b, c)**

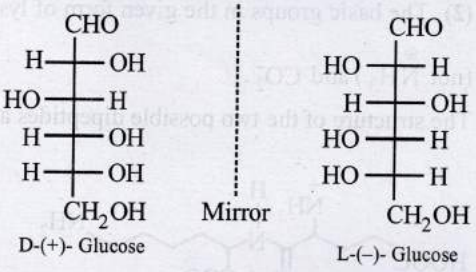
Invert sugar is an equimolar mixture of D-(+) glucose and D-(–) fructose.

$$\underset{\text{(+) Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underbrace{\underset{\substack{\text{D(+)–Glucose}\\(+52°)}}{C_6H_{12}O_6} + \underset{\substack{\text{D(–)–fructose}\\(-92°)}}{C_6H_{12}O_6}}_{\text{Invert sugar}}$$

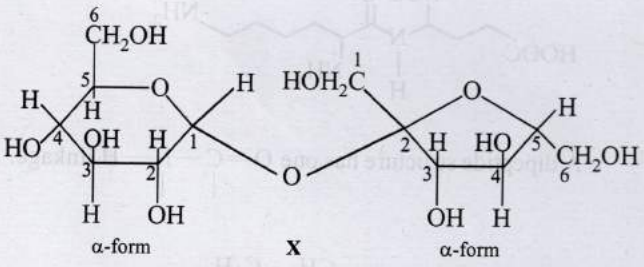
Since the specific rotation of the hydrolysis product of (+) sucrose is inverted, i.e., (–), it is known as inverted sugar.

- Specific rotation of invert sugar $= \frac{-92° + 52°}{2} = -20°$
- D-glucose on oxidation with Br_2-water produces gluconic acid and not saccharic acid.

14. **(a)**

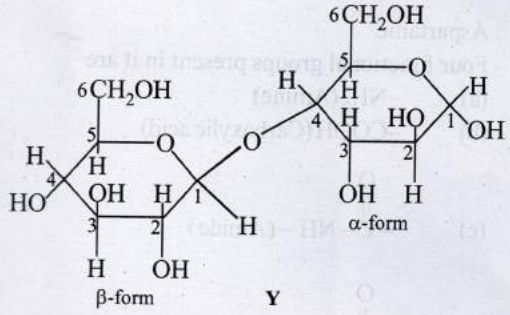


15. **(b, c)**



Both the units of disaccharide X are bonded by C1 – C2 linkage. The reducing groups (aldehydic and ketonic respectively) are bonded together. Thus, X is non-reducing sugar.

Also, X has α-glycosidic linkage.



While Y has a hemiacetal group, hence it is reducing sugar.

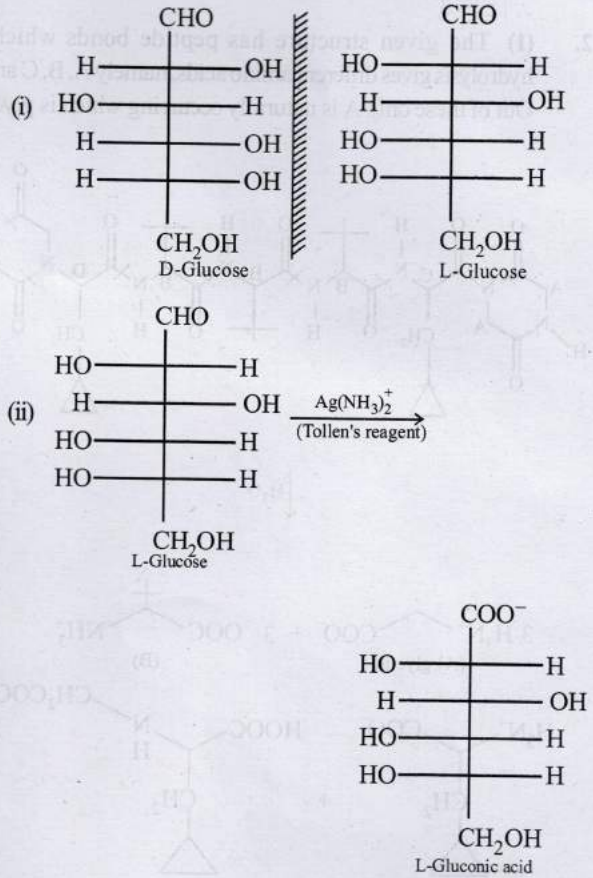
Also Y has β-linkage.

