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# Biomolecules — JEE (Main) Pattern Topic Test

FREE SAMPLE TEST · CHEMISTRY · PATTERN OF JEE (MAIN)

| DURATION | MAXIMUM MARKS | QUESTIONS | NAME / ROLL NO. |
|---|---|---|---|
| 60 minutes | 100 | 25 (20 + 5) | |

## GENERAL INSTRUCTIONS

1. This question paper has two sections, A and B. All 25 questions are compulsory.
2. Section A has TWENTY (20) multiple-choice questions. Each has FOUR options, (1), (2), (3) and (4), of which ONLY ONE is correct.
3. Section B has FIVE (05) questions whose answer is a numerical value. Enter the value rounded off to the nearest integer.
4. Marking scheme for both sections: +4 for a correct answer, −1 for an incorrect answer, 0 if the question is not attempted.
5. Use of a calculator, log tables or any other aid is not allowed.
6. The answer key and worked solutions are at the end of this booklet. Attempt the paper in 60 minutes before you look at them.

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**Topics covered:** Carbohydrates: monosaccharides · Carbohydrates: disaccharides and polysaccharides · Amino acids and proteins · Vitamins · Nucleic acids · Hormones

## SECTION A (Q1–20) · Multiple choice · +4 / 0 / −1

Each question has FOUR options. ONLY ONE of them is correct.

**1.** In sucrose and in its free cyclic form, D-fructose exists as a five-membered ring (furanose) formed when the –OH on C-5 adds to the C-2 keto group. The ring contains

(1) 5 carbon atoms and 1 oxygen atom

(2) 3 carbon atoms and 1 oxygen atom

(3) 4 carbon atoms and 1 oxygen atom

(4) 4 carbon atoms and 2 oxygen atoms

**2.** In sucrose, the two monosaccharide units are joined by a glycosidic linkage between

(1) C-1 of α-D-glucose and C-4 of β-D-fructose

(2) C-1 of β-D-glucose and C-2 of α-D-fructose

(3) C-1 of α-D-glucose and C-2 of β-D-fructose

(4) C-1 of α-D-glucose and C-6 of β-D-fructose

**3.** Which of the following statements about starch is correct?

(1) Amylose is branched and forms about 80–85% of starch.

(2) Amylopectin is insoluble in water and has α-D-glucose units joined by C1–C4 linkages in the chain and C1–C6 linkages at the branches.

(3) Both amylose and amylopectin contain β-D-glucose units.

(4) Amylose has C1–C6 linkages only.

**4.** The prefix D in D-glucose means that

(1) glucose rotates plane-polarised light to the right

(2) the –OH group on C-2 is on the right in the Fischer projection

(3) the –OH group on the lowest chiral carbon (C-5) is on the right in the Fischer projection, as in D-glyceraldehyde

(4) glucose is a dextrorotatory aldose made from starch

**5.** The molecular formula of 2-deoxy-D-ribose, the sugar in DNA, is

(1) $C_5H_{10}O_5$

(2) $C_5H_{10}O_4$

(3) $C_6H_{12}O_6$

(4) $C_5H_8O_4$

**6.** Which of the following amino acids is NOT optically active?

(1) glycine

(2) alanine

(3) valine

(4) serine

**7.** The α-helix, a secondary structure of proteins, is held in shape mainly by

(1) disulphide bonds between cysteine units

(2) ionic bonds between $-COO^-$ and $-NH_3^+$ side chains

(3) hydrogen bonds between the –NH group of one amino acid unit and the C=O group of a unit in the next turn of the same chain

(4) peptide bonds between two different chains

**8.** Statement I: When an egg is boiled, the soluble globular protein albumin coagulates because the protein is denatured.
Statement II: Denaturation breaks the peptide bonds of the protein and so destroys its primary structure.
In the light of the above statements, choose the correct answer from the options given below:

