P R E F A C E

The principal purpose of writing this book **"GATE Life Science Topic Wise Solved Exam Questions"** is to cater the needs of the candidates aspiring for GATE Life Science examinations. It is observed that all the aspirants of GATE Life Science exam are in confusion and dilemma, as student do not know what to prepare and to what extent. The latest trend of GATE exam is randomized computer based multiple choice, multiple select and numerical answer type questions. For student it becomes very difficult to find out the topic from which question has been asked and in its absence students fails to develop any strategy for the exam.

It is imperative for every GATE life Science exam aspirant to understand the concepts and the pattern of exam. Through this book an effort has been made for aspirants to target GATE Life Science exam with full confidence. For sure success, a student should approach this exam with a strategy and planning in his/her mind. To help students, we have compiled this book in user-friendly and well-structured manner. Last 25 Year GATE exam question are sorted in 6 sections and sections are further divided into total 48 chapter as per GATE syllabus. This fine shorting of questions will help the student to understand the important topic of the subject, which is most frequent in examinations. Every section starts with the table showing questions asked during different years of GATE Life Science exam. The students will also be able to understand a change in trend of the questions over time. This will help them to understand the important topics of the subject and to prepare for exam in systemic planned way, which will enhance their selection chances. The quality of the question asked in GATE exams is always as par with other examinations. Practice of these questions will also help the students who are preparing for GATE BT, CSIR NET, ICMR, DBT, SET and other exams in Life Science or related streams.

A word or suggestion from your side may add another feather to the cap in the compilation of questions in this book. The author looks forward to the comments, suggestions and criticism from the students. Constructive suggestions and feedback from users would be highly appreciated, gratefully acknowledged and suitably incorporated.

A C K N O W L E D G E M E N T

Compiling this book **"GATE Life Science - Topic Wise Solved Exam Questions"** has been a satisfying and happy journey for us. All the sections and chapters have taken a final shape after endless inputs of time and effort. Though many teachers assisted us in compiling this book, we, first of all, would like to thank all our students, who have helped motivated to bring such book.

We would like to specially mention the effort made by Mr. Radheshyam Choudhary, Director IFAS Publications, who extended immense support in myriad ways for bringing out the book in its present form.

Our special thanks to Dadasaheb Sondge, Digambar Jagtap and Pranshu Dwivedi for their suggestions and for providing valuable contributions. We are grateful to the reviewers, Rishabh Jain, Pratiksha Sen, and Mamta Marar for their helpful suggestions for improving the contents of this book.

This book is a team effort, and producing it would be impossible without the outstanding people of IFAS publication. We are thankful to the team at IFAS Publication, most notably Gitanjalee Jadhav for helpful suggestions to improve the quality of the content and regular reminders for timely completion of the project. It has been a pleasure to work with Vikendra Metha and Govind Kumar who took great care during the copy-editing and production processes of this book.

And finally our humble greetings to all who put their significant efforts and are unmentioned.

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NUMBER OF QUESTION ASKED IN GATE - XL LIFE SCIENCE (2000 to 2024)																										
Biochemistry		**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
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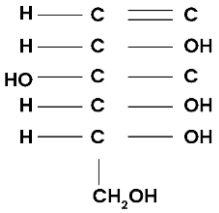
CHAPTER-1 ORGANIZATION OF LIFE (Biomolecules)

Previous Year Exam Questions

[GATE 2000]

1. How many asymmetric carbon atoms are present in the compound whose structure is as follows?



(A) 1 (B) 2
(C) 3 (D) 4

[GATE 2000, Answer writing type]

2. Early experiments on the problem of protein folding suggested that the native three-dimensional structure of a protein was an automatic consequence of its primary structure. Cite an experimental evidence that shows that this is the case.

[GATE 2000]

3. Match the entries in Column I with Column II and write matching pairs in the answer book.

Column I	Column II
P. Van der Waals bonds	1. Spatial arrangement of amino acids that are near each other in the linear sequence
Q. γ-Globulins	2. Glycosylation inhibitor
R. Tertiary structure	3. Cooperativity of oxygen binding
S. Hill-coefficient (ηH)	4. Involves polarizable atoms
T. Tunicamycin	5. Immune protection

(A) P-3; Q-1; R-4; S-2; T-5
(B) P-5; Q-3; R-1; S-2; T-4
(C) P-4; Q-5; R-1; S-3; T-2
(D) P-3; Q-1; R-2; S-4; T-3

[GATE 2000]

4. Histones have very high percentage of arginine and lysine residues (15%-30%). For this class of proteins which of the following reagents would be a suitable choice for generating peptides in the determination of the amino acid sequence of the protein?
(A) Cyanogen bromide (B) Thermolysin
(C) Trypsin (D) N-bromosuccinimide

[GATE 2000]

5. The properties of water include
(A) The ability to form hydrophobic bonds with itself.
(B) A disordered structure in the liquid state.
(C) A low dielectric constant.
(D) Being a dipole, with the negative end at the oxygen atom.

[GATE 2001]

6. Gangliosides contain
(A) a ceramide structure.
(B) glucose or galactose.
(C) sialic acid.
(D) all of the above.

[GATE 2001]

7. The active site amino acid residue that could be involved in a reaction catalyzed by an enzyme with a pH optimum of 4 would be
(A) arginine (B) cysteine
(C) serine (D) glutamate

[GATE 2001, Answer writing type]

8. Give correct answers to the following:
(A) Which of the following amino acids are likely to have their side chains on the inside of globular proteins in solution?
(B) What is the coenzyme form of vitamin B6? Name the reactions in which this coenzyme is involved.
(C) In preparation of mitochondria, oxidation of fatty acids is carried out in the presence of CoA, O_2, ADP and PO_4.
(i) How many molecules of ATP will be produced per two carbon fragments converted to CO_2?
(ii) What will this number be if amytal is added to the preparation?
(D) Northern analysis of nuclear RNA and cytoplasmic RNA from the liver when probed with aldolase genomic clone showed that the nuclear RNA specific to aldolase had a molecular weight higher than that of cytoplasmic RNA. Explain why?

[GATE 2001]

9. The length of a helical section of a polypeptide chain of 20 residues would be
   (A) 30 Å (B) 20 Å
   (C) 5.4 Å (D) 3.6 Å

[GATE 2001]

10. Which of the following types of interactions is mainly responsible for the aggregation of proteins in dilute solutions?
   (A) Hydrogen bonds
   (B) Hydrophobic interactions
   (C) Disulfide bonds
   (D) Peptide bonds

[GATE 2002]

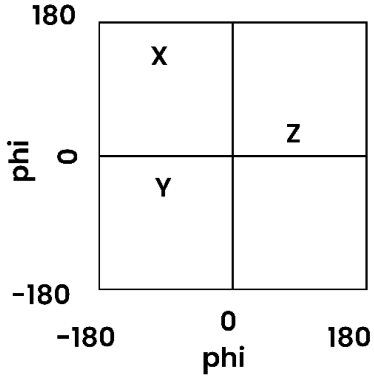
11. Which of the following has a quaternary structure?
   (A) α –Chymotrypsin (B) Hemoglobin
   (C) Insulin (D) Myoglobin

[GATE 2002]

12. Which of the following statements is correct in the case of chaperone proteins?
   (A) These do not prevent aggregation.
   (B) They cleave incorrect S-S bonds.
   (C) They act on fully synthesized polypeptides.
   (D) They are involved in the transport of proteins across mitochondria and endoplasmic reticulum.

[GATE 2003]

13. In the following Ramachandran diagram, which type of secondary structure does the regions marked X, Y and Z represent?



   (A) X: Right-handed α -helix; Y: Left-handed α -helix; Z: β –sheet
   (B) X: Left-handed α -helix; Y: Right-handed α -helix; Z: β –sheet
   (C) X: β -sheets, Y: Right-handed α -helix, Z: Left-handed α –helix
   (D) X: β -sheet; Y: Left-handed α -helix; Z: Right-handed α -helix

[GATE 2003]

14. Of the following peptide sequences, which one is the digestive enzyme trypsin most likely to cleave?
   (A) ---Val- Lys- Pro- Met ----
   (B) ---Arg- Val- Phe- Tyr ----
   (C) ----Trp- Asp- Gln- Pro ----
   (D) ----Glu- Gly- Trp- Gly ----

[GATE 2003]

15. Which one of the following statements about protein secondary structure is correct?
   (A) An α -helix is primarily stabilized by ionic interactions between the side chains of the amino acids.
   (B) β -sheets exist only in antiparallel form.
   (C) β -turns often contain proline.
   (D) An α -helix can be composed of more than one polypeptide chain.

[GATE 2003]

16. Choose the correct common sequence motif of Zn finger proteins from the following choices. X stands for any amino acid.
   (A) X_3-Cys-X_{2-4}-Cys-X_{1-2}-His-X_{3-4}-His-X_4
   (B) X_3-Cys-Cys-X_{2-4}-His-His-X_4
   (C) X_3-Cys-Cys-His-His-X_4
   (D) X_y-Cys-H_{2-4}, 4-His-X_{1-2}-His-X_{3-4}-Cys-X_4

[GATE 2003]

17. Which amino acid residue is most likely to be found in the interior of a water-soluble globular protein?
   (A) Ser (B) Arg
   (C) Val (D) Asp

[GATE 2005]

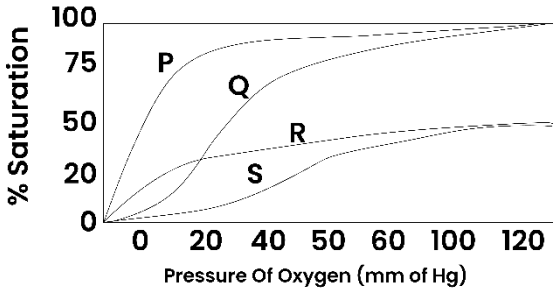
18. Which pair of amino acid residues can interact in the interior of a protein only through van der Waals forces?
   (A) Arg, Thr (B) Ser, Thr
   (C) Glu, His (D) Val, Leu

[GATE 2005]

19. For a double stranded DNA, which one of the following base-ratios will always be equal to 1?
   (A) (A +T)/(G+C) (B) (A +G)/(C+T)
   (C) C/T (D) A/G

Statement for Linked Answer Questions 42 and 43:

The figure shows the oxygen binding curves: for hemoglobin (Hb) and myoglobin (Mb)



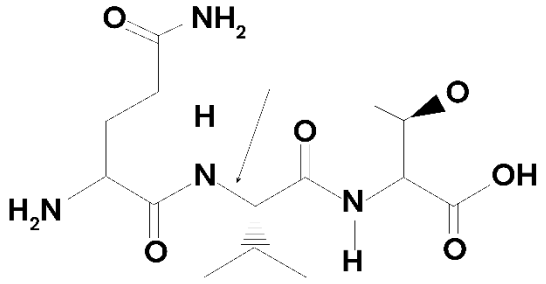
[GATE 2006]

20. Identify the collect curves for Hb and Mb
    (A) P: Mb; Q: Hb (B) Q: Mb; P: Hb
    (C) R: Mb; Q: Hb (D) S: Mb; R: Hb

[GATE 2006]

21. Sickle cell anemia arises due to the formation of a hydrophobic patch in one of the proteins shown in the above curves. This is due to the replacement of
    (A) Glu 6 by Val 6 in the β-subunit of P.
    (B) Glu 6 by Val 6 in the β-subunit of Q.
    (C) Glu 6 by Val 6 in the β-subunit of R.
    (D) Glu 6 by VM 6 in the β-subunit of S.

