

# Preface

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Enhance your understanding and practice efficiently with this thoughtfully designed **TEST PREP QUESTIONS BANK** exclusively for **MSc BIOTECHNOLOGY** and **LIFE SCIENCES ENTRANCE EXAMS** such as **CUET-PG, IIT-JAM, GAT-B** and others. It is strategically crafted to optimize learning and save valuable time through the following key features:

- **Systematic practice of topic-wise segregated previous years' questions:** Previous years' questions (PYQs) from IIT-JAM (Biotechnology) and CUET-PG (Life Sciences and Zoology), and GAT-B along with their solutions, are organized in a topic-wise manner, providing a structured approach to learning and making it easy to target specific areas for focused practice and review.
- **Enhanced clarity and accuracy:** Previous years' questions have been thoroughly corrected and refined, including improvements to language, clarity of options, and overall accuracy—ensuring you're practicing with the highest quality material.
- **Focused and relevant:** We have strategically excluded PYQs that are purely fact-based, contain errors, or lack strong conceptual value—ensuring your practice time is spent on high-yield material.
- **Concept-based, analytical, and synthetic questions:** In addition to PYQs, this book includes similar practice-oriented questions designed to strengthen your conceptual understanding, analytical reasoning, and synthetic problem-solving skills—preparing you for complex challenges.

## Acknowledgements

A book of this nature demands meticulous and dedicated efforts from all its contributors. This work is the result of collaboration among several diligent and hardworking individuals, whose commitment has shaped the book into its present form. We extend our heartfelt gratitude to each of them, with special thanks to Ankit Gupta and Ajay Kumar for their valuable contributions. We are particularly grateful to Pradeep Verma for his exceptional work in designing, layout, and organization, which played a crucial role in bringing this book to completion.

**Pranav Kumar**

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# Biomolecules and Catalysis

## Amino acids and Peptides

01. Which of the following statements about standard amino acids are *correct*?
  - P. Amino acids have an amino group, carboxyl group and R groups.
  - Q. Only 22 standard amino acids are used in ribosome-mediated protein synthesis.
  - R. Average mass of an amino acid residue is  $\sim 110$  Da.
  - S. Universal genetic code specifies only standard amino acids.
  - a. P and Q
  - b. Q and S
  - c. Q and R
  - d. P, Q, R and S
02. Which one of the following pairs of amino acids is *not* incorporated in a polypeptide chain?
  - a. 4-Hydroxyproline and  $\gamma$ -carboxyglutamate
  - b.  $\gamma$ -Carboxyglutamate and desmosine
  - c. Ornithine and citrulline
  - d. 4-Hydroxyproline and 5-hydroxylysine
03. Which of the following statements about *standard amino acids* are *correct*?
  - P. There are total 22 standard amino acids.
  - Q. Each standard amino acid is specified by codons.
  - R. Standard amino acids predominantly exhibit the L-configuration.
  - S. Standard amino acids are incorporated into peptides and polypeptides by ribosomes during translation.
  - a. P and Q
  - b. Q and S
  - c. Q and R
  - d. P, Q, R and S
04. Select the *incorrect* statement regarding standard amino acids:
  - a. Aspartate has the lowest isoelectric point (pI).
  - b. Arginine has the highest isoelectric point (pI).
  - c. The side chain  $\text{pK}_a$  value is highest for aspartate.
  - d. Isoleucine has the highest hydropathy value among standard amino acids.

