Class 12 Chemistry · Chapter 10: Biomolecules

Answer key and marking scheme · 20 marks · about 40 minutes · based on NCERT

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1. The letter D in D-(+)-glucose tells us that [1]

(a) glucose is dextrorotatory

(b) the −OH on C-5, the lowest asymmetric carbon, is on the right in the Fischer projection, as in (+)-glyceraldehyde

(c) the −OH on C-2 is on the right in the Fischer projection

(d) every −OH in the Fischer projection is on the right

Answer: (b) D gives the configuration relative to glyceraldehyde, judged at the lowest asymmetric carbon (C-5) with −CHO at the top; the sign of rotation is shown separately by (+). In D-glucose the −OH on C-3 is on the left, so not every −OH is on the right.

2. Glucose, and also gluconic acid, are oxidised by nitric acid to saccharic acid, COOH−$(CHOH)_4$−COOH. This shows that glucose contains [1]

(a) five −OH groups on different carbon atoms

(b) a keto group

(c) a primary alcoholic (−CH_2OH) group

(d) a secondary alcoholic group at C-6

Answer: (c) Gluconic acid already has COOH at C-1; a second COOH can appear at C-6 only if C-6 carries a primary alcoholic −CH_2OH group, which nitric acid oxidises.

3. Take the specific rotations of D-(+)-glucose as +52.5° and of D-(−)-fructose as −92.4°, and the rotation of an equimolar mixture as the mean of the two. The specific rotation of invert sugar is [1]

(a) −19.95°

(b) +19.95°

(c) −39.9°

(d) −72.45°

Answer: (a) Hydrolysis of sucrose gives equal amounts of the two: (+52.5° − 92.4°)/2 = −19.95°. The sign is negative because fructose's laevorotation is larger. −39.9° forgets to take the mean; −72.45° adds the magnitudes.

4. The five-membered ring of D-fructofuranose is formed when [1]

(a) the −OH at C-4 adds to the keto group at C-2

(b) the −OH at C-5 adds to C-1

(c) the −OH at C-5 adds to the keto group at C-2

(d) the −OH at C-6 adds to the keto group at C-2

Answer: (c) Addition of the C-5 −OH to the >C=O at C-2 closes a ring of one oxygen and four carbons (C-2 to C-5), like furan. C-1 carries no carbonyl; a C-4 −OH would give a four-membered ring and a C-6 −OH a six-membered one.

5. α-D-glucopyranose and β-D-glucopyranose differ only in the configuration at [1]

(a) C-5

(b) C-2

(c) C-4

(d) C-1

Answer: (d) The two cyclic forms are anomers: they differ only in the position of the −OH at C-1, the anomeric carbon, which was the aldehyde carbon before cyclisation.

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6. One strand of a DNA segment reads 5′–A–T–G–C–C–A–3′. Write the complementary strand, and find the number of hydrogen bonds holding the segment together, taking two for each A=T pair and three for each G≡C pair. [2]

Adenine pairs with thymine and guanine with cytosine: complementary strand 3′–T–A–C–G–G–T–5′. Base pairs: A=T, T=A, A=T are three A–T pairs (3 × 2 = 6 hydrogen bonds); G≡C, C≡G, C≡G are three G–C pairs (3 × 3 = 9). Total 15 hydrogen bonds.

- complementary strand 3′–T–A–C–G–G–T–5′ (1)
- 15 hydrogen bonds, with the working (1)

7. Write balanced equations, with the conditions over the arrow, for obtaining glucose (a) from sucrose in the laboratory, (b) from starch commercially. [2]

(a) $C_{12}H_{22}O_{11} + H_2O$ —(dilute HCl or H_2SO_4, boiled in alcoholic solution)→ $C_6H_{12}O_6$ (glucose) + $C_6H_{12}O_6$ (fructose). (b) $(C_6H_{10}O_5)n + nH_2O$ —(dilute H_2SO_4, 393 K, 2–3 atm)→ $nC_6H_{12}O_6$ (glucose).

- (a) balanced equation from sucrose, acid named, glucose and fructose as products (1)
- (b) balanced equation from starch with dilute H_2SO_4, 393 K and pressure (1)

8. Write the equation for the formation of the dipeptide alanylglycine (Ala-Gly), in which the carboxyl group of alanine forms the peptide bond, and mark the peptide linkage in the product. [2]

$H_2N–CH(CH_3)–COOH + H_2N–CH_2–COOH \rightarrow H_2N–CH(CH_3)–CO–NH–CH_2–COOH + H_2O$. The peptide linkage is the –CO–NH– between the carbonyl carbon of alanine and the nitrogen of glycine; the free $–NH_2$ is on the alanine end and the free –COOH on the glycine end.

- correct equation with the water eliminated (1)
- –CO–NH– marked between alanine's C=O and glycine's N (1)

9. Describe the Haworth structure of β-D-(+)-glucopyranose: where the ring oxygen lies and which groups point up or down at C-2 to C-5. Name the anomeric carbon, state what changes in the α form, and say why the ring is called a pyranose. [3]

The ring has six members: five carbons and the oxygen between C-5 and C-1. C-5 carries CH_2OH up; the –OH at C-4 is down, at C-3 up, at C-2 down. C-1 is the anomeric carbon: in the β form its –OH is up; in α-D-(+)-glucopyranose it is down, all else the same. A ring of one oxygen and five carbons is named pyranose by analogy with pyran.

- ring O between C-5 and C-1; CH_2OH up at C-5, –OH down at C-4, up at C-3, down at C-2 (1)
- C-1 anomeric, –OH up in β, down in α (1)
- pyranose: six-membered ring like pyran (1)

10. (a) A sucrose solution is warmed with dilute acid until half the sucrose has been hydrolysed. Which sugars are now present, and in what mole ratio? (b) Using the specific rotations +52.5° and −92.4°, explain why the fully hydrolysed product is laevorotatory and why it is called invert sugar. (c) Why is sucrose a non-reducing sugar? [3]

(a) $C_{12}H_{22}O_{11} + H_2O \rightarrow C_6H_{12}O_6$ (D-(+)-glucose) + $C_6H_{12}O_6$ (D-(–)-fructose): each mole hydrolysed gives one mole of each. With half the sucrose left, sucrose : glucose : fructose = 1 : 1 : 1. (b) Glucose rotates +52.5° and fructose −92.4°; the laevorotation of fructose is larger, so the mixture is laevorotatory. Sucrose itself is dextrorotatory, so the sign changes from (+) to (–) on hydrolysis: the product is invert sugar. (c) The glycosidic linkage joins C1 of α-D-glucose and C2 of β-D-fructose, using both reducing groups.

- (a) sucrose, D-(+)-glucose and D-(–)-fructose, 1 : 1 : 1 (1)
- (b) larger laevorotation of fructose; sign changes from + to − (1)
- (c) both reducing groups in the C1–C2 linkage (1)

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11. A forensic laboratory compares DNA from a hair root found at a scene with DNA from the blood of three suspects. (a) What property of a person's DNA makes this comparison possible? (b) Why may DNA from a hair root be compared with DNA from blood? (c) Give one other use of DNA fingerprinting. [3]

(a) The sequence of bases in each person's DNA is unique to that person. (b) The sequence is the same in every cell of the body and cannot be altered by any known treatment, so hair-root DNA and blood DNA of one person match. (c) Any one: determining paternity; identifying a dead body by comparison with the DNA of parents or children; identifying racial groups.

- (a) unique base sequence for each person (1)
- (b) same in every cell, unalterable (1)
- (c) one valid use (1)

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