Statement for Linked Answer Questions 44 and 45:



[GATE 2006]

22. The dihedral angle indicated by an arrow in the tripeptide structure corresponds to the
    (A) psi angle. (B) phi angle.
    (C) chi angle. (D) omega angle.

[GATE 2006]

23. The amino acid sequence of the above tripeptide is
    (A) Glutamine - valine – threonine
    (B) Asparagine - valine - serine
    (C) Glutamine - leucine - threonine
    (D) Asparagine - valine – threonine

[GATE 2006]

24. Which one of the following cannot be considered as a weak interaction?
    (A) Van der Waals forces
    (B) Peptide bonds
    (C) Hydrogen bonds
    (D) Ionic interaction

[GATE 2006]

24. Which one of the following statements refers to glycogen, and which one refers to cellulose?
    P. Branched molecule containing β(1→4) glycosidic bond
    Q. Straight chain molecule containing β(1→4) glycosidic bond
    R. Branched molecule containing α(1→6) glycosidic bond
    S. Straight chain molecule containing α(1→6) glycosidic bond
    (A) P: Glycogen; S: Cellulose
    (B) Q: Glycogen; R: Cellulose
    (C) R: Glycogen; Q: Cellulose
    (D) S: Glycogen; P: Cellulose

[GATE 2007]

26. How does hemoglobin carry carbon dioxide generated in tissues back to the lungs?
    (A) By coordination with heme
    (B) By forming N-terminal carbamate
    (C) By forming C-terminal carbamate
    (D) By linking to the epsilon-amino group of lysine

[GATE 2007]

27. The maximum number of hydrogen bonds that a molecule of water can form is
    (A) 1 (B) 2
    (C) 3 (D) 4

[GATE 2008]

28. Equal volumes of two buffers of pH 4 and pH 6 of identical ionic strengths are mixed. The resultant pH is
    (A) close to 4 (B) close to 5
    (C) close to 6 (D) exactly 5

[GATE 2008]

29. Match the transition state or chemical entity of each enzyme that is responsible for their catalytic function.

Column I	**Column II**
P. Ribonuclease	1. Oxyanion
Q. Lysozyme	2. Pentacovalent phosphorus
R. Chymotrypsin	3. Carbonium ion
S. Carboxypeptidase	4. Mixed anhydride

    (A) P-3; Q-2; R-4; S-1 (B) P-2; Q-3; R-1; S-4
    (C) P-2; Q-1; R-3; S-4 (D) P-4; Q-3; R-2; S-1

Statement for Linked Answer Questions 37 and 38:

Nearly 46% of 45S pre-rRNA is unstable. The remaining portion of it forms mature 5.8S, 18S and 28S rRNA having lengths 160 bases, 1.9 kb and 5.1 kb, respectively. The content of pre rRNA per human genome is 7.8×10^{-15} g.

[GATE 2008]

30. The molecular weight of 45S pre-rRNA is
    (A) 2×10^6 (B) 4.5×10^5
    (C) 4.5×10^6 (D) 3.9×10^7

[GATE 2008]

31. The number of pre-rRNA genes per genome is approximately.
    (A) 10 (B) 100
    (C) 1000 (D) 10,000

[GATE 2008]

32. Match the polysaccharides in Column I with their constituent monosaccharide in Column II

Column I	Column II
P. Chitin	1. D-Glucose
Q. Hemicellulose	2. N-Acetyl glucosamine
R. Glycogen	3. D-Xylose
	4. D-Galactose

    (A) P-1; Q-3; R-4 (B) P-2; Q-4; R-1
    (C) P-4; Q-2; R-3 (D) P-2; Q-3; R-1

[GATE 2009]

33. The advantage of hemoglobin having a high histidine content is
    (A) Histidine binds to oxygen
    (B) Histidine carries oxygen to the tissues
    (C) Histidine imparts buffering capacity to hemoglobin
    (D) 'R' group of histidine has low pKa.

[GATE 2010]

34. Chymotrypsin and lysozyme are involved respectively in.
    P. Removal of successive carboxyl terminal residues.
    Q. Hydrolytic cleavage of peptide bond.
    R. Cleavage of glycosidic C-O bond.
    S. Oxygen transport in blood.
    (A) P, O (B) Q, R
    (C) Q, S (D) R, S

[GATE 2010]

35. The rise per residue of α-helix is about 1.5 Å. A protein spans 4 nm bilayer 7 times through its transmembrane α-helical domain. Approximately, how many amino acid residues constitute the transmembrane domain of the protein?
    (A) 105 (B) 450
    (C) 30 (D) 190

[GATE 2011]

36. The polarity of water molecule is due to.
    (A) Its tetrahedral structure
    (B) Bonding electrons being attracted more to oxygen
    (C) Bonding electrons being attracted more to hydrogen
    (D) Its weak electrolytic property

[GATE 2011]

37. Collagen, a-keratin and tropomyosin have common structural features. They are
    P) Disulphide bridges to neighbouring proteins.
    Q) Repeating sequences of amino acids
    R) A high B-sheet content
    S) Super-helical coiling
    (A) P, Q (B) Q, R
    (C) Q, S (D) P, R

[GATE 2012]

38. Which one of the following pairs of amino-acids in the protein has high prospensity to take up the α-helix conformation?
    (A) Gly-Asp (B) Pro-His
    (C) Gly-Pro (D) Ala-Arg

[GATE 2012]

39. Which one of the following closely defines 'Molten Globule' state of protein?
    (A) State with high degree of secondary structures and loss of tertiary structure
    (B) State with complete loss of secondary structure
    (C) Completely unfolded state
    (D) Loss of quaternary structure

[GATE 2012]

40. Which one of the following amino-acids has highest fluorescence quantum yield (ϕ) in aqueous solution?
    (A) Tyrosine (B) Tryptophan
    (C) Phenylalanine (D) Histidine

[GATE 2013]

41. Which one of the following amino acids has a higher propensity for *cis* peptide bond formation?
    (A) Histidine (B) Cysteine
    (C) Glycine (D) Proline

[GATE 2013]

42. The length of an α-helix composed of 36 amino acid residues is.
    (A) 10 Å (B) 54 Å
    (C) 27 Å (D) 360 Å

[GATE 2013]

43. Which one of the following amino acid residues is specifically recognised by chymotrypsin during peptide bond cleavage?
(A) Phe (B) Leu
(C) Val (D) Asp

[GATE 2014]

44. Which one of the following proteases does **NOT** cleave on the carboxyl side of any Arginine residue in a protein?
(A) Trypsin (B) Proteinase K
(C) Thrombin (D) Chymotrypsin

[GATE 2014]

45. Choose the option with two reducing sugars.
(A) Lactose and Maltose
(B) Trehalose and Sucrose
(C) Maltose and Trehalose
(D) Lactose and Sucrose

[GATE 2015]

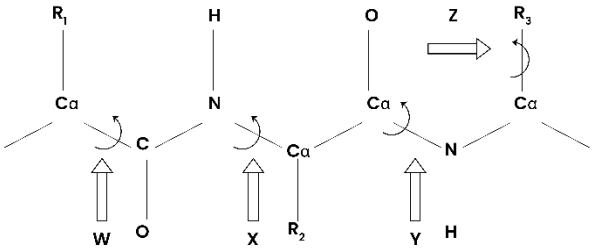
46. Which one of the following amino acid substitutions is likely to cause the largest change in protein conformation?
(A) Phe→Ile (B) Ser→ Thr
(C) Gln →Tyr (D) Glu → Val

[GATE 2015]

47. Which one of the following does NOT constitute the lipid moiety in lipid-linked membrane proteins?
(A) Palmitic acid (B) Stearic acid
(C) Farnesyl groups (D) Myristic acid

[GATE 2015]

48.