(1) Both Statement I and Statement II are true

(2) Statement I is true but Statement II is false

(3) Statement I is false but Statement II is true

(4) Both Statement I and Statement II are false

**9.** Assertion A: The C–N bond in a peptide link (–CO–NH–) is shorter than a normal C–N single bond, and the peptide group is planar.
Reason R: The lone pair of the nitrogen is delocalised on to the C=O group, giving the C–N bond partial double bond character.
In the light of the above statements, choose the correct answer from the options given below:

(1) Both A and R are true and R is the correct explanation of A

(2) Both A and R are true but R is NOT the correct explanation of A

(3) A is true but R is false

(4) A is false but R is true

**10.** Match List-I (vitamin) with List-II (deficiency disease).
List-I: (A) Vitamin K (B) Vitamin E (C) Vitamin B2 (D) Vitamin B6
List-II: (I) Convulsions (II) Increased blood clotting time (III) Cheilosis (fissuring at the corners of the mouth) (IV) Increased fragility of red blood cells and muscular weakness
Choose the correct answer from the options given below:

(1) A-II, B-IV, C-III, D-I

(2) A-II, B-III, C-IV, D-I

(3) A-IV, B-II, C-III, D-I

(4) A-II, B-IV, C-I, D-III

**11.** Which vitamin contains a cobalt atom in its structure?

(1) vitamin B1

(2) vitamin C

(3) vitamin B6

(4) vitamin B12

**12.** In a nucleic acid chain, successive nucleotides are joined by

(1) phosphodiester links between C-5′ of one sugar and C-3′ of the next

(2) glycosidic links between C-1′ of one sugar and C-4′ of the next

(3) peptide bonds between the bases

(4) hydrogen bonds between the phosphate groups

**13.** In double-stranded DNA, the base pair held together by three hydrogen bonds is

(1) adenine–thymine

(2) guanine–cytosine

(3) adenine–uracil

(4) guanine–adenine

**14.** Which of the following hormones contains iodine?

(1) insulin

(2) adrenaline

(3) thyroxine

(4) testosterone

**15.** Which of the following is a steroid hormone?

(1) insulin

(2) testosterone

(3) glucagon

(4) adrenaline

**16.** Glycogen is

(1) an unbranched polymer of β-D-glucose found in plant cell walls

(2) a highly branched polymer of α-D-glucose, stored in the liver, muscles and brain

(3) a disaccharide found in milk

(4) a polymer of fructose stored in plant roots

**17.** Human beings cannot digest cellulose, although it is a polymer of glucose, because

(1) cellulose is not made of glucose units

(2) humans lack the enzymes that hydrolyse the β-glycosidic linkages of cellulose

(3) cellulose is a protein

(4) cellulose has C1–C6 linkages only

**18.** Fructose is a ketose, yet it reduces Tollens' reagent and Fehling's solution. This is because

(1) fructose contains a free –CHO group

(2) in alkaline solution, fructose (an α-hydroxy ketone) is converted through an enediol into aldoses, which are oxidised

(3) fructose is hydrolysed to glucose by water

(4) all ketones reduce Tollens' reagent

**19.** The six-membered cyclic (pyranose) form of D-glucose is a hemiacetal formed by the reaction of

(1) the –OH on C-4 with the C-1 aldehyde group

(2) the –OH on C-6 with the C-1 aldehyde group

(3) the –OH on C-2 with the C-5 –OH group

(4) the –OH on C-5 with the C-1 aldehyde group

**20.** Which hormone raises the level of glucose in the blood?

(1) insulin

(2) thyroxine

(3) oestradiol

(4) glucagon

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**SECTION B (Q21–25) · Numerical value · +4 / 0 / −1**

The answer to each question is a NUMERICAL VALUE. Enter it rounded off to the nearest integer.

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**21.** The specific rotations of α-D-glucose and β-D-glucose are +111° and +19.2°. A solution of either form slowly changes until its specific rotation is +52.5° (mutarotation), the open-chain form being negligible. The percentage of the β form in the equilibrium mixture (to the nearest integer) is _____.