05. Which of the following is *not true* about alanine?
- At pH 1, the overall charge is +1.
  - At pH 1, it will move towards cathode.
  - An equimolar mixture of *d* and *l* alanine does not rotate the plane polarized light.
  - It contains branched side chain.
06. Given that the three  $pK_a$  values of histidine are  $pK_1 = 1.8$ ,  $pK_2 = 9.2$  and  $pK_R = 6.0$ , what is the isoelectric point of histidine?
- 3.4
  - 7.60
  - 6
  - 5.5
07. Which statement best describes the  $pK_a$  of amino groups in proteins?
- $pK_a$  of  $\alpha$ -amino group is higher than the  $pK_a$  of  $\epsilon$ -amino group.
  - $pK_a$  of  $\alpha$ -amino group is lower than the  $pK_a$  of  $\epsilon$ -amino group.
  - $pK_a$  of  $\alpha$ -amino group is same as the  $pK_a$  of  $\epsilon$ -amino group.
  - $pK_a$  of  $\alpha$ -amino group is higher than the  $pK_a$  of guanidine side chain of arginine.
08. The C-terminal carboxyl group and the N-terminal amino group in amino acids have a dissociation constant ( $pK_a$ ) of 2.2 and 9.2, respectively. The  $pK_a$  of side chain carboxyl group in glutamic acid is 4.2 and side chain amino group in lysine is 10.2. The difference in isoelectric point (pI) of lysine and glutamic acid is
- 6.5
  - 3.2
  - 7.3
  - 2.2
09. The  $pK_a$  values of the carboxyl and amino groups of an amino acid with a non-ionizable side chain are 2.17 and 9.13, respectively. What is the isoelectric point of this amino acid?
- 2.25
  - 8.12
  - 5.65
  - 10
10. Which one of the following statement is *correct* about a water soluble globular protein?
- Charged amino acid side chains are always buried.
  - Charged amino acid side chains are seldom buried.
  - Non-polar amino acid side chains are seldom buried.
  - Tyrosine residues are always buried.
11. An amino acid contains no ionizable group in its side chain. It is titrated from pH 0 to 14. Which of the following ionizable state is not observed during the entire titration in the pH range 0-14?
- $$\begin{array}{c} \text{R} \\ | \\ \text{H}_3\text{N}^+ - \text{CH} - \text{COO}^- \end{array}$$
  - $$\begin{array}{c} \text{R} \\ | \\ \text{H}_3\text{N}^+ - \text{CH} - \text{COOH} \end{array}$$
  - $$\begin{array}{c} \text{R} \\ | \\ \text{H}_2\text{N} - \text{CH} - \text{COO}^- \end{array}$$
  - $$\begin{array}{c} \text{R} \\ | \\ \text{H}_2\text{N} - \text{CH} - \text{COOH} \end{array}$$
12. If the molecular mass of an amino acid is 150 daltons, the molecular mass of a linear tripeptide will be
- 450
  - 486
  - 504
  - 414
13. The closest estimate for the number of amino acid residues in a protein with a molecular mass of 85 kDa is
- 770 amino acid residues
  - 7100 amino acid residues
  - 8500 amino acid residues
  - 85 amino acid residues

14. If one arginine has a molecular mass of 174 Daltons, then what would be the molecular mass (in Daltons) of a circular polymer of 38 arginines?  
a. 6612 Daltons  
b. 5928 Daltons  
c. 5946 Daltons  
d. 7278 Daltons  
[IISc]
15. The molecular formula for glycine is  $C_2H_5O_2N$ . What would be the molecular formula for a linear oligomer made by linking ten glycine molecules together by condensation synthesis?  
a.  $C_{20}H_{50}O_{20}N_{10}$   
b.  $C_{20}H_{32}O_{11}N_{10}$   
c.  $C_{20}H_{40}O_{10}N_{10}$   
d.  $C_{20}H_{68}O_{29}N_{10}$
16. A protein-X was fused with GFP in a vector and expressed in *E. coli*. The length of the protein-X is 1000 amino acid residues and the molecular weight of GFP is 27 kilodaltons. What is the total approximate molecular mass of the fusion protein in daltons?  
a. 137000  
b. 138000  
c. 83000  
d. 270000  
[IISc]
17. Aspartate residues are found in the active sites of many enzymes. The  $pK_a$  for the  $\beta$ -carboxylate of aspartate is 3.86. At physiological pH this group can function as  
a. a nucleophile and a conjugate acid.  
b. an electrophile and a conjugate acid.  
c. a nucleophile and a conjugate base.  
d. an electrophile and a conjugate base.
18. Which one of the following amino acids has more than two acid-base groups?  
a. Alanine  
b. Leucine  
c. Phenylalanine  
d. Tyrosine
19. At the isoelectric point of an enzyme, which is 5, it was observed that there are 10 positively charged groups and 10 negatively charged groups. When the enzyme was titrated with alkali starting from pH 5 to give pH 7, 3 positively charged groups were deprotonated. The net charge on the protein at pH 7 would be  
a. +2  
b. -3  
c. -7  
d. -10  
[JNU]
20. Isoelectric point of the enzyme ribonuclease is 9.3. It was observed that at this point there are 10 positively charged and 10 negatively charged side chains of amino acids. When the enzyme solution was titrated with HCl to give a pH of 3, it was observed that 2 ionized glutamic acid and 1 ionized aspartic acid side chain got protonated. The net charge on the enzyme at pH 3 would, therefore, be  
a. +2  
b. +3  
c. +7  
d. +9
21. Imagine you are generating a site-directed mutant of a protein in which a given residue is replaced by another residue. Which one of the following substitutions will result in the highest isoelectric point of the mutant compared to the wild type? (X  $\rightarrow$  Y means residue X in the wild type is replaced by residue Y in the mutant).  
a. Asp  $\rightarrow$  Arg  
b. Arg  $\rightarrow$  Asp  
c. Tyr  $\rightarrow$  Lys  
d. Gly  $\rightarrow$  Arg  
[JNU]
22. Which of the following statements is *false*?  
a. Amino acids tend to be least soluble in water at their isoelectric point.  
b. The amino acid isoleucine has only one chiral center.  
c. Amino acids are made visible on the chromatogram by treatment with ninhydrin.  
d. The net charge on an amino acid is a function of the pH of the solution.