Column I	Column II
W	i. Ψ
X	ii. χ
Y	iii. ϕ
Z	iv. ω

Which of the following identifies the correctly matched pairs?
(A) W-iii , X-i ; Y-iv; Z-ii (B) W-i ; X-iii , Y-iv; Z-ii
(C) W-i ; X-iii ; Y-ii ; Z-iv (D) W-iii ; X-i : Y-ii ; Z-iv

[GATE 2016]

49. Hydrolysis of a peptide involves cleavage of the bond between the atoms
(A) N and C_a (B) C and O
(C) C_a and C (D) N and C

[GATE 2016]

50. Amino acid residues predominantly involved in protein-DNA interactions are
(A) alanines (B) negatively charged
(C) prolines (D) positively charged

[GATE 2016]

51. Cellulose serves as a structural polymer whereas starch does not. This is because cellulose contains
(A) $\beta 1 \rightarrow 4$ linked glucose monomers and inter-chain hydrogen bonds
(B) $\beta 1 \rightarrow 4$ linked glucose monomers and intra-chain hydrogen bonds
(C) $\alpha 1 \rightarrow 4$ linked glucose monomers and inter-chain hydrogen bonds
(D) $\alpha 1 \rightarrow 4$ linked glucose monomers and intra-chain hydrogen bonds

[GATE 2018]

52. To which one of the following classes of enzymes does chymotrypsin belong?
(A) Oxidoreductase (B) Hydrolase
(C) Transferase (D) Isomerase

[GATE 2018]

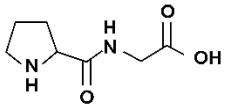
53. Which one of the following conformations of glucose is most stable?
(A) Boat (B) Half Chair
(C) Chair (D) Planar

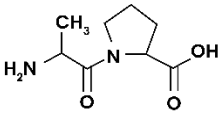
[GATE 2018]

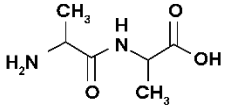
54. Which one of the following amino acids is responsible for the intrinsic fluorescence of proteins?
(A) Pro (B) Met
(C) His (D) Trp

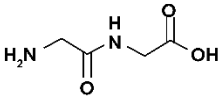
[GATE 2019]

55. The dipeptide with least rotational barrier in the peptide bond is

A)


B)


C)


D)


[GATE 2019]

56. Which one of the following is an incorrect biomolecule-modification pair?
    (A) Lipid – Palmitoylation
    (B) DNA and Protein – Methylation
    (C) Protein - Glycosylation
    (D) RNA – Polyadenylation

[GATE 2019]

57. The crystal structure of a peptide has an ordered structural repeat of amino acids with a distance of ~ 6.5 Å between the alternate C_α atoms. Which one of the following pair of dihedral angles (Φ and Ψ) accurately represents the peptide structure?
    (A) $\phi \approx -60°, \Psi \approx -50°$
    (B) $\phi \approx -120°, \Psi \approx -50°$
    (C) $\phi \approx -60°, \Psi \approx +120°$
    (D) $\phi \approx -120°, \Psi \approx +120°$

[GATE 2020]

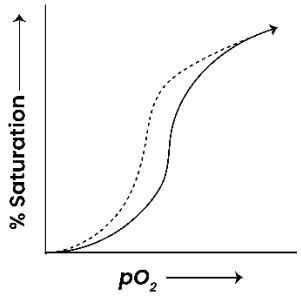
58. The reaction involved in the direct conversion of L-phenylalanine to L-tyrosine is
    (A) Reduction (B) Transamination
    (C) Decarboxylation (D) Hydroxylation

[GATE 2020]

59. The correct combination of glycosidic linkages present in glycogen is
    (A) α 1→6 and β 1 → 4 (B) α 1→4 and α 1 → 6
    (C) α 1→6 and β 1 → 6 (D) α 1→4 and β 1 → 6

[GATE 2021]

60. In the plot given below, the solid line represents oxygen binding to hemoglobin under physiological conditions. The broken line represents the condition(s) of



    (A) Loss of cooperativity
    (B) High pH
    (C) High CO_2 concentration
    (D) Increase in 2, 3- Bisphosphoglycerate concentration

[GATE 2021]

61. Which of the following lipids is non-ionic?
    (A) Sphingomyelin
    (B) Lecithin
    (C) Phosphatidyl inositol
    (D) Galactocerebroside

[GATE 2021]

62. A molecule that forms a donor-acceptor energy transfer pair with the *dansyl* group is _____
    (A) Aspartate (B) Histidine
    (C) Tryptophan (D) Lysine

[GATE 2021]

63. Which one of the following molecules (~1mg/mL) do NOT absorb at 280 nm in an aqueous solution of pH 7.00 at room temperature?
    (A) Adenosine triphosphate
    (B) Tyrosine
    (C) Phenylalanine
    (D) Poly deoxy-Guanylate (poly dG)

[GATE 2021]

64. Considering the open chain forms, which of the following pair(s) represent/s an epimer?
    (A) D-glucose and D-fructose
    (B) D-glucose and D-mannose
    (C) D-mannose and D-fructose
    (D) D-galactose and D-glucose

[GATE 2021]

65. pKa value of the guanidinium group of Arginine is_____
    (A) 4.30 (B) 12.50
    (C) 7.40 (D) 9.20

[GATE 2022]

66. Which of the following carbohydrates has/have a $\beta 1 \rightarrow 4$ glycosidic linkage?
    (A) Maltose (B) Cellulose
    (C) Chitin (D) Lactose

[GATE 2023]

67. Which one of the following amino acids has more than two acid-base groups?
    (A) Alanine
    (B) Leucine
    (C) Phenylalanine
    (D) Tyrosine

[GATE 2023]

68. Four statements about lipids are given below as options. Choose the statement(s) which is/are CORRECT.

(A) Cholesterol is amphipathic
(B) Self-assembly of phospholipids in water is due to hydrophobic effect
(C) The temperature at which the gel phase changes to liquid crystalline phase increases with an increase in the degree of unsaturation of fatty acyl tails
(D) The choline head group of lipids is positively charged

[GATE 2024]

69. Which one of the following pairs of amino acids is NOT incorporated in a polypeptide chain?
(A) 4-Hydroxyproline and γ-carboxyglutamate
(B) γ-Carboxyglutamate and desmosine
(C) Ornithine and citrulline
(D) 4-Hydroxyproline and 5-hydroxylysine

[GATE 2024]

70. Metabolic intermediates provide the backbone for the synthesis of amino acids. Match the metabolic intermediates listed in **Column I** with their corresponding amino acids given in **Column II**.

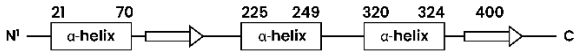
Column I	Column II
P. α-Ketoglutarate	i. Histidine
Q. Ribose 5- phosphate	ii. Glutamate
R. 3-Phosphoglycerate	iii. Aspartate
S. Phosphoenolpyruvate	iv. Phenylalanine
	v. Serine

(A) P-ii; Q-i; R-v; S-iv (B) P-iii; Q-ii; R-i; S-v
(C) P-iv; Q-iii; R-ii; S-v (D) P-ii; Q-i; R-iv; S-v

NAT

[GATE 2018]

1. The secondary structure topology diagram of 400 amino acid long "Protein-X" is depicted in the figure. The start and end amino acid residue numbers of each α-helix are marked. The percentage (correct to integer number) of residues forming α-helix is____.



[GATE 2019]

2. The electrostatic interaction energy between a positively charged atom A and negatively charged atom B separated by 3 Å in water is -6 kJ/mol. Considering the relative permittivity of water to be 80, the electrostatic interaction energy in kJ/mol (rounded off to one decimal place) between atoms A and B in vacuum is_____.

[GATE 2019]

3. 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 (rounded off to two decimal places) is _.

[GATE 2020]

4. Considering that the three pK_as of histidine are pK_1=1.8, pK_2=9.2 and pK_R=6.0, its isoelectric point will be _____(rounded off to one decimal place).

[GATE 2020]

5. The second pKa of phosphoric acid is 6.8. The ratio of Na_2HPO_4 to NaH_2PO_4 required to obtain a buffer of pH 7.0 is _____ (rounded off to two decimal places).

[GATE 2023]

6. A protein has seven cysteine residues. The maximum number of disulfide bonds of different combinations that can possibly be formed by these seven cysteine residues is _____ (in integer).

[GATE 2023]

7. A lyophilized sample of 20 nanomoles of an oligonucleotide is dissolved in water and the volume of the solution is made up to 200 µL. The concentration (in µM) of the oligonucleotide in this solution is _____ (in integer).

[GATE 2023]

8. A 100 ml solution of pH 10 was well-mixed with a 100 ml solution of pH 4. The pH of the resultant 200 ml solution is _____ (rounded off to two decimal places).

[GATE 2024]

9. A newly identified viral protein contains one long α-helix spanning 60 amino acid residues. The number of main chain H-bonds formed in this helix is _____. *(Answer in integer)*

[GATE 2024]

10. In a lactic acid solution at pH 4.8, the concentrations of lactic acid and lactate are 0.01 M and 0.087 M, respectively. The calculated pKa of lactic acid is _____. (Round off to one decimal place)

[GATE 2024]

11. If a 10 mM solution of a biomolecule in a cuvette of path length 10 mm absorbs 90% of the incident light at 280 nm, the molar extinction coefficient of the biomolecule at this wavelength is _____ $M^{-1}cm^{-1}$. *(Round off to two decimal places)*

[GATE 2024]

12. A 5250 base-pair long plasmid with 10 negative supercoils would have a linking number of _____, considering 10.5 base pairs per turn for B DNA. *(Answer in integer)*

ANSWER KEY									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
D	-	C	C	D	D	D	-	A	B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	D	C	B	C	A	C	D	B	A
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
B	B	A	D	C	B	D	A	B	C
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
C	D	C	B	D	B	C	D	A	B
41	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
D	B	A	D	A	D	B	B	D	D
51	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
A	B	C	D	B	A	D	D	B	B
61	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**
D	C	C	B, D	B	B,C,D	D	A,B,D	C	A

NAT									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
20 to 20	-480.1 to -479.9	6.49 to 6.51	7.5 to 7.7	1.58 to 1.60	48	100	4.29	56	3.93
11	**12**								
100	490								