Answer: _____

**22.** Sucrose (specific rotation +66.5°) is hydrolysed to an equimolar mixture of D-glucose (+52.5°) and D-fructose (−92.4°). The magnitude of the specific rotation of this invert sugar (in degrees, to the nearest integer) is _____. (Glucose and fructose have the same molar mass.)

Answer: _____

**23.** Glycine has pKa values of 2.34 (–COOH) and 9.60 ($-NH_3^+$). Its isoelectric point is x/10. The value of x (to the nearest integer) is _____.

Answer: _____

**24.** The molar mass (in g/mol) of the tripeptide Gly–Ala–Gly is _____. (Glycine $C_2H_5NO_2$, alanine $C_3H_7NO_2$; H = 1, C = 12, N = 14, O = 16)

Answer: _____

**25.** A double-stranded DNA segment has 100 base pairs, and 30% of all its bases are adenine. The total number of hydrogen bonds between the two strands is _____.

Answer: _____

**END OF THE QUESTION PAPER**

## ANSWER KEY

| Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 |
|---|---|---|---|---|---|---|---|---|---|
| (3) | (3) | (2) | (3) | (2) | (1) | (3) | (2) | (1) | (1) |

| Q11 | Q12 | Q13 | Q14 | Q15 | Q16 | Q17 | Q18 | Q19 | Q20 |
|---|---|---|---|---|---|---|---|---|---|
| (4) | (1) | (2) | (3) | (2) | (2) | (2) | (2) | (4) | (4) |

| Q21 | Q22 | Q23 | Q24 | Q25 |
|---|---|---|---|---|
| 64 | 20 | 60 | 203 | 240 |

## WORKED SOLUTIONS

**Q1. Answer (3).** The ring is C-2, C-3, C-4, C-5 and the oxygen that was on C-5: four carbons and one oxygen, five atoms in all. C-1 and C-6 (both $CH_2OH$) stay outside the ring, and C-2 becomes the new (anomeric) chiral centre.

**Q2. Answer (3).** The link joins the two reducing (anomeric) carbons, C-1 of α-D-glucose and C-2 of β-D-fructose. As neither free hemiacetal group is left, sucrose is a non-reducing sugar.

**Q3. Answer (2).** Amylose (15–20% of starch) is a water-soluble, unbranched chain of α-D-glucose units joined C1–C4. Amylopectin (80–85%) is insoluble and branched: C1–C4 links along the chains, C1–C6 links at the branch points.

**Q4. Answer (3).** D and L describe the configuration relative to glyceraldehyde: the –OH on the chiral carbon farthest from the C=O (C-5 in glucose) is on the right. The sign of rotation is shown separately, by (+) or (−); D-fructose, for example, is laevorotatory.

**Q5. Answer (2).** Ribose is $C_5H_{10}O_5$. In 2-deoxyribose the –OH on C-2 is replaced by –H, which removes one oxygen atom: $C_5H_{10}O_4$.

**Q6. Answer (1).** In glycine, $H_2N–CH_2–COOH$, the α-carbon carries two hydrogen atoms, so it is not chiral. In the others the α-carbon has four different groups (H, $NH_2$, COOH and $CH_3$, $CH(CH_3)_2$ or $CH_2OH$).

**Q7. Answer (3).** In the α-helix the chain coils into a right-handed spiral, and each –NH is hydrogen-bonded to the C=O of a unit one turn further along the same chain. In the β-pleated sheet the hydrogen bonds are between neighbouring chains.

**Q8. Answer (2).** I is true: heat disturbs the hydrogen bonds that hold the secondary and tertiary structure, the globules unfold, and the protein coagulates. II is false: in denaturation the primary structure (the sequence held by peptide bonds) is left intact; only the higher structures and the biological activity are lost.

**Q9. Answer (1).** Resonance $–C(=O)–NH– \leftrightarrow –C(–O^-)=NH^+–$ gives the C–N bond partial double bond character (about 132 pm instead of 147 pm), which stops rotation and keeps the six atoms of the group in one plane. Both true; R explains A.