16. (i) – (c), (ii) – (a), (iii) – (d), (iv) – (b)

17. **(c)** Statement-1 is correct, but statement-2 is incorrect because glucose on reaction with Fehling's solution gives Cu_2O and gluconic acid.

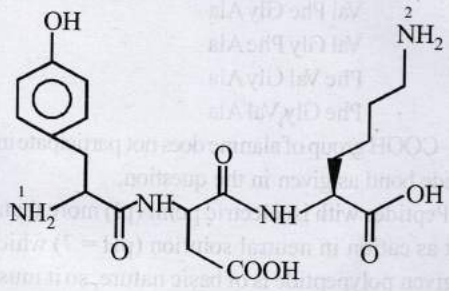
18. In the two disaccharides, structure *A* will be reducing sugar since, both monosaccharides units are not linked through their reducing centers i.e., it has hemiacetal linkage, while in structure *B*, both the monosaccharide units are linked through their reducing centers, i.e., it has acetal linkage, hence it will be non-reducing.

19. L-Glucose is an enantiomer of D-glucose, hence



Topic-2 : Amino Acids and Proteins

1. **(5)** $|z_1| + |z_2| + |z_3| = 5$



At pH = 2 $\overset{1}{NH_2}$ and $\overset{2}{NH_2}$ of tyrosine and lysine are positively charged (+1 each)

$+2 |z_1| = 2$

At pH = 6, NH_2 of Lysine (+1), COOH (–1) of glutamic acid, so because of dipolar ion, $|z_2| = 0$

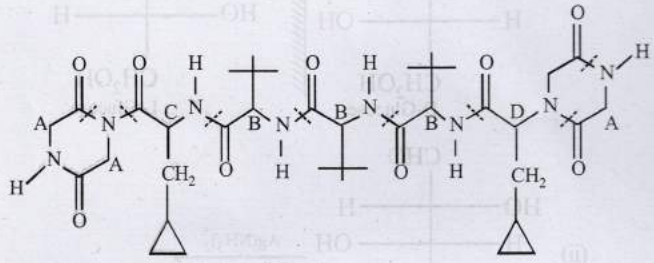
At pH = 11, COOH of glutamic acid (–1)

COOH of lysine (–1)

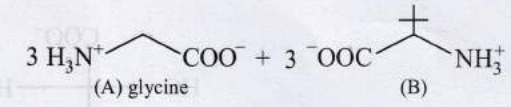
OH of phenol (–1)

$\therefore |z_3| = 3$

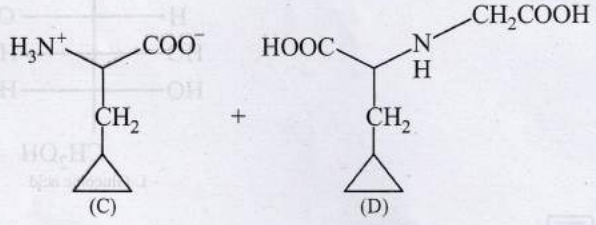
2. **(1)** The given structure has peptide bonds which on hydrolysis gives different amino acids, namely A, B, C and D. Out of these only A is naturally occurring which is glycine.



$\downarrow H_3O^+$



(A) glycine (B)



(C) (D)

3. **(4)** According to question, C – terminal must be alanine and N – terminal do have chiral carbon means it should not be glycine. So possible sequence is :

Val Phe Gly Ala
Val Gly Phe Ala
Phe Val Gly Ala
Phe Gly Val Ala

The –COOH group of alanine does not participate in forming peptide bond as given in the question.

4. **(4)** Peptides with isoelectric point (pI) more than 7 would exist as cation in neutral solution (pH = 7) which means the given polypeptide is of basic nature, so it must contain two or more amino groups. Hence IV, VI, VIII and IX are correct options.

5. **(6)**

Molecular weight of decapeptide = 796 g/mol

Total bonds to be hydrolysed = (10 – 1) = 9 per molecule

Total weight of H_2O added = 9 × 18 = 162 g/mol

Total weight of hydrolysis products = 796 + 162 = 958 g

Total weight % of glycine (given) = 47%

$$\text{Total weight of glycine in product} = \frac{958 \times 47}{100}\text{g} = 450\text{g}$$

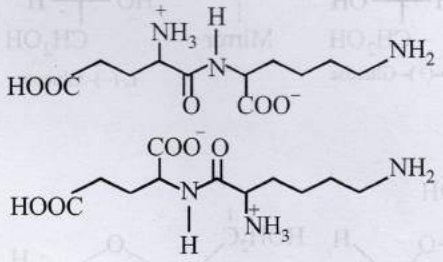
Molecular weight of glycine = 75 g/mol

$$\text{Number of glycine molecules} = \frac{450}{75} = 6$$

A dipeptide has one peptide bond. Thus, a decapeptide has 9 peptde bonds.

6. **(2)** The basic groups in the given form of lysine is NH_2 (not $\overset{\oplus}{N}H_3$) and CO_2^-.

7. The structure of the two possible dipeptides are



A dipeptide structure has one $O=\underset{|}{C}-\underset{|}{N}-H$ linkage.

8. $H_2N-\underset{\underset{CH_2-COOH}{|}}{CH}-CONH-\underset{\underset{CH_2-C_6H_5}{|}}{CH}-COOCH_3$

Aspartame

(i) Four functional groups present in it are

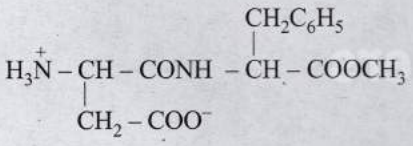
(a) $-NH_2$ (Amine)

(b) –COOH (Carboxylic acid)

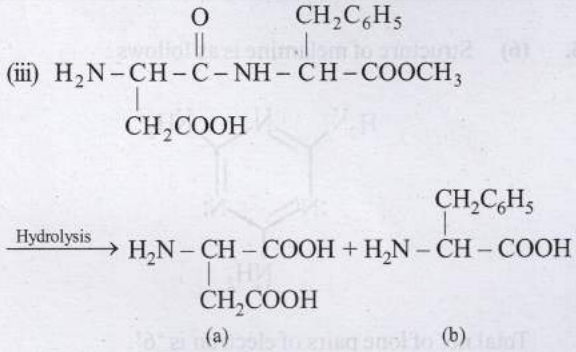
(c) $-\overset{\overset{O}{\|}}{C}-NH-$ (Amide)

(d) $-\overset{\overset{O}{\|}}{C}-O-CH_3$ (Ester)

(ii) Zwitterion structure is given as follows :



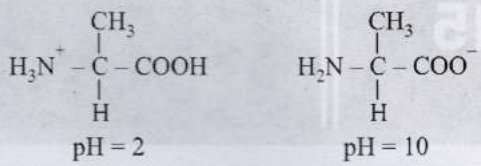
(iii)



Hence, on hydrolysis two amino acids (a) and (b) are obtained.

(iv) Of the above two amino acids, (b) $NH_2 - CH(CH_2C_6H_5) - COOH$ is more hydrophobic due to presence of non-polar and bulky benzyl group.

9. pH = 2 indicates acidic character whereas pH = 10 indicates basic character.



Topic-3 : Nucleic Acids, Enzymes, Vitamins and Hormones

1. (41)

Total energy = [BE of H-bond of A – T × No. of A = T pair × 2] + [BE of H-bond of G – C × No. of G ≡ C pari × 3]

= [1 × 7 × 2] + [1.5 × 6 × 3]

= 14 + 27

= 41 kcal