-:EXPLANATION:-

1. **Topic:** Carbohydrates
   Answer (D)
   Explanation: Asymmetric carbon is one to which four different functional groups are attached. The given molecule is glucose with six carbon atoms and it has four asymmetric carbons.
2. **Explanation:** Christian Anfinsen and his colleagues performed an experiment in early 1960s to demonstrate the process of protein folding. The scientist isolated Ribonuclease A from bovine pancrease. Ribonuclease A is an enzyme which contains 124 amino acid residues and its molecular weight is 13,700Da. In the presence of urea and a reducing agent known as β-mercaptoethanol, ribonuclease A got denatured and its disulphide bonds got reduced. Then, the denaturing agent and β-mercaptoethanol was removed from the protein, and it was observed that the protein refolded into its native conformation with the formation of four correctly paired disulphide bonds. This experiment demonstrated that the primary structure of proteins contain all the necessary information required to fold the protein into its three-dimensional form.
3. **Topic:** Protein
   Answer (C)
   Explanation: Van der Waals bonds are weak electrostatic force of interaction that occur in all types of molecules, both polar and non-polar. γ-globulins are proteins that forms antibodies and play role in immune protection. Tertiary structure of protein represents the three-dimensional conformation of protein. It is stabilized by various non-covalent bonds like hydrophobic interactions, salt bridges, hydrogen-bonds and van der Waals interactions and covalent intra-chain disulphide bonds. Hill-coefficient represents the degree of cooperativity during oxygen binding curve of hemoglobin. Tunicamycin is a drug which inhibits N-linked glycosylation of proteins.
4. **Topic:** Protein sequencing
   Answer (C)
   Explanation: Trypsin cleaves the peptide bond on the carboxyl side of lysine and arginine which is not followed by proline residue.
5. **Topic:** Water
   Answer (D)
   Explanation: Water is a polar molecule because its atoms share electrons unequally. The oxygen is more electronegative than hydrogen and therefore pulls shared pair of electron between H-O towards itself. Polarity of a molecule is measured with the help of dipole moment (μ). Net dipole moment of water is 1.84 debye(D).
6. **Topic:** Lipids
   Answer (D)
   Explanation: Gangliosides are sphinoglycolipids that contains ceramide (sphingosine covalently attached to fatty acid) and oligosaccharides having N-acetyl neuraminic acid (NAM). NAM is also known as sialic acid.
7. **Topic:** Amino acids
   Answer (D)
   Explanation: At pH=4, the amino acid that can exist as an active residue of active site of an enzyme should be polar and acidic in nature. Glutamate and aspartate are two acidic amino acids as they have carboxyl group in their side chains.
8. **Explanation**:
   (a) Val, Pro, Phe, Asp, Lys, Ile, His
   (b) Co-enzyme form of vitamin B6 is Pyridoxal phosphate. It participates during transamination reactions, α- and β- decarboxylation, aldol reactions and β- and γ-elimination reactions.
   (c)
   (i) During one cycle of β-oxidation one molecule of two carbon compound that is acetyl CoA is formed and 1 NADH and 1 $FADH_2$ are produced to give 4 ATP. Acetyl CoA formed, enter into TCA cycle to get converted to carbon dioxide and total 10 ATP are produced in this pathway (1 ATP, 1 $FADH_2$, and 3 NADH). Therefore, total 14 ATP are produced.
   (ii) Amytal inhibits complex 1 of electron transport chain and therefore, NADH will not be oxidised to generate ATP. Total 4 ATP will be produced from β-oxidation and TCA.
   (d) It is because the nuclear mRNA is in the pre-mRNA form which will undergo maturation process before moving to cytosol, due to which there will be decrease in the molecular weight of mature mRNA present in the cytosol.

9. **Topic:** secondary structure of proteins
Answer (A)
Explanation: In case of right-handed α-helix, the rise per amino acid residue is 1.5 Å. Accordingly, the length of α-helix formed by 20 amino acids = $20 \times 1.5\ \text{Å} = 30\ \text{Å}$

10. **Topic:** Protein folding and aggregation
Answer (B)
Explanation: The driving force behind protein aggregation is the reduction in free surface energy by the removal of hydrophobic residues from contact with the solvent.

11. **Topic:** Globular proteins
Answer (B)
Explanation: Hemoglobin is a globular, multimeric protein having quaternary structure. In adults, it is composed of two α-polypeptide chains and two β-polypeptide chains ($\alpha_2\beta_2$). It contains 4 hemes (each subunit has 1 heme) as prosthetic group.

12. **Topic:** Protein sorting
Answer (D)
Explanation: Molecular chaperones are protein folding modulators that help in proper folding of proteins. They bind to the incompletely folded or unfolded proteins so as to fold them correctly. They also play important role during signal transduction and protein trafficking mechanisms.

13. **Topic:** Ramachandran Plot
Answer (C)
Explanation: Many values of ψ and ϕ are not allowed because of steric hindrance between atoms of polypeptide backbone and side chains groups of amino acids. The permitted values of ψ and ϕ can be found out with the help of Ramachandran plot. Shaded portion of the plot indicate the permitted values of ψ and ϕ while unshaded region indicates the unallowed values.

14. **Topic:** Protein sequencing
Answer (B)
Explanation: Trypsin cleaves the peptide bond on the Carboxyl side of lysine and arginine which is not followed by proline residue. Therefore option (B) is correct.

15. **Topic:** Protein secondary structure
Answer (C)
Explanation: Glycine and proline are often found in β-turns. Glycine is present in the β-turns because it is smallest amino acid and contains hydrogen atom as side chain and therefore it is very flexible. The reason behind occurrence of proline in the β-turn is that its side chain has built in bent.

16. **Topic:** DNA-protein interactions
Answer (A)
Explanation: Zinc finger motif is characterized by coordination of one or more zinc ions. Several types of zinc finger motifs are present but most common is C_2-H_2 type in which two cysteine in one chain and two histidine in other one are coordinated to zinc ion. The motif contains a consensus sequence of approximately thirty amino acid residues and the sequence is mentioned in option (A).

17. **Topic:** Globular proteins
Answer (C)
Explanation: Valine is non-polar in nature and can form hydrophobic interactions. Therefore, it lies in the interior of globular proteins. External surface of globular proteins contain polar and charged amino acid residues (serine, arginine and aspartate) so that they can interact with the polar surrounding environment to increase the solubility of globular proteins.

18. **Topic:** Amino acids
Answer (D)
Explanation: valine and isoleucine are non-polar amino acids, therefore they interact with each other with help of van der Waals forces. Serine and threonine are polar amino acids and can form hydrogen bonding with neighboring residues. Glutamate is acidic while histidine is basic amino acid and these can interact with the help of ionic interactions.

19. **Topic:** Nucleic acids
Answer (B)
Explanation: According to Chargaff's rule:
In a double stranded DNA, the total number of purines (A, G) is always equal to the number of pyrimidines (C, T). Therefore, (A+G) = (C+T) or $\frac{(A+G)}{(C+T)} = 1$

20. **Topic:** Globular proteins
Answer (A)
Explanation: Oxygen binding curve of myoglobin is hyperbolic in nature (P) and that of hemoglobin is sigmoid in nature (Q).

21. **Topic:** Globular proteins

Answer (B)

Explanation: Sickle-cell anemia is a molecular disease which occur due to point mutation in β-chain of hemoglobin. The 6th amino acid residue in β-chain is glutamate which in negatively charged at physiological pH. By point mutation, it is replaced by valine, which is non-polar in nature. Therefore, a hydrophobic patch is developed on the surface of hemoglobin and shape of RBC changes.

22. **Topic:** Peptide bond

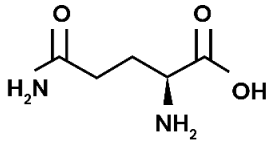
Answer (B)

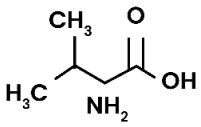
Explanation: The angle around C_α-C bond is called psi angle (ψ) and the angle around N-C_α bond is called phi angle (ϕ).

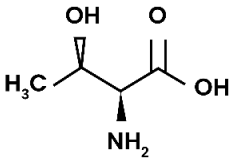
23. **Topic:** Amino acids and Peptide bond

Answer (A)

Explanation: This tri-peptide is made up of glutamine, valine and threonine whose respective structures are given below:







24. **Topic:** Stabilising interactions

Answer (B)

Explanation: Peptide bonds are strong interactions because these are covalent in nature.

25. **Topic:** Carbohydrates

Answer (C)

Explanation: Glycogen is a highly branched polysaccharide made up of α-glucose. Linearly, glucose molecules are joined together by α(1,4)-glycosidic bond while branching occur by the virtue of α(1,6)-glycosidic bond. Cellulose is a linear polysaccharide and a component of plant cell wall. It is made up of β-glucose joined together by β(1,4)-glycosidic bond.

26. **Topic:** Globular proteins

Answer (B)

Explanation: 70% of carbon-dioxide is transported through blood plasma as bicarbonate ion. Only 23% of carbon dioxide is transported by hemoglobin as carbaminohemoglobin. Carbon dioxide binds to unprotonated amino group of N-terminal amino acid residue of α- and β- chains.

27. **Topic:** Water

Answer (D)

Explanation: One water molecule can form maximum 4 hydrogen bonds with neighbouring water molecules. However, at room temperature water only form 3.4 hydrogen bonds with other water molecules because its molecules are disordered and are in continuous motion. In ice, water molecules are properly organised and form 4 hydrogen bonds with each other.

28. **Topic:** pH and buffers

Answer (A)

Explanation: Let us assume there are 1 L volume of both buffers.

<u>For buffer having pH=4:</u>

$pH = -\log [H^+]$

Therefore, $[H^+] = 10^{-4}\text{Molar}$

$= 10^{-4}\text{moles/L}$

<u>For buffer having pH=6:</u>

$pH = -\log[H^+]$

Therefore, $[H^+] = 10^{-6}\text{Molar}$

$= 10^{-6}\text{moles/L}$

Adding two buffers together.

Total volume=2L

Total concentration of $H^+ = 10^{-4} + 10^{-6} = \frac{1}{10000} + \frac{1}{1000000} = \frac{101}{1000000} = 1.01 \times 10^{-4}$

In 2L, there will be 1.01×10^{-4} moles

In 1L, number of moles = $\frac{1.01\times10^{-4}}{2} = 0.505\times 10^{-4}$ moles

pH of resultant buffer= $-\log [H^+]$

$= -\log (0.505 \times 10^{-4}) = -(\log 0.505 + \log 10^{-4})$

$= -(-0.2967 - 4) = 4.3$

29. **Topic:** Enzymes

Answer (B)

Explanation: Ribonuclease is an endonuclease that catalyzes the cleavage of RNA molecule and result in the formation of 2', 3'- cyclic phosphate intermediate. Lysozyme are hydrolytic enzymes that

can cleave β-(1, 4)-glycosidic bond between N-acetylmuramic acid and N-acetylglucosamine of bacterial cell wall. They act through the formation of carbonium ion. In the esterolytic reaction of carboxypeptidase. A deacylation of the mixed anhydride intermediate is catalyzed by a metal-bound hydroxide group.

