Biomolecules

Standard difficulty · 20 questions · 40 marks · Time: 42 minutes

Name: _____ Date: _____ Score: ____ / 40

Show your working for Sections B and C. Answers are on the last page — try every question first!

Section A — Choose the correct answer — 8 × 1 = 8 marks

1. Glucose is an:
(a) aldopentose **(b)** disaccharide **(c)** ketohexose **(d)** aldohexose

2. Galactose is a:
(a) polysaccharide **(b)** disaccharide
(c) monosaccharide (aldohexose) **(d)** monosaccharide (aldopentose)

3. A deficiency of vitamin B_1 (thiamine) causes:
(a) beriberi
(b) cheilosis (cracked lips) and a sore tongue
(c) pernicious anaemia
(d) xerophthalmia and night blindness

4. A double-stranded DNA sample has 16% adenine. The percentage of guanine in it is:
(a) 34% **(b)** 32% **(c)** 84% **(d)** 16%

5. A polypeptide made of 8 amino acids contains how many peptide bonds?
(a) 6 **(b)** 8 **(c)** 7 **(d)** 9

6. Glucose reacts with HCN. The product is:
(a) a silver mirror (gluconic acid forms) **(b)** sorbitol
(c) glucose cyanohydrin **(d)** saccharic acid (glucaric acid)

7. The template strand of a DNA segment reads 5′-CCACCACC-3′. The mRNA transcribed from it reads:
(a) 3′-GGUGGUGG-5′ **(b)** 3′-GGAGGAGG-5′ **(c)** 3′-GGTGGTGG-5′ **(d)** 3′-CCACCACC-5′

8. Assertion (A): Lactose is a reducing sugar.
Reason (R): A sugar is reducing when it has a free aldehyde or ketone group, or a free hemiacetal carbon.
(a) Both A and R are true, and R is the correct explanation of A.
(b) Both A and R are true, but R is not the correct explanation of A.
(c) A is true, but R is false.
(d) A is false, but R is true.

Section B — Short answer — 8 × 2 = 16 marks

9. What are reducing sugars? Give two examples.

10. Write the mRNA transcribed from the DNA template strand 5′-TTAACCTCTACC-3′.

11. How many hydrogen bonds hold together the double-stranded DNA segment whose one strand is 5′-GCGCCCTGGAAT-3′?

12. Find the molar mass of the peptide Glu–Lys–Asp–Lys. (Molar masses: Glu 147, Lys 146, Asp 133 g/mol; water 18)

13. What kind of carbohydrate are lactose and maltose? Is each reducing, and what does each give on complete hydrolysis?

14. A person suffers from pernicious anaemia. Which vitamin is lacking, and is it fat-soluble or water-soluble?

15. 273.6 g of sucrose is completely hydrolysed. What mass of glucose forms? ($C_{12}H_{22}O_{11}$ = 342 g/mol, $C_6H_{12}O_6$ = 180 g/mol)

16. How many different tripeptides can be made from 6 different amino acids if each is used at most once?

Section C — Word problems — 4 × 4 = 16 marks

17. Give the evidence for the open-chain structure of glucose, and explain why the cyclic structure was later proposed.

18. One strand of a DNA double helix is 5′-GGCACGCTC-3′. Write (a) the complementary strand, (b) the mRNA transcribed using the given strand as template, (c) the number of hydrogen bonds between the strands, (d) the percentage of A + T in the double helix.

19. A peptide is made from lysine, alanine, serine, leucine, valine, each used once, in the order Lys–Ala–Ser–Leu–Val. Find (a) the number of peptide bonds, (b) its molar mass, (c) how many different sequences these 5 amino acids could form. (Molar masses: Lys 146, Ala 89, Ser 105, Leu 131, Val 117 g/mol; water 18)

20. Compare sucrose and maltose: give the type of carbohydrate, whether each is reducing, and the products of complete hydrolysis. How could you tell them apart in the lab?

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Answer key

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Q	Answer	Working
1	**(d) aldohexose**	—
2	**(c) monosaccharide (aldohexose)**	—
3	**(a) beriberi**	vitamin B_1 (thiamine) is water-soluble
4	**(a) 34%**	Chargaff: A = T = 16%; G = C = (100 − 32)/2 = 34%
5	**(c) 7**	each new peptide bond joins two residues and releases one water molecule
6	**(c) glucose cyanohydrin**	—
7	**(a) 3′-GGUGGUGG-5′**	A → U, T → A, G → C, C → G
8	**(a) Both A and R are true, and R is the correct explanation of A.**	A is true: it has a free aldehyde or ketone (hemiacetal) group. R is true and explains A.
9	**Sugars that reduce Fehling's solution and Tollens' reagent because they have a free aldehyde or ketone (hemiacetal) group. Examples: glucose, fructose, maltose, lactose.**	—
10	**3′-AAUUGGAGAUGG-5′**	A → U, T → A, G → C, C → G; the mRNA runs antiparallel to the template
11	**32**	A–T pairs have 2 hydrogen bonds, G–C pairs 3: 4 × 2 + 8 × 3
12	**518 g/mol**	147 + 146 + 133 + 146 − 3 × 18
13	**lactose: disaccharide, reducing, glucose and galactose; maltose: disaccharide, reducing, two glucose units**	—
14	**vitamin B_{12}; water-soluble**	A, D, E and K are fat-soluble; B and C are water-soluble
15	**144 g**	$C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6$ (glucose) + $C_6H_{12}O_6$ (fructose); 0.8 mol of each
16	**120**	6 × 5 × 4
17	**Open chain: HI gives n-hexane (six carbons in a straight chain); acetylation gives a pentaacetate (five –OH groups); HCN and hydroxylamine react (a carbonyl group); bromine water gives gluconic acid (an aldehyde). But glucose does not give Schiff's test or form a bisulphite compound, and its pentaacetate does not react with hydroxylamine; it exists as two forms (α and β) with different rotations. So it exists mainly as a six-**	—

Q	Answer	Working
	membered ring (pyranose) formed by the C-5 –OH adding to the aldehyde.	
18	**(a) 3′-CCGTGCGAG-5′; (b) 3′-CCGUGCGAG-5′; (c) 25; (d) 22.22%**	A–T: 2 H-bonds, G–C: 3; each base pair has the same A + T share on both strands
19	**(a) 4; (b) 516 g/mol; (c) 120**	5! orders; mass = sum − 4 × 18
20	**sucrose: disaccharide, non-reducing, glucose and fructose; maltose: disaccharide, reducing, two glucose units; Tollens' or Fehling's test: only the reducing sugar (maltose) gives a positive result**	reducing sugars reduce Tollens' and Fehling's reagents