

CHAPTER - 23

BIOMOLECULES

SYNOPSIS

I. BIOMOLECULES

They are complex organic molecules which are necessary to maintain life. They are carbohydrates, proteins, enzymes, vitamins, nucleic acids, hormones etc.

Carbohydrates: They are polyhydroxy aldehyde or ketone which on hydrolysis give lower members of polyhydroxy aldehyde or ketone.

They are mainly two types

- 1) sugars
- 2) non sugars

They are broadly classified into

- 1) Mono-saccharides
- 2) Oligo-saccharides
- 3) Poly-saccharides.

Glucose : Present in sweet fruits and honey. Glucose is an aldohexose and hence called dextrose. It is probably most abundant organic compound on earth. It can be prepared from sucrose and starch. In aqueous solution glucose exists as an equilibrium mixture of two anomers α and β forms, with a small amount of the open chain form

Fructose

It is the most important of all ketoses. It is also called fruit-sugar. At equilibrium D-fructose exists 67.5% in the pyranose form, 31.5% in the furanose form and 1% in noncyclic form

Sucrose

One of the common disaccharide which on hydrolysis gives equimolar mixture of D(+) glucose and D(–) fructose. These two monosaccharides are held together by glycosidic linkage between C₁ of α D(+) glucose and C₂ of β – D – (–) fructose. Since the reducing groups of glucose and fructose are involved in glycosidic bond formation, sucrose is a non-reducing sugar. Sucrose is dextrorotating but after hydrolysis sucrose brings about a change in optical activity

Maltose

Maltose is composed of two α -D-glucose units. In maltose C_1 of one glucose unit is linked to C_4 of another glucose unit to form the glycosidic linkage. Free aldehydic group at the C_1 of the glucose unit whose C_4 is attached to C_1 renders maltose a reducing sugar

Lactose

It is more commonly known as milk sugar. It is composed of β -D-galactose and β -D-glucose. In lactose glucose is reducing half and galactose is nonreducing half. It is a hetero disaccharide

Starch

Starch is a mixture of two components – water soluble amylose and water insoluble amylopectin. Amylose constitute 15 – 20 % of starch. Amylose is a long unbranched chain while amylopectin is branched chain. Starch is a food reserve in plants

Cellulose

It is the abundant organic substance in the plant kingdom. It is predominant constituent of cell wall of plant cells. It is a straight chain polysaccharide composed of only β -D-glucose. Cotton contains about 90% pure cellulose and rest fats and waxes.

Glycogen

The carbohydrates are stored in human body as glycogen. It is also known as animal starch

Mutarotation: This is a property shown by certain carbohydrates like glucose and fructose. The change in specific rotation shown by an optically active compound to attain equilibrium is known as mutarotation.

Function of carbohydrate is to act as bio fuels and provide energy for the functioning of living systems. Carbohydrates provide raw material for many industries like paper, breweries, textiles etc.

Proteins and Aminoacids

Proteins are macromolecules made up of amino acids joined by peptide linkages. Amino acids contain $-COOH$ and $-NH_2$ groups. Their general formula is $R-CH(NH_2)-COOH$.

Amino acids have zwitter ion structure due to presence of acid group and basic group.

Proteins are essential for the growth and maintenance of living cells, they are major components of muscles, skin, hair, nails tissues etc.

Structure and shape of protein can be studied in four levels

- 1) Primary structure - the sequence of aminoacids in protein
- 2) Secondary structure - the α -Helix structure and β -pleated sheet structure.
- 3) Tertiary structure - The overall folding of the polypeptide chain due to further folding of secondary structure
- 4) Quarternary structure - The spatial arrangement of subunits with respect to each other

Proteins are classified into two types based on their structure

- 1) Fibrous proteins
- 2) Globular proteins

Denaturation of protein : When a protein in its native form is subjected to temperature change or pH change it loses its biological activity. This is called denaturation of protein

Enzymes: They are biological catalyst and they are globular proteins. They catalyse the reaction million times faster than a normal catalyst. Most of the enzymes require a non-protein component to perform their

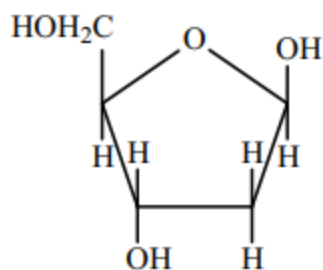
action; they are co-factors. Co-factors contains Na^+ , K^+ , Mg^{2+} , Fe^{2+} , Zn^{2+} , etc and an organic group. The organic groups are known as co-enzymes which are derived from vitamins.