30. **Topic:** Nucleic acids

Answer (C)

Explanation: Unstable pre-rRNA= 46%, therefore remaining 54% is stable and it forms 5.8S, 18S and 28S rRNAs. Length of 5.8S rRNA is 160 bases and that of 18S and 28S are 1.9kb and 5.1kb, respectively. Total number of bases in pre-rRNA= (0.16+1.9+5.1)× 100/54

= (7.16×100)/54

=13.26 kb = 13.26× 1000 bases

Average molecular weight of one molecule of ribonucleotide= 325 Da

The molecular weight of 45S pre-rRNA

= 325 × 13.26 × 1000 Da

= 4309500 Da

= 4.3× 10^6 Da

31. **Topic:** Nucleic acids

Answer (C)

Explanation: Pre-rRNA content of human genome = 7.8 x 10^{-15} g

1 Dalton = 1.67×10^{-24}g

Therefore, 7.8 x 10^{-15} g

= 7.8 x 10^{-15} g/1.67×10^{-24}g= 4.73×10^9 Da

Number of genes

=4.73×10^9 Da/4.3× 10^6 Da= 1000

32. **Topic:** Carbohydrates

Answer (D)

Explanation: Chitin is a polysaccharide which is made up of β (1, 4)-linked N-acetyl-glucosamine. It is found in the exoskeleton of insects and crustaceans. Hemicellulose are polysaccharides present in plant cell walls and include xyloglucans, xylans, mannans and others. Glycogen is a polysaccharide made up of β (1, 4)-linked D-glucose.

33. **Topic:** globular proteins

Answer (C)

Explanation: Histidine residues present in hemoglobin can undergo protonation and deprotonation upon change in pH and therefore imparts buffering capacity to it.

34. **Topic:** Enzymes

Answer (B)

Explanation: Chymotrypsin is a digestive enzyme which belongs to the class 'hydrolases'. It is a protease that cleaves on the C-terminus of peptide bond formed by aromatic amino acids. Lysozyme digest the bacterial cell wall made up of carbohydrates by breaking the glycosidic linkage.

35. **Topic:** Proteins secondary structure

Answer (D)

Explanation: Rise per amino acid residue of an α-helix= 1.5Å

Area spanned by protein= 4 nm = 4×10 Å $= 40$ Å

Total area spanned by protein in 7 times= 7×40 Å $= 280$ Å

Number of amino acid residues= 280/1.5= 187 which is approximately equals to 190

36. **Topic:** Water

Answer (B)

Explanation: Water is a polar molecule because its atoms share electrons unequally. The oxygen is more electronegative than hydrogen and therefore pulls shared pair of electron between H-O towards itself Polarity of a molecule is measured with the help of dipole moment (μ). Net dipole moment of water is 1.84 debye (D).

37. **Topic:** Proteins

Answer (C)

Explanation: Collagen has a triple helical coiled coil structure.it contains three amino acids: glycine, proline and hydroxyproline in abundance. These amino acids make up the characteristic repeating motif gly-pro-X. Keratin is a fibrous protein and there are two types of keratin proteins: α-keratins and β-keratins. α-keratin has predominantly helical conformation. Tropomyosin is made up of two α-helical chains arranged in coiled-coil form.

38. **Topic:** Proteins secondary structure

Answer (D)

Explanation: Certain amino acids like alanine, leucine, histidine, arginine, lysine, methionine, glutamate and glutamine are categorized as helix former while amino acid glycine and proline tend to destabilize the helical conformation of proteins.

39. **Topic:** Protein folding

Answer (A)

Explanation: Molten globule is an intermediate state that occurs when a protein undergoes transition from unfolded state to folded native state. It has most of the secondary structure of native state but it is less compact and lacks proper packing interactions.

40. **Topic:** Amino acids

Answer (B)

Explanation: The fluorescence quantum yield is the ratio of photons absorbed to photons emitted by fluorescence. Aromatic amino acids like tyrosine, tryptophan and phenylalanine act as intrinsic fluorophores of proteins. Tryptophan show much stronger fluorescence and higher quantum yield than the other two aromatic amino acids and tryptophan show four times more absorbance at 280nm as compared to tyrosine.

41. **Topic:** Peptide bond

Answer (D)

Explanation: Most amino acid form peptide bond in *trans* configuration but proline can occur in both *trans* and *cis* arrangement because in case of proline α-amino group is covalently linked to its side chain to form pyrrolidone ring and because of this ring structure, both *cis* and *trans* forms are equally stable.

42. **Topic:** secondary structure of proteins

Answer (B)

Explanation: In case of right-handed α-helix, the rise per amino acid residue is 1.5 Å. Accordingly, the length of α-helix formed by 36 amino acids = $36 \times 1.5\ \text{Å} = 54\ \text{Å}$

43. **Topic:** Protein sequencing

Answer (A)

Explanation: Chymotrypsin is a protease and it catalyzes the hydrolysis of peptide bond formed by aromatic amino acids (phenylalanine, tyrosine and tryptophan) at their carboxyl side.

44. **Topic:** Protein sequencing

Answer (D)

Explanation: Chymotrypsin is a protease that catalyzes the hydrolysis of peptide bond formed by aromatic amino acids at their carboxyl side.

45. **Topic:** Carbohydrates

Answer (A)

Explanation: Both sucrose and trehalose are non-reducing disaccharides because their monomeric carbohydrate units are joined together by the virtue of their anomeric ends. No anomeric ends are available in both sucrose and trehalose.

46. **Topic:** amino acids

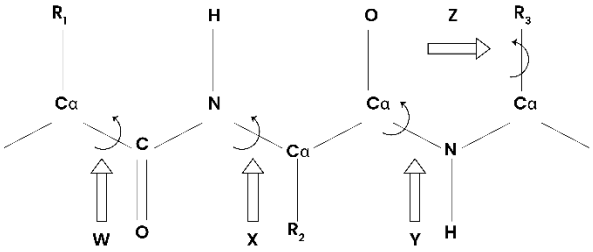
Answer (D)

Explanation: glutamate is a negatively charged amino acid while valine is aliphatic amino acid. Substitution of glutamate with valine will have an adverse effect on the overall structure of protein because both amino acids have different chemical nature and glutamate can participate in ionic interactions to stabilize the overall structure of proteins while valine cannot participate in ionic-interactions.

47. **Topic:** Plasma membrane and membrane proteins

Answer (B)

Explanation: Membrane proteins that are covalently attached to lipid molecules are called lipid-linked proteins. Stearic acid does not constitute the lipid moiety in lipid-linked membrane proteins. Isoprenyl (farnesyl/geranylgeranyl), myristoyl, palmitoyl act as lipid anchors. GPI-linked proteins also fall under the category of lipid-linked proteins.



Column I	Column II
W	i. Ψ
X	ii. χ
Y	iii. ϕ
Z	iv. ω

48. **Topic:** Peptide bond and proteins

Answer (B)

Explanation: The angle around C_α-C bond is called psi angle(ψ). The angle around N-C_α bond is called phi angle (ϕ). The angle around C-N bond is called omega(ω) and the angle around C_α-R is called chi angle (χ).

49. **Topic:** peptide bond

Answer (D)

Explanation: A peptide bond is the amide bond which is formed when the carboxyl group of one amino acid becomes linked to the amino group of another to form a peptide.

50. **Topic:** protein-DNA interactions

Answer (D)

Explanation: DNA is a negatively charged molecule due to the presence of phosphate group therefore it interacts with positively charged amino acid residues containing proteins with the help of electrostatic interactions.

51. **Topic:** carbohydrates

Answer (A)

Explanation: Cellulose is a structural polysaccharide made up of β-D- glucose joined together by $\beta 1 \rightarrow 4$ linkage. Several linear chains of cellulose are held together by inter-chain hydrogen bonds.

52. **Topic:** enzymes

Answer (B)

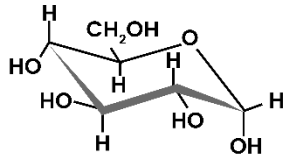
Explanation: There are six classes of enzymes which are oxidoreductases, transferases, hydrolases, lyases, isomerases, and ligases. Chymotrypsin is a hydrolase because it catalyzes the hydrolysis of peptide bond formed by aromatic amino acids.

53. **Topic:** carbohydrates

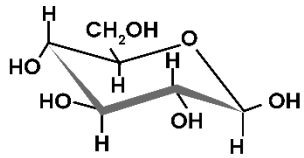
Answer (C)

Explanation: There can be either β-glucose or α-glucose anomeric form. For glucose, chair conformation is the most stable arrangement because all the substituents are equatorial. The chair conformation for α-glucose and β-glucose are shown below:

The Chair Form of α-D-Glucopyranose is



The Structure of β -D-glucopyranose is



54. **Topic:** amino acids

Answer (D)

Explanation: Aromatic amino acids: tryptophan, tryrosine and phenylalanine are responsible for intrinsic fluorescence of proteins.

55. **Topic:** Peptide bond

Answer (B)

Explanation: Rotation around peptide bond is not possible due to partial double bond character. Peptide bonds are in the *trans* conformation. However, *cis* forms can occur in peptide bonds that precede a proline residue. In such cases, the *cis* form occurs as the proline side-chain offers less of a hindrance.

56. **Topic:** Protein modification

Answer (A)

Explanation: Proteins undergo palmitoylation not lipids.

57. **Topic:** Proteins secondary structure

Answer (D)

Explanation: The distance between adjacent amino acid in case of β-sheet is $\sim 3.5\text{Å}$ and hence between alternate amino acid would be $\sim 6.5\text{Å}$ therefore the given structure represents β-sheet and the value of dihedral angles (Φ and Ψ) for parallel β sheet is -120 and 120, respectively. Hence option (D) is correct.

58. **Topic:** amino acids metabolism

Answer (D)

Explanation: On the basis of structure, the difference between L-phenylalanine and L-tyrosine is the presence of hydroxyl group attached to the aromatic ring, in case of tyrosine. Hence, L-phenylalanine undergoes hydroxylation to get converted to L-tyrosine.