**Q10. Answer (1).** Vitamin K: increased blood clotting time. Vitamin E: increased fragility of red blood cells and muscular weakness. Vitamin B2 (riboflavin): cheilosis, digestive disorders, burning of the skin. Vitamin B6 (pyridoxine): convulsions.

**Q11. Answer (4).** Vitamin B12 (cyanocobalamin) has a cobalt ion at the centre of a corrin ring. It is the vitamin whose lack causes pernicious anaemia.

**Q12. Answer (1).** The phosphate group forms ester links with the 5′-OH of one pentose and the 3′-OH of the next: a phosphodiester backbone. The bases hang from C-1′ of each sugar, and hydrogen bonds between bases hold the two strands of DNA together.

**Q13. Answer (2).** Guanine pairs with cytosine through three hydrogen bonds; adenine pairs with thymine through two. (Adenine–uracil pairs occur with RNA, and two purines never pair.) So DNA rich in G–C is harder to separate into strands.

**Q14. Answer (3).** Thyroxine, made by the thyroid gland, is an iodinated derivative of the amino acid tyrosine. A lack of iodine in the diet lowers thyroxine production and causes goitre.

**Q15. Answer (2).** Testosterone (like oestradiol and the corticoids) has the four-ring steroid skeleton. Insulin and glucagon are polypeptides, and adrenaline is an amino acid derivative.

**Q16. Answer (2).** Glycogen (animal starch) has a structure like amylopectin but more highly branched. When the body needs glucose, enzymes break glycogen down. Cellulose is the β-glucose polymer of plant walls and lactose the milk sugar.

**Q17. Answer (2).** Cellulose is a straight chain of β-D-glucose units joined by C1–C4 β-glycosidic linkages. Human digestive enzymes (amylases) hydrolyse α-linkages of starch but not β-linkages; ruminants digest cellulose with the help of micro-organisms.

**Q18. Answer (2).** Both reagents are alkaline. Base removes an α-hydrogen from fructose, $–CO–CH_2OH$, forming an enediol, which can re-form as glucose or mannose (with a –CHO group); these reduce the reagents. Ordinary ketones such as propanone do not.

**Q19. Answer (4).** The –OH on C-5 adds to the C=O at C-1, giving a ring of five carbons and one oxygen (pyranose). C-1 becomes a new chiral centre, giving the α and β anomers.

**Q20. Answer (4).** Glucagon, from the pancreas, raises blood glucose by causing the breakdown of glycogen in the liver. Insulin does the opposite, so the two together keep the glucose level within narrow limits.

**Q21. Answer 64.** Let x be the fraction of β: $19.2x + 111(1 - x) = 52.5$, so $x = (111 - 52.5)/(111 - 19.2) = 58.5/91.8 = 0.637$, i.e. 64%.

**Q22. Answer 20.** An equimolar mixture of two isomers is a 1 : 1 mixture by mass, so its specific rotation is the average: $(52.5 - 92.4)/2 = -19.95°$. The sign changes from + to − (hence 'invert'); the magnitude is 20.

**Q23. Answer 60.** At the isoelectric point the zwitterion $H_3N^+–CH_2–COO^-$ dominates and the net charge is zero: $pI = (pKa_1 + pKa_2)/2 = (2.34 + 9.60)/2 = 5.97 = 59.7/10$, so x = 60.

**Q24. Answer 203.** Joining three amino acids forms two peptide bonds and releases two water molecules: $2 \times 75 + 89 - 2 \times 18 = 239 - 36 = 203$ g/mol.

**Q25. Answer 240.** 200 bases; A = 30% = 60, so T = 60 and 60 A–T pairs; the remaining 40 pairs are G–C. Hydrogen bonds = $60 \times 2 + 40 \times 3 = 120 + 120 = 240$.

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All questions are original and © Master Testing Agency. Free to download and use for personal practice; not for resale. Every answer in this paper was checked independently by computer: sugars and amino acids were built as graphs for chiral centres and formulas, the mutarotation, invert sugar, isoelectric point, peptide mass and DNA questions were calculated, and the fact questions were checked against separate tables.