Nucleic acids: They are biomolecules found in the nuclei of all living cells in the form of nucleoproteins. Each nucleotide has 3 parts; sugar(pentose), nitrogen base(purine base and pyrimidine base) and phosphoric acid.

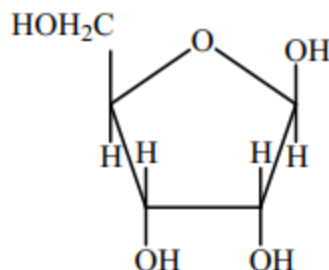
They are mainly of two types -

DNA and RNA.

Complete hydrolysis of DNA or RNA yields pentose sugar, phosphoric acid and nitrogen containing heterocyclic compounds called bases. In DNA sugar moiety is β -D-2-deoxyribose and in RNA it is β -D-ribose



β -D-2-deoxyribose



β -D-ribose

DNA contains four bases - Adenine, Guanine, cytosine and thymine

RNA also contain four bases - Adenine, guanine, cytosine and uracil

A unit formed by the attachment of a base to 1' position of sugar is known as nucleocide. When a nucleocide is linked to phosphoric acid at 5' position of sugar moiety is known as a nucleotide.

Two important functions of nucleic acids are

- i) Replication
- ii) Protein synthesis.

Vitamins: They are group of organic compounds that require are in smaller quantities for healthy growth. They are not made by the body except vitamin D and Vitamin B_{12} . So others are supplied through diet or by food supliments.

Deficiency of vitamins known as Avitaminoses. Deficiency of each vitamin will cause specific diseases. Vitamins A,D,E and K are fat soluble while vitamin B groups and vitamin C are water soluble.

Hormones: They biomolecules produced by ductless glands called endocrine glands. They control biological functions and act as chemical messengers.

They are

Steroid Hormones : Eg. Sex Hormones, Adrenal cortex hormones etc.

Peptide Hormones : Eg. Oxytocin, Vasopressin, Insulin etc.

Amine Hormones : Eg. Adrenaline, Thyroxine etc.

PART-I (JEE MAIN)

SECTION-I- Straight objective type questions

- The first member of aldose series of sugars is
 1) An aldodiose 2) An aldotriose 3) An aldotetrose 4) An aldopentose
- α -D-(+)-glucose and β -D-(+)-glucose are examples of
 1) Enantiomers 2) Conformers 3) Epimers 4) Anomers

- Match column I with column II

Column I (Carbohydrate)

A) Sucrose

B) Maltose

C) Lactose

D) Starch

E) Cellulose

Column II (Glycosidic linkage)

P) C₁ of α -D-glucose – C₄ of α -D-glucose

Q) C₁ of α -D-glucose – C₄ of α -D-glucose;
C₁ of α -D-glucose – C₆ of α -D-glucose

R) C₁ of β -D-glucose – C₄ of β -D-glucose

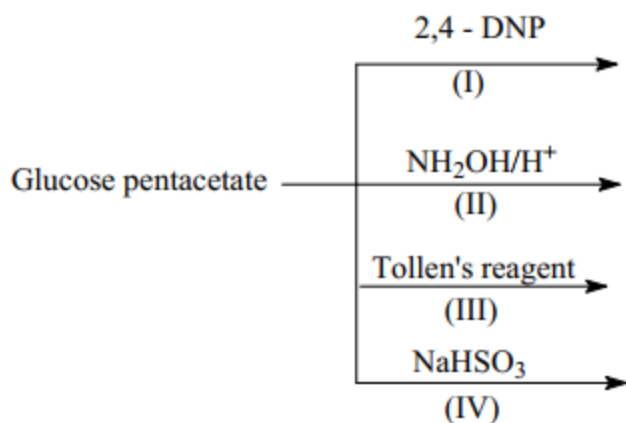
S) C₁ of β -D-galactose – C₄ of β -D-glucose

T) C₁ of α -D-glucose – C₂ of β -D-fructose

Choose the correct option

- 1) A - T, B - P, C - S, D - Q, E - R
 2) A - T, B - S, C - R, D - Q, E - R
 3) A - T, B - S, C - P, D - R, E - Q
 4) A - T, B - P, C - S, D - R, E - Q
- Which of the following is a non-reducing sugar?
 1) Sucrose 2) Glucose 3) Fructose 4) Lactose
- Consider the following reagents :
 I. Br₂ water II. Tollen's reagent III. Fehling solution
 Which of the above can be used to make distinction between an aldose and a ketose ?
 1) I, II and III 2) II and III only 3) I only 4) II only