59. **Topic:** Carbohydrates

Answer (B)

Explanation: Glycogen is a polysaccharide made up of α-D-glucose. Glucose molecules are joined linearly by α 1→4 bond while branching occur by the virtue of α 1 → 6 bond.

60. **Topic:** Globular proteins

Answer (B)

Explanation: The line has shifted towards left and it indicates the affinity of oxygen for hemoglobin has increased. Correct option is (B) and this is due to Bohr's effect. At high pH, the concentration of protons in the solution decreases due to which the side chain of histidine residue of β-globin chain of hemoglobin becomes deprotonated. Quaternary structure of deoxy-hemoglobin will be less stabilized due to decreased ionic interactions and hence the affinity of hemoglobin towards oxygen increases.

61. **Topic:** Lipids

Answer (D)

Explanation: galactocerebroside is made up of ceramide and galactose sugar. Ceramide is made up of sphingosine and a fatty acid attached to it via amide bond. Both galactose and ceramide are non-ionic in nature.

62. **Topic:** Amino acids

Answer (C)

Explanation: A donor-acceptor energy transfer pair must be able to absorb energy so that it can show fluroscence. Tryptophan act as intrinsic flurophore and act as donor-acceptor energy transfer pair with dansyl group.

63. **Topic:** Amino acids

Answer (C)

Explanation: Phenylalanine show characteristic absorbance at 257.4 nm. Nucleotides and nucleic acids (adenosine triphosphate and poly dG) show characteristic maxima at 260 nm and at 280 nm, they absorb about half as much UV as compared to 260 nm.

64. **Topic:** carbohydrates

Answer (B & D)

Explanation: Epimers are diastereomers that contain more than one chiral center but differ from each other in the absolute configuration at only one chiral center. D-glucose and D-mannose differ from each other at C-2 position only, and D-glucose and D-galactose differ from each other at C-4 position only.

65. **Topic:** amino acids

Answer (B)

Explanation: Arginine is a basic amino acid, its pKa of guanidinium (pKR) value would be above 7, that is towards basic pH.

66. **Topic:** Bio molecules (Carbohydrate)

Answer (B, C, D)

Explanation: Cellulose, Chitin and Lactose is an example of sugars having $\beta 1 \rightarrow 4$ glycosidic linkage. But maltose has $\alpha 1 \rightarrow 4$ glycosidic linkage.

67. **Topic:** Amino acid

Answer (D)

Explanation: Tyrosine

Amino acids contain at least two acid-base groups: the amino group (-NH2) and the carboxyl group (-COOH). However, some amino acids, such as tyrosine, also contain additional acid-base groups. In the case of tyrosine, it has a phenolic hydroxyl group (-OH) that can also act as an acid or a base, depending on the pH of the environment. At low pH, the phenolic hydroxyl group can be protonated, while at high pH, it can lose a proton and become negatively charged. Therefore, tyrosine has a total of three acid-base groups: the amino group, the carboxyl group, and the phenolic hydroxyl group

68. **Topic:** Lipids

Answer (A), (B) and (D).

Explanation: (A) is true. Cholesterol is amphipathic. It is a steroid molecule that is mostly hydrophobic, with a small hydrophilic hydroxyl group. (B) is true. Self-assembly of phospholipids in water is due to hydrophobic effect, which is the tendency of hydrophobic tails to aggregate together to minimize their exposure to water. The hydrophilic head groups of the phospholipids interact with the surrounding water molecules, resulting in the formation of bilayer structures. (C) is false. The temperature at which the gel phase changes to liquid crystalline phase decreases with an increase in the degree of unsaturation of fatty acyl tails. This is because unsaturated fatty acyl chains introduce kinks in the acyl chain, making it more difficult for the chains to pack together in a tight, ordered structure. As the degree of unsaturation increases, the chains become more disordered, and the gel phase transition temperature decreases. (D) is true. The choline head group is a quaternary ammonium cation with a permanent positive charge, which is neutralized by an anionic group in the lipid molecule, such as phosphate in phosphatidylcholine.

69. **Topic:** Amino acid

Answer (C)

Explanation: Ornithine and citrulline are not incorporated into polypeptide chains during protein synthesis. They are amino acids involved in other metabolic pathways, such as the urea cycle, and are not part of the standard set of amino acids used for protein synthesis.

70. **Topic:** Amino acid

Answer: (A)

Explanation:

P. α-Ketoglutarate is a precursor for glutamate.

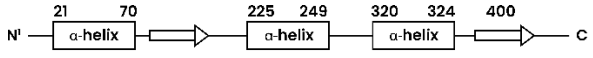
Q. Ribose 5-phosphate is involved in the pentose phosphate pathway and contributes to the synthesis of histidine.

R. 3-Phosphoglycerate is an intermediate in glycolysis and contributes to the synthesis of serine.

S. Phosphoenolpyruvate is a precursor for the synthesis of aspartate

NAT

1. **Explanation:**



The number of amino acid residues forming each α-helix is:

From 21 to 70= 50 residues

From 225 to 249= 25 residues

From 320 to 324= 5 residues

Total number of residues forming α-helix=50+25+5=80 residues

The percentage of residues forming α-helix with total 400 amino acids= $\left(\frac{80}{400}\right) \times 100 = 20\%$

2. **Explanation:**

Dielectric constant of water=80

Energy $\alpha \frac{1}{\text{Dielectric constant}}$

$$\frac{\text{Energy}_{\text{water}}}{\text{Energy}_{\text{vaccum}}} = \frac{\text{Dielectric constant}_{\text{vaccum}}}{\text{Dielectric constant}_{\text{water}}}$$

$$\frac{-6}{\text{Energy}_{\text{vaccum}}} = \frac{1}{80}$$

$$\text{Energy}_{\text{vaccum}} = 80 \times (-6) = -480\text{kJ/mol}$$

3. **Explanation:**

For glutamic acid:

pI= $\frac{pK_1+pK_R}{2} = \frac{2.2+4.2}{2} = \frac{6.4}{2} = 3.2$

For Lysine:

pI= $\frac{pK_2+pK_R}{2} = \frac{9.2+10.2}{2} = \frac{19.4}{2} = 9.7$

The difference in pI of lysine and glutamic acid= 9.7-3.2=6.50

4. **Explanation:**

pK_1= 1.8, pK_2= 9.2 and pK_R= 6.0

Histidine is a basic amino acid, therefore:

pI=$\frac{pK2+pK_R}{2} = \frac{9.2+6.0}{2} = \frac{15.2}{2} = 7.6$

5. **Explanation:**

Apply Henderson-Hasselbalch equation:

$$\text{pH} = \text{pKa} + \log\left(\frac{\text{Na}_2\text{HPO}_4}{\text{NaH}_2\text{PO}_4}\right)$$

$$7 = 6.8 + \log\left(\frac{\text{Na}_2\text{HPO}_4}{\text{NaH}_2\text{PO}_4}\right)$$

$$0.2 = \log\left(\frac{\text{Na}_2\text{HPO}_4}{\text{NaH}_2\text{PO}_4}\right)$$

$$\text{antilog}(0.2) = \left(\frac{\text{Na}_2\text{HPO}_4}{\text{NaH}_2\text{PO}_4}\right)$$

$$1.58 = \left(\frac{\text{Na}_2\text{HPO}_4}{\text{NaH}_2\text{PO}_4}\right)$$

6. **Explanation**: The correct answer for the maximum number of disulfide bonds that can be formed by 7 cysteine residues is 48.

To calculate this, we can use the formula: 2^n - 1

Where n is the number of cysteine residues. In this case, n = 7, so we get: 2^7 - 1 = 128 - 1 = 127

However, we need to divide this number by 2, because each disulfide bond involves two cysteine residues, so we get: 127 / 2 = 63.5

Since we can't have a half disulfide bond, we round down to get: 63 disulfide bonds.

However, we need to subtract the number of non-disulfide bonds (i.e. the number of possible ways to choose 7 cysteine residues without forming a disulfide bond), which is:

7 choose 1 + 7 choose 2 + 7 choose 3 + 7 choose 4 + 7

choose 5 + 7 choose 6 = 64

So the final answer is: 63 - 64 = 48

Therefore, the maximum number of disulfide bonds of different combinations that can possibly be formed by these seven cysteine residues is 48.

7. **Explanation: 100 µM**

200 µL has 20 nanomoles of an oligonucleotide

Means 1000 µL (1 ml) will have 100 nanomoles

1000 mL will have 100 X 1000 nanomoles

= 100 micromoles/1000 mL

= 100 µM

8. **Explanation:** In this case, we can assume that the solution of pH 10 is the weaker acid (due to its lower concentration of hydrogen ions) and the solution of pH 4 is the stronger base (due to its higher concentration of hydrogen ions).