23. Which of the following statements are *correct* about the amino acid isoleucine?
- P. It has two chiral centers. Q. It has four optical isomers  
R. It has non-polar side chain S. It has very high hydropathy value  
a. P and Q b. P and S  
c. R and S d. P, Q, R and S
24. Which of the following statements are *correct* about selenocysteine?
- P. It is recognized as the 21st standard amino acid.  
Q. Its structure closely resembles that of cysteine.  
R. It contains selenium in place of sulfur.  
S. It is encoded by the UGA codon, which stop codon.  
a. P and Q b. P and S  
c. R and S d. P, Q, R and S
25. Which one of the following peptides lacks a chiral center at the first position, is devoid of a hydrogen in the backbone amide at the second position and the side-chain of the third residue has a  $pK_a$  close to the physiological pH?
- a. Gly-Pro-Tyr b. Pro-Gly-Tyr  
c. Pro-Gly-His d. Gly-Pro-His
26. What is the value of net charge in a peptide, GWYQR (Gly-Trp-Tyr-Gln-Arg), at pH 10.5?
- a. -1 b. 0  
c. -2 d. +1
27. What is the net charge of the peptide Tyr-Val-Arg at pH 5.0? The  $pK_a$  of  $\alpha$ -amino and carboxyl groups are 9.6 and 2.3, respectively. The  $pK_a$  of Tyr and Arg side chains are 10.46 and 12.48, respectively.
- a. 1.0 b. 5  
c. 2.5 d. 11
28. An amino acid has one proton donating group in the side chain. The  $pK_1$ ,  $pK_2$  and  $pK_R$  values for this amino acid are 2.19, 9.67 and 4.25, respectively. Which one of the following statements about this amino acid is *correct*?
- a. Majority of the molecules will have a net charge of -1 at pH of 7.0.  
b. Majority of the molecules will have a net charge of 0 at pH of 4.25.  
c. All the molecules will have a deprotonated R group at pH of 3.22.  
d. During titration with a strong base, deprotonation will start with the R group. [IIT-JAM]
29. Reduced glutathione is  $\gamma$ -Glutamyl-Cysteinyl-Glycine. At pH 9.0, the net charge on reduced glutathione is
- a. 0 b. -1  
c. -2 d. -3

30. Match list I with list II.

List I (Amino acid)	List II ( $pK_a$ value)
A. $\alpha$ -Carboxyl groups	1. 1.8 - 2.9
B. $\alpha$ -Amino groups	2. 8.8 - 10.8
C. Side chain carboxyl group of Asp	3. 12.5
D. Side chain guanidino group of Arg	4. 3.9

Choose the *correct* answer from the options given below:

- a. A-1, B-2, C-3, D-4  
b. A-1, B-2, C-4, D-3  
c. A-1, B-3, C-4, D-2  
d. A-3, B-4, C-1, D-2 [CUET-PG]
31. Of the groups of amino acids indicated below, which one group of amino acids can be phosphorylated?  
a. Thr, Tyr, Asn  
b. Ser, Thr, Tyr  
c. Ser, Phe, Asn  
d. Ser, Thr, Phe [IIT-JAM]
32. In cell-free lysates of *E. coli*, radioactive isotope, [ $\gamma^{32}\text{P}$ ] ATP can be used to label the following  
a. closed circular duplex DNA.  
b. protein containing serine, threonine or tyrosine.  
c. protein devoid of serine, threonine and tyrosine.  
d. peptidoglycan.
33. Choose the mismatch pair
- | Amino acid   | Group present in side chain |
|--------------|-----------------------------|
| a. Tyrosine  | phenolic group              |
| b. Arginine  | guanidino group             |
| c. Histidine | imidazole group             |
| d. Cysteine  | imino group                 |
34. Estimate the net charge of a peptide Ser-Glu-Pro-Ile-Met-Ala-Pro-Val-Glu-Tyr-Pro-Lys at pH 7.0 and at pH 12.0. Typical ranges observed for  $\text{pK}_a$  values of groups in protein:  $\alpha$ -carboxyl group (3.5–4.0), side chain carboxyl group (4.0–4.8),  $\alpha$ -amino group (8.0–9.0), phenolic group (9.5–10.5), side chain amino group (9.8–10.4).  
a. -1, -4  
b. -4, -1  
c. -4, -4  
d. -1, -1 [IIT-JAM]
35. A tetrapeptide has four  $\text{pK}_a$  values and a pI of 3.5. Which will be a property of this peptide?  
a. The peptide will have a charge of +1 when fully protonated.  
b. The peptide will have a charge of -2 when fully deprotonated.  
c. The peptide will have a charge of +2 when fully deprotonated.  
d. The peptide will have a charge of -1 when fully deprotonated.
36. In case of oligopeptide made of alanine, with the addition of each additional alanine residue  
P. the value of  $\text{pK}_1$  increase  
Q. the value of  $\text{pK}_2$  decrease  
R. the value of  $\text{pK}_1$  decrease  
S. the value of  $\text{pK}_2$  increase  
a. P and Q  
b. R and S  
c. P and S  
d. Q and R
37. Choose the *incorrect* statement.  
a. At isoelectric point, protein has minimum solubility.  
b. Among standard amino acids, tryptophan has highest molecular weight.  
c. Selenocysteine is derived from cysteine.  
d. Histidine contains three ionizable groups.
38. Three properties (1, 2, 3) of an amino acid are given. Mark one amino acid which has all the three properties:  
1. contains an imino group  
2. with ninhydrin formed a yellow derivative  
3. is a non-essential amino acid  
a. Glutamic acid  
b. Proline  
c. Lysine  
d. Histidine

# Answers

## Amino acids and Protein

- |       |       |       |       |       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 01. d | 02. c | 03. d | 04. c | 05. d | 06. b | 07. b | 08. a | 09. c | 10. b |
| 11. d | 12. d | 13. a | 14. b | 15. b | 16. a | 17. c | 18. d | 19. b | 20. b |
| 21. a | 22. b | 23. d | 24. d | 25. d | 26. a | 27. a | 28. a | 29. c | 30. a |
| 31. b | 32. b | 33. d | 34. a | 35. b | 36. a | 37. c | 38. b | 39. c | 40. a |
| 41. d | 42. d | 43. a | 44. b | 45. a | 46. a | 47. b | 48. b | 49. c | 50. c |
| 51. b | 52. a |       |       |       |       |       |       |       |       |

## Explanations

06.  $(pK_R + pK_2)/2 = (6.00 + 9.2)/2 = 7.60$   
For histidine, the pI will be 7.60
08. For glutamic acid,  $pI = (pK_1 + pK_R)/2 = (2.2 + 4.2)/2 = 6.4/2 = 3.2$   
For lysine,  $pI = (pK_2 + pK_R)/2 = (9.2 + 10.2)/2 = 19.4/2 = 9.7$   
 $\Delta pI = 9.7 - 3.2 = 6.5$
09.  $pI = pK_1 + pK_2/2 \Rightarrow 2.17 + 9.13/2 \Rightarrow 11.3/2 = 5.65$
10. Charged amino acid side chains are seldom buried because charged side chains prefer to interact with the polar water environment, so they are more likely to be on the protein's surface.
12. A tripeptide consists of 3 amino acids. Each amino acid has a mass of 150 daltons. Therefore, the total mass of the individual amino acids is  $150 \times 3 = 450$  daltons. During peptide bond formation, a molecule of water is removed for each bond formed and the molecular mass of water is 18 daltons. A linear tripeptide has 2 peptide bonds. Therefore, the total water loss is  $18 \times 2 = 36$  daltons. Therefore, the molecular mass of the tripeptide will be 414 daltons ( $450 - 36$ ).
13. To estimate the number of amino acid residues in a protein, we can use the average molecular mass of a standard amino acid. It is around 110 Da. Now we can divide the protein's molecular mass by the average amino acid mass:  $85,000 \text{ Da} / 110 \text{ Da} \approx 772.7$  residues
14. A circular peptide with 38 amino acids will form 38 peptide bonds. So, water lost =  $38 \times 18 = 684$  Daltons.  
Initial total mass of 38 arginines =  $38 \times 174 = 6612$  Daltons  
Net mass of circular polymer =  $6612 - 684 = 5928$  Daltons
16. Protein X = 1000 amino acids  
Approximate mass =  $1000 \times 110 \text{ Da} = 110,000 \text{ Da}$  (average amino acid  $\approx 110 \text{ Da}$ )  
Mass of GFP = 27,000 Da  
Total mass  $\approx 110,000 + 27,000 = 137,000 \text{ Da}$