6. Observe the following laboratory tests for glucose pentacetate and mention +ve (or) -ve for tests I-IV



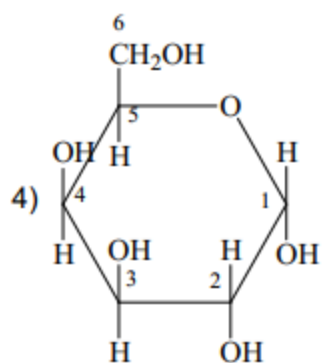
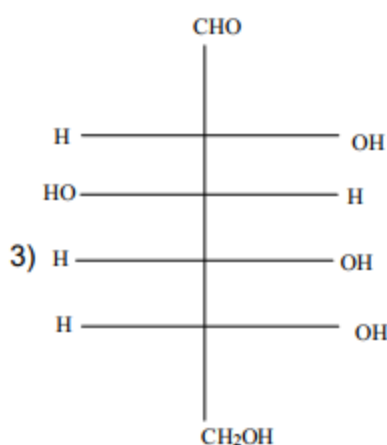
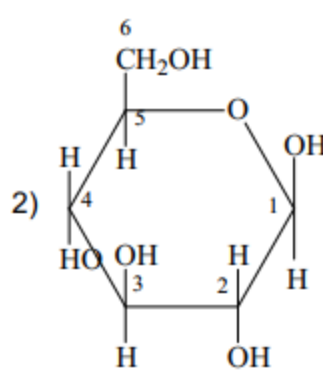
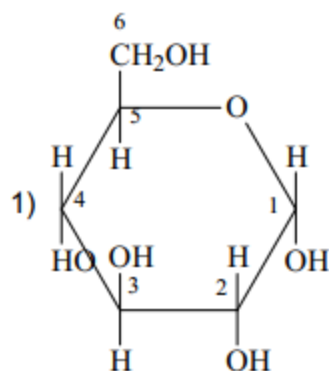
1) + + + +

2) - - - -

3) + - - -

4) + + - -

7. Haworth projection of α -D-(+)-glucose is :



8. Which of the following carbohydrates is/are branched polymer(s) of glucose?

1) Glycogen

2) Amylopectin

3) Cellulose

4) Both 1 and 2

9. Which of the following is an aromatic amino acid ?
- | | |
|---------------|------------|
| 1) Arginine | 2) Leucine |
| 3) Tryptophan | 4) Alanine |
10. The side chain of amino acids 'S', 'C' and 'M' contain
- 1) -SH, -SMe and -OH groups, respectively
 - 2) -OH, -SMe and -SH groups, respectively
 - 3) -SMe, -SH and -OH groups, respectively
 - 4) -OH, -SH and -SMe groups, respectively
11. Which one of the following is a fibrous protein?
- | | |
|------------|----------------|
| 1) Insulin | 2) Albumin |
| 3) Keratin | 4) Haemoglobin |
12. The incorrect statement regarding proteins is
- 1) Proteins are polymers of α - amino acids
 - 2) Chemically, peptide linkage is an amide formed between -COOH group and -NH₂ group of amino acids
 - 3) A tripeptide contains four amino acids linked through peptide bonds
 - 4) Insulin contains 51 amino acids
13. Amino acids are classified as acidic, basic or neutral depending upon the relative number of amino and carboxyl groups in their molecule. Which of the following can be labelled as a neutral α -amino acid?
- 1) $(\text{CH}_3)_2\text{CH}-\underset{\substack{| \\ \text{NH}_2}}{\text{CH}}-\text{COOH}$
 - 2) $\text{HOOC}-\text{CH}_2-\text{CH}_2-\underset{\substack{| \\ \text{NH}_2}}{\text{CH}}-\text{COOH}$
 - 3) $\text{H}_2\text{N}-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{COOH}$
 - 4) $\text{HOOC}-\text{CH}_2-\underset{\substack{| \\ \text{NH}_2}}{\text{CH}}-\text{COOH}$

14. Enzymes are not ——
- 1) Proteins
 - 2) Carbohydrates
 - 3) Specific for a particular reaction/substrate
 - 4) Biocatalysts
15. Denaturation of proteins does not affect
- 1) 1° structure only
 - 2) 1° and 2° structures only
 - 3) 4° structure only
 - 4) 2° and 3° structures only
16. Which one of the following vitamins is water soluble ?
- 1) Vitamin E
 - 2) Vitamin K
 - 3) Vitamin A
 - 4) Vitamin B
17. Select the incorrectly matched pair
- 1) Vitamin B₁ – Thiamine
 - 2) Vitamin B₂ – Riboflavin
 - 3) Vitamin B₁₂ – Pyridoxine
 - 4) Vitamin C - Ascorbic acid
18. Statement I: Deficiency of vitamin A leads to Xerophthalmia
Statement II: Deficiency of vitamin E leads to increased fragility of RBCs
Choose the correct option
- 1) Both Statement I and Statement II are correct
 - 2) Both Statement 1 and Statement II are incorrect
 - 3) Statement I is correct but Statement II is incorrect
 - 4) Statement I is incorrect but Statement II is correct

19. **Statement I:** In DNA and RNA, nucleotides are linked together by phosphodiester linkage

Statement II: Hydrolysis of both DNA and RNA give a pentose sugar.

Choose the correct option

- 1) Both Statement I and Statement II are correct
- 2) Both Statement 1 and Statement II are incorrect
- 3) Statement I is correct but Statement II is incorrect
- 4) Statement I is incorrect but Statement II is correct

20. The nitrogen base that is not present in RNA is

- 1) Adenine
- 2) Thymine
- 3) Uracil
- 4) Cytosine

SECTION-II - Numerical Type Questions

21. How many -OH groups are present in the sugar component of DNA?

22. Total number of chiral centres present in sucrose is —

23. Total number of essential amino acids among the following is —

Glycine, Valine, Leucine, Glutamine, Threonine, Isoleucine

24. Total number of carbonyl groups present in adenine, guanine, thymine, cytosine and uracil is

25. Total number of hormones among the following is —

Estradiol, Epinephrine, Glucagon, Thyroxine, Progesterone, Insulin

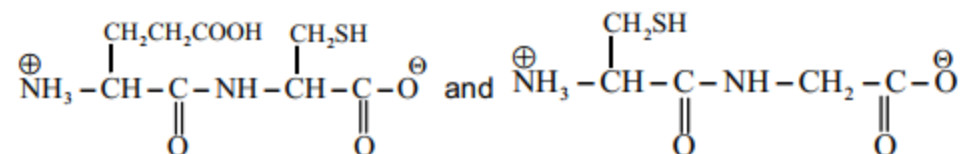
PART-II (JEE ADVANCED)

Section-III - Only one option correct type

26. All common amino acids except the following will react with cold nitrous acid (HNO_2) and evolve nitrogen gas.

- A) Cysteine B) Proline C) Histidine D) Lysine

27. A tripeptide (X) on partial hydrolysis gave the following two dipeptides:

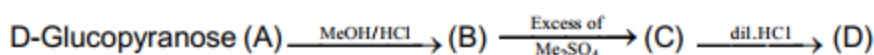


Identify the tripeptide.

- A) Glu-Cys-Gly B) Gly-Glu-Cys C) Cys-Gly-Glu D) Cys-Glu Gly

Passage-I

Consider the following reaction sequence



28. Which of the following statements is incorrect about (A)?

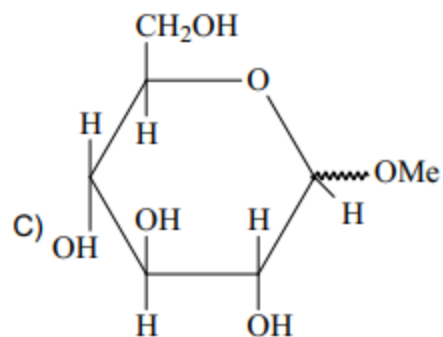
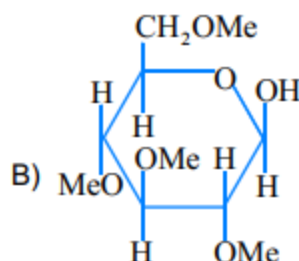
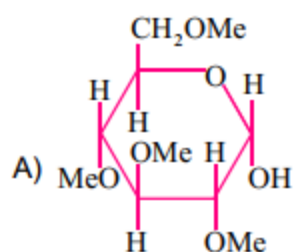
A) It contains an acetal linkage

B) It contains a hemiacetal linkage,

C) It has a six-membered cyclic ring

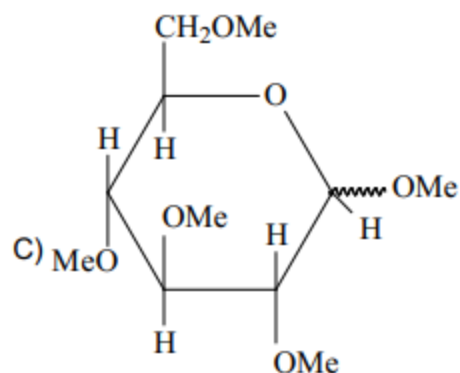
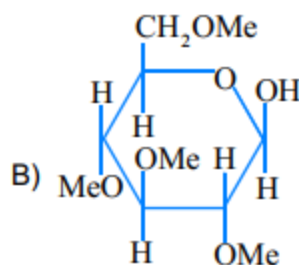
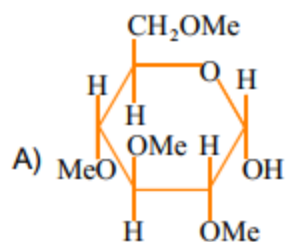
D) It has a δ -hemiacetal linkage.

29. Compound (B) is:



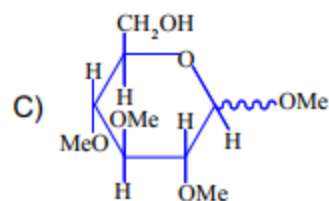
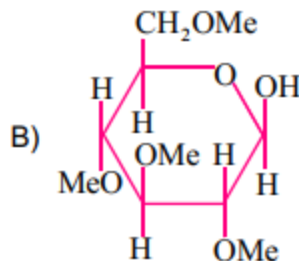
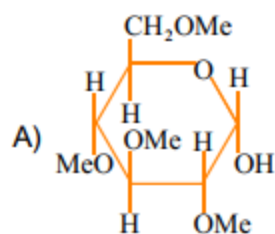
D) Both (A) and (B)

30. Compound (C) is:



D) Both A and B

31. Compound (D) is:



D) Both (A) and (B)

Passage-II

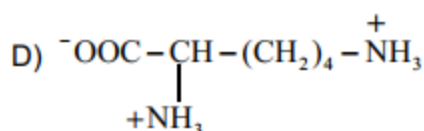
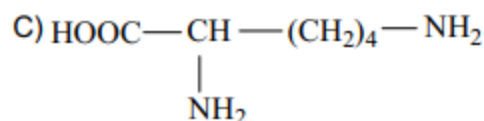
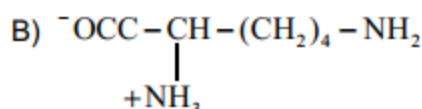
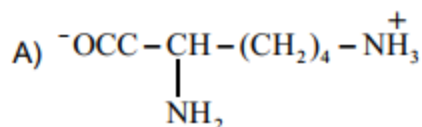
Certain amino acids and their pK_a values are listed in the table given below

AMINO ACIDS	pK_{a_1} (-COOH)	pK_{a_2} (-NH ₂)	pK_{a_3} (Side Chain)
$\text{HOOC}-\text{CH}_2-\underset{\substack{ \\ \text{NH}_2}}{\text{CH}}-\text{COOH}$ <p>Aspartic acid</p>	2.1	9.8	3.9
$\text{HOOC}-\underset{\substack{ \\ \text{NH}_2}}{\text{CH}}-(\text{CH}_2)_4-\text{NH}_2$ <p>Lysine</p>	2.2	9.0	10.5
$\text{HOOC}-\underset{\substack{ \\ \text{NH}_2}}{\text{CH}}-\text{CH}-\text{OH}$ <p>Threonine</p>	2.6	9.1	—
$\text{HOOC}-\underset{\substack{ \\ \text{NH}_2}}{\text{CH}}-\text{CH}_2\text{CH}_2\text{CONH}_2$ <p>Glutamine</p>	2.2	9.1	—

32. When an electric field is applied to a mixture of the above four amino acids, maintaining pH of the solution at 7, the one that migrates towards the positive electrode is

A) Aspartic acid B) Lysine C) Threonine D) Glutamine

33. The Zwitter ionic form of lysine is



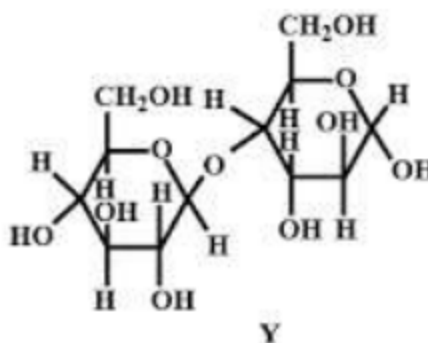
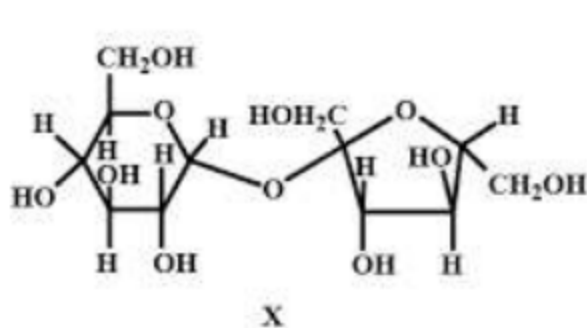
Section IV - One or more option correct type

34. Fructose $\xrightarrow{\text{NaBH}_4}$ A + B .

The products A and B in the above reaction are

A) Diastereomers B) Enantiomers
C) Anomers D) Optically active hexahydroxy compounds

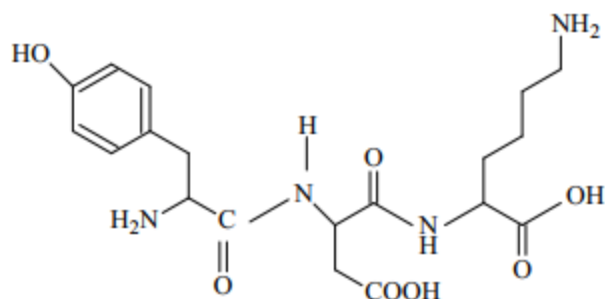
35. The correct statement(s) about the following sugars X and Y is/are



- 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 glycosidic linkage in X and Y are α and β , respectively
D) The glycosidic linkage in X and Y are β and α , respectively
36. Choose the correct statement(s) regarding structure of nucleic acids
- A) A unit formed by the attachment of a base to 1' position of sugar is known as nucleoside
B) A nucleotide is formed when nucleoside is linked to phosphoric acid at 5' position of sugar moiety
C) Nucleotides are joined together by phosphodiester linkage between 5' and 3' carbon atoms of the pentose sugar
D) Complete hydrolysis of RNA yields an aldopentose sugar, phosphoric acid and nitrogen bases

Section V - Numerical type questions

37. Structure of a peptide is given below.



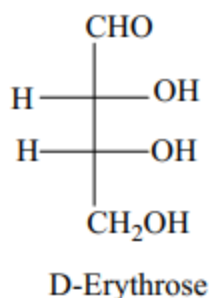
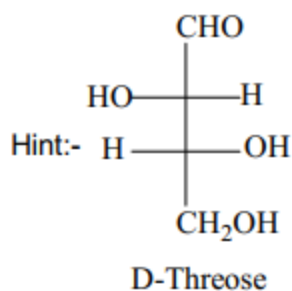
The sum of absolute values of net charge of the peptide at pH = 11 and pH = 2 is

38. How many chiral carbon atom are present in the product formed when glucose reacts with conc. HNO_3 ?
39. 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

Section-VI - Matrix match type

40. Match the following

Column-I (Reaction)	Column-II (Product)
I) D - Threose $\xrightarrow{\text{HNO}_3}$	P) Meso - Butan-1, 2, 3, 4 - tetraol
II) D - Erythrose $\xrightarrow{\text{HNO}_3}$	Q) D - Tartaric acid
III) D - Threose $\xrightarrow{\text{H}_2/\text{Ni}}$	R) Meso - Tartaric acid
IV) D - Erythrose $\xrightarrow{\text{H}_2/\text{Ni}}$	S) D - Butan-1, 2, 3, 4 - tetraol



- A) I \rightarrow Q; II \rightarrow R; III \rightarrow S; IV \rightarrow P
 C) I \rightarrow Q; II \rightarrow R; III \rightarrow P; IV \rightarrow S

- B) I \rightarrow R; II \rightarrow Q; III \rightarrow S; IV \rightarrow P
 D) I \rightarrow R; II \rightarrow Q; III \rightarrow P; IV \rightarrow S