Since the two solutions are mixed in equal volumes, we can assume that the resulting solution has a total volume of 200 ml and a total concentration of hydrogen ions of:

[H+] = (1 x 10^{-4}mol/L x 100 mL / 200 mL) + (1 x 10^{-4}mol/L x 100 mL / 200 mL) = 5.05 x 10^{-5}mol/L

Using the formula pH = -log [H+], we get: pH = -log(5.05 x 10^{-5}) pH = 4.29 (rounded off to two decimal places)

Therefore, the pH of the resulting solution is approximately 4.29 to 4.31

9. **Explanation:** In an α-helix, each amino acid contributes to the formation of hydrogen bonds with the amino acid located four residues ahead in the sequence. Therefore, the number of main chain hydrogen bonds in a helix is calculated as (number of amino acid residues - 4).For a helix spanning 60 amino acid residues: Number of H-bonds = 60 - 4= 59 So, the answer is 56.
10. **Explanation:** Let's reevaluate the pKa using the Henderson-Hasselbalch equation: pH=pKa+log([A−][HA])
    Given that pH=4.8, [A−]=0.087 M, and [HA]=0.01 M, we can rearrange the equation to solve for pKa: pKa=pH−log([A−][HA])
    pKa=4.8−log(0.0870.01)
    pKa≈4.8−log(8.7)
    pKa≈4.8−0.9395
    pKa≈3.8605
    Rounded off to one decimal place, the calculated pKa of lactic acid is approximately 3.93
11. **Explanation:** The molar extinction coefficient (ε) can be calculated using the Beer-Lambert Law: $A=\varepsilon \cdot c \cdot l$
    Where:
    A is the absorbance (0.90 for 90% absorption, as it ranges from 0 to 1). c is the concentration of the biomolecule in molarity ($10^{-2}\ m$).
    l is the path length of the cuvette in centimeters (10 mm, which is equivalent to 1.0 cm). Rearranging the equation to solve for ε:
    $\varepsilon = A / C.$
    l
    Plug in the values:
    $\varepsilon = 1/10^{-2}\ 1$
    $\varepsilon = 10^{2}$
    $\varepsilon = 100\ M^{-1}cm^{-1}$
    So, the molar extinction coefficient of the biomolecule at 280 nm is $100M^{-1}cm^{-1}$.
12. **Explanation:** The linking number (Lk) in a closed, circular DNA molecule can be calculated using the formula: $Lk=Tw-Wr$
    where:
    Tw is the twist, the number of turns of the DNA helix. Wr is the writhe, the number of supercoils.
    The twist (Tw) can be calculated as = Number of base pairs/Base pairs per turn Tw = Base pairs per turn Number of base pairs
    Given that the plasmid is 5250 base pairs long and has 10.5 base pairs per turn for B DNA: Tw=500
    Now, substitute Tw and Wr into the linking number formula: Lk=500-10 Lk=490
    Therefore, the linking number of the plasmid is 490.

CHAPTER-2 ENZYME KINETICS, METABOLISM, PHOTOSYNTHESIS

Previous Year Exam Questions

[GATE 2000]

1. Which of the following statements about cyclic photo-phosphorylation is not correct?
   (A) It does not involve NADPH formation.
   (B) It uses electrons supplied by photosystem II.
   (C) It involves a substrate-level phosphorylation.
   (D) It does not generate oxygen.

[GATE 2000]

2. Deficiency of which one of these enzymes causes defect in the storage of glycogen?
   (A) Lactate dehydrogenase
   (B) Glyceraldehyde-3-phosphate dehydrogenase
   (C) Phosphorylase
   (D) Glycogen synthetase

[GATE 2000]

3. The turnover number of chymotrypsin is 100 $s^{-1}$and for DNA polymerase it is 15 s^{-1}. The means that
   (A) Chymotrypsin binds to its substrates with higher affinity than does DNA polymerase.
   (B) The velocity of the chymotrypsin reaction is always greater than that of DNA polymerase.
   (C) The velocities of reactions catalyzed by both enzymes at saturating substrate levels could be made equal if 6.7 times more DNA polymerase than chymotrypsin were used.
   (D) The velocities of chymotrypsin reaction at a particular enzyme concentration and saturating substrate levels is lower than that of DNA polymerase reaction under the same conditions.

[GATE 2000]

4. Which of the following statements is true? Enzyme catalysis of a chemical reaction
   (A) Increases the forward and reverse reaction rates.
   (B) Decrease $\Delta G^{0'}$ so that the reaction can proceed spontaneously.
   (C) Increases the energy of transition state.
   (D) Decreases the entropy of reaction.

[GATE 2000]

5. Which of the following enzymes can be irreversibly inactivated with *diisopropyl fluorophosphate* (DIPF)?
   (A) Carboxypeptidase A (B) Trypsin
   (C) Lysozyme (D) *Eco*RI endonuclease

[GATE 2000]

6. In the transaminases, the cofactor is linked via Schiff base, formed between the cofactors and the
   (A) α-NH_2, group of N-terminal amino acid.
   (B) β-NH_2, group of asparagine.
   (C) ε-NH_2, group of lysine.
   (D) None of the above.

[GATE 2000]

7. Cholecalciferol (Vitamin D), in order to become biologically active undergoes hydroxylation at two positions in the molecule. Hydroxylation at the 25^{th} position is done in the liver whereas hydroxylation at the 1^{st} position occurs in
   (A) skin. (B) pancreas.
   (C) intestine. (D) kidney.

[GATE 2000, Answer writing type]

8. Answer the following
   (A) In the Entner-Doudoroff pathway, 2-keto-3-deoxy-6-phosphogluconate is acted upon by an enzyme resulting in the formation of two 3-carbon compounds. Name the enzyme and the products formed.

[GATE 2000, Answer writing type]

   (B) Two first-order rate constants K_2 and K_3 and one second-order rate constant K_1 define K_m by the relationship,

$$K_m = \frac{K_2 + K_1}{K_1}$$

   By substituting the appropriate units for the rate constants in this expression, show that K_m must be expressed in the terms of concentration.

[GATE 2000, Answer writing type]

   (C) Arsenate, AsO_4^{3-} is an uncoupling reagent for oxidative phosphorylation but unlike dinitrophenol it does not transport protons across the inner mitochondrial membrane. How might arsenate function as an uncoupler?

[GATE 2000, Answer writing type]

(D) Sketch the appropriate plots if the following variables are plotted. Assume that single Michaelis-Menten kinetics apply.
(i) V versus [S]
(ii) [S] versus time and (iii) [ES] versus time

[GATE 2000, Answer writing type]

(E) When lactose is used as an inducer, there is a lag before the enzymes of the lactose operon are synthesized. With IPTG there is no lag. Explain

[GATE 2000, Answer writing type]

(F) If $^{18}O_2$ were added to C_3 plants on a bright sunny day, would you expect glycine subsequently isolated from the leaves to be labelled? **Explain**.

[GATE 2001]

9. Match the entries in Column I with the appropriate one in the Column II and write matching pairs in the answer book.

Column I	**Column II**
P. Ionophore	1. Cathepsin
Q. Ouabain	2. Na^+-K^+ - ATPase
R. Malonate	3. Homogentisic acid oxidase
S. Alkaptonuria	4. Phenylalanine hydroxylase
T. Protein hydrolysing enzymes	5. Penicillin
	6. Gramicidin A
	7. Competitive inhibitor of succinic dehydrogenase

(A) P-3; Q-2; R-7; S-5; T-1
(B) P-7; Q-3; R-6; S-1; T-2
(C) P-6; Q-2; R-7, S-3; T-1
(D) P-3; Q-2; R-6; S-7; T-1

[GATE 2001, Answer writing type]

10.

(A) The K_M of a certain enzyme is 1 µM. At a substrate concentration of 1 mM, the V_{max} is 50 µmoles/min. However, the V_{max} remained the same, even at a ten-fold lower concentration of the substrate. Explain.

(B) Restriction analysis of a fragment of dsDNA with *Hind*III gave fragments of sizes 2.8 kb and 1.2 kb. The same DNA upon digestion with *Bam*H1, yielded fragment sizes of 1.8 kb, 1.3 kb and 0.9 kb. Double digestion of the DNA with both these enzymes yielded fragment sizes 1.8 kb, 1.0 kb, 0.9 kb and 0.3 kb. Use this data and draw a restriction map of the DNA fragment.

(C) Define isoenzymes.

[GATE 2001]

11. A rat liver extract is treated with avidin. Which of the following conversion in gluconeogenesis will not occur?
(A) Glyceraldehyde-3-P→ Glucose-6-P
(B) Malate → Oxaloacetate
(C) Pyruvate → Phosphoenolpyruvate
(D) Fumarate → Phosphoenolpyruvate

[GATE 2001]

12. The direct effect of cyclic AMP in the protein kinase A pathway is to
(A) activate adenylate cyclase.
(B) dissociate regulatory subunits from protein kinase A.
(C) phosphorylate protein kinase A.
(D) release hormones from the target tissue.

[GATE 2001]

13. β-amylase cleaves
(A) α (1-4) glycosidic bonds.
(B) β (1-4) glycosidic bonds.
(C) α (1-6) glycosidic bonds.
(D) β (1-6) glycosidic bonds.

[GATE 2001]

14. The largest energy reserve (kilocalories) in humans is.
(A) blood glucose.
(B) liver glycogen.
(C) muscle glycogen.
(D) adipose tissue triacylglycerol.

[GATE 2001]

15. A muscle extract is dialyzed exhaustively against 10 mM sodium phosphate buffer, pH 7.0. The extract does not contain any ATPase activity. If ATP is now added, the following cofactor that also must be added to convert glucose to glucose-6-phosphate is
(A) NADH
(B) FADH,
(C) Mg^{2+}
(D) Fe^{3+}

[GATE 2001]

16. Injection of dinitrophenol (DNP) into a rat causes an immediate increase in its body temperature, because
(A) DNP acts as an inhibitor of mitochondrial ATPase.
(B) DNP blocks the electron transport chain.
(C) DNP inhibits succinic dehydrogenase.
(D) DNP uncouples electron transport from oxidative phosphorylation.

[GATE 2002]

17. Which of the following anti-tumour agent acts by impairing the *de novo* purine synthesis?
    (A) Cytosine arabinoside
    (B) 5-Fluorouracil
    (C) Methotrexate
    (D) Hydroxyurea

[GATE 2002]

18. Which of the following is a conservative substitution?
    (A) Val to Ile (B) Asp to Pro
    (C) Lys to Leu (D) Trp to Ala

[GATE 2002]

19. Platelet aggregation is
    (A) initiated at the site of injury by the conversion of fibrinogen to fibrin.
    (B) causes release of serotonin.
    (C) is inhibited by uninjured blood vessels by the secretion of prostacyclins.
    (D) is inhibited by ADP and thromboxane.

[GATE 2002]

20. Oral administration of large amounts of tyrosine may interfere with the intestinal absorption of
    (A) leucine (B) glycine
    (C) aspartate (D) all of the above

[GATE 2002]

21. The K_M of an enzyme is
    (A) One half of the V_{max}
    (B) A dissociation constant.
    (C) The substrate concentration that gives maximal velocity.
    (D) The substrate concentration that gives half maximal velocity.

[GATE 2002]

22. The basal metabolic rate
    (A) is not influenced by energy intake.
    (B) increases in response to starvation.
    (C) increases in direct proportion to energy expenditure.
    (D) decreases during periods of starvation.

[GATE 2002]

23. In human, fatty acids
    (A) can be synthesized from excess dietary carbohydrate or protein.
    (B) must be supplied entirely by diet.
    (C) are not required at all in the diet.
    (D) containing double bonds cannot be synthesized.

[GATE 2002, Answer writing type]

24. A purified enzyme preparation (3 mg mL^{-1}) was diluted 10 times. 10 µL of the diluted enzyme catalyzed the formation of 30 nmoles of product/min under standard assay conditions.
    (A) Express the velocity as µmoles of product/min/mg.
    (B) What does the velocity expressed in µ moles/min/mg signify?
    (C) If the molecular weight of the enzyme is 30,000. Calculate its turnover number.

[GATE 2003]

25. The enzymes where catalysis involves transfer of electrons are named as
    (A) isomerases. (B) transferases.
    (C) oxidoreductases (D) lyases.

[GATE 2003]

26. Vitamin D is derived from which of the following precursors by the action of UV light?
    (A) 7-Dehydrocholesterol
    (B) Lanosterol
    (C) Glycocholate
    (D) Squalene epoxide

[GATE 2003]

27. Following are four enzymatic reactions involved in glycolysis. In which of the following steps is ATP generated?
    (A) 2-phosphoglycerate to phosphoenol pyruvate
    (B) Glucose-6-phosphate to fructose-6-phosphate
    (C) Phosphoenol pyruvate to pyruvate
    (D) Glyceraldehyde-3-phosphate to 1, 3-bisphosphoglycerate

[GATE 2003]

28. Pick the correct statement.
    (A) In *O*-linked glycosylation, sugars are attached to the protein via *O*-glycosidic bonds to the carboxyl groups of Asp and Glu.
    (B) In *O*-linked glycosylation, performed oligosaccharides are attached to the relevant protein.
    (C) In *O*-linked glycosylation, N-acetylglucosamine is added via *O*-glycosidic bonds to the OH groups of Ser and Thr after which other sugars are added sequentially.
    (D) *O*-linked glycosylation is inhibited by the passage of the newly synthesized protein through the Golgi complex

[GATE 2003]

29. Which of the following statements is not true with regard to photosynthesis?
    (A) The dark reactions use NADPH and ATP to drive the synthesis of carbohydrate from CO_2 and H_2O.
    (B) The principal photoreceptor, chlorophyll is derived biosynthetically from protoporphyrin IX.
    (C) Photosystem II (PS II) generates a strong reductant capable of reducing $NADP^+$
    (D) The components involved in the electron transport from H_2O to NADPH are largely organized into three thylakoid membrane-bound particles.

[GATE 2003]

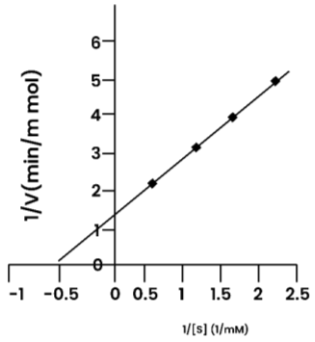
30. The RNase A catalyzed hydrolysis of tRNA, follows a two-step process with the intermediate formation of a 2',3'-cyclic nucleotide. In these steps,
    (A) His 12 acts as a general base in the transphosphorylation step abstracting a proton from an RNA 2'-OH group.
    (B) His 119 acts as a general base in the transphosphorylation step abstracting a proton from all RNA 2'-OH group.
    (C) The 2',3'-cyclic intermediate is hydrolysed when His 12 acts as a general base.
    (D) His 12 acting as a general acid in the transphosphorylation step promotes bond scission by protonating the leaving group.

[GATE 2003]

31. Suppose [4-^{14}C] oxaloacetate is fed to mitochondria. After one turn of the citric acid cycle, which carbon(s) of succinate would be labelled?
    (A) None
    (B) Equally distributed between C-1 and C-4
    (C) Equally distributed between C-2 and C-3
    (D) C-4

[GATE 2003]

32. The graph shows a Lineweaver-Burk plot for an enzyme catalyzed reaction:



Which of the following statements is correct?
    (A) The V_{max} is 5 mmol min^{-1} and with competitive inhibition V_{max} remains unchanged.
    (B) K_M is 2 mmol min^{-1} and with competitive inhibition both K_M and V_{max} decrease.
    (C) K_M is 0.5 mM and with competitive inhibition V_{max} increases, but K_M remains unchanged.
    (D) K_M is 2.0 mM and with competitive inhibition K_M increases but V_{max} remains unchanged.

[GATE 2003]

33. For the reaction, Fructose-6-phosphate + P_i ⇋ Fructose 1, 6-bisphosphate + H_2O. The equilibrium constant at pH 7 and 300 K is 10^{-3}. The standard free energy change (in kcal per mole) for the reactions approximately equal to: (R = 2 cal deg^{-1} mol^{-1}).
    (A) +4.1 (B) -4.1
    (C) +2.2 (D) -2.2

[GATE 2004]

34. The co-enzyme involved in transfer of carboxyl group is
    (A) NADH (B) Coenzyme A
    (C) S-Adenosyl methionine (D) Biotin

[GATE 2004]

35. Electron flow in cytochrome oxidase in the respiratory chain can be blocked by
    (A) Rotenone (B) Amytal
    (C) Cyanide (D) Cycloheximide

[GATE 2004]

36. The biochemical reactions leading from glucose to the generation of glyceraldehyde-3-phosphate consume ATP. The number of ATP molecules consumed for the conversion of one molecule of glucose to glyceraldehyde-3-phosphate is
    (A) 2 (B) 1
    (C) 3 (D) 4

[GATE 2004]

37. The net reaction of the citric acid cycle is
    (A) Acetyl CoA + $2NAD^+$ + FAD + GDP + Pi + $2H_20$ → $2CO_2$ + 2NADH + $FADH_2$ + GTP + $2H^+$ + CoA
    (B) Acetyl CoA + $3NAD^+$ + FAD + GDP + Pi + $2H_2O$ → $2CO_2$ +3NADPH + $FADH_2$ + GTP + $2H^+$ + CoA
    (C) Acetyl CoA + $2NAD^+$ + 2FAD + 2GDP + Pi + $2H_2O$ → $2CO_2$ + 2NADH + 2FADH, + 2GTP+CoA
    (D) Acetyl CoA + NAD^+ + FAD + GDP + Pi +H_2O→ $2CO_2$ + NADH + $FADH_2$ + GTP +CoA

[GATE 2004]

38. Choose the correct match

Column I	Column II
P. β-ketoacyl-ACP synthase	1. Reduces double bond forming saturated acyl-ACP
Q. β-ketoacyl-ACP reductase	2. Reduces β-keto group to β-hydroxy group
R. Enoyl-ACP-reductase	3. Condenses acyl and malonyl groups
S. Acyl Carrier Protein (ACP)	4. Carries acyl group in thioester linkages

	P	Q	R	S
(A)	2	1	3	4
(B)	3	2	1	4
(C)	4	1	2	3
(D)	3	1	2	4

[GATE 2004]

39. Oligosaccharide chain is added to the Asparagine residue of a newly synthesized protein on the luminal side of the endoplasmic reticulum membrane. The asparagine of the newly synthesized protein that is linked to oligosaccharide chain is a part of the sequence (x can be any amino acid other than proline)

(A) Asn-x-Asp (B) Asn-x-Thr
(C) Asn-x-Ile (D) Asn-x-Gly

[GATE 2004]

40. Which of the following statements is not true with respect to the photosystem II found in the chloroplasts? [Photosystem I (PSI), Photosystem II (PS II)].

(A) PS II is located in the grana.
(B) Chlorophyll molecule in the reaction centre for the PS II is bound to a 110 KD integral membrane protein.
(C) A complex of cytochromes b and f transports electrons from PS II to PS I.
(D) PS II reaction centre is bound to two Mn^{2+} ions.

[GATE 2004]

41. Choose the statement that is not correct with respect to the protein kinase (PKC).

(A) Activated PKC can phosphorylate the specific tryptophan residue on the target protein.
(B) PKC is a Ca^{2+} dependent kinase.
(C) PKC can be activated by diacylglycerol.
(D) Activation of PKC can lead to the activation of MAP kinase.

[GATE 2005]

42. Activated fatty acyl groups are transported into the mitochondria by

(A) Coenzyme A (B) Oxaloacetate
(C) Carnitine (D) Citrate

[GATE 2005]

43. Which one of the following fatty acids will have melting point higher than the palmitic acid (16:0)?

(A) Myristic acid (14:0)
(B) Palmitoleic acid (16:1)
(C) Oleic acid (18:1)
(D) Stearic acid (18:0)

[GATE 2005]

44. A diabetes mellitus patient excretes glucose in urine even when kept on a carbohydrate free diet. This is because

(A) Fats are catabolised in liver to form glucose
(B) Amino acids are catabolised in liver to form glucose
(C) Increased production of amino acids
(D) Increased breakdown of glycogen

[GATE 2005]

45. The pK_a of lysine are given below pK_a (COOH) = 2.2, pK_a (α-NH_3^+) = 9.0, pK_a (ε-NH_3^+) = 10.0 The pI of lysine is

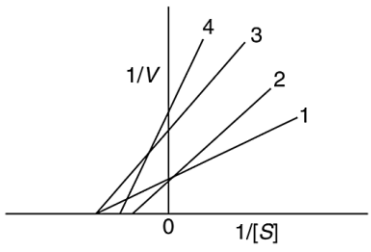
(A) 7.07 (B) 9.50
(C) 6.16 (D) 5.60

[GATE 2005]

46. The coenzymes involved in the formation of Acetyl CoA from Pyruvate are

(A) Thiamine pyrophosphate, Lipoic acid and FAD
(B) Pyridoxal phosphate, Biotin and FAD
(C) Vitamin B_{12}, Folic acid and Vitamin C
(D) NADH, Lipoic acid and Vitamin E

Common Data for Questions 104-105. The kinetic data for an enzymatic reaction in the presence and absence of inhibitors are plotted in the following figure.



[GATE 2005]

47. Which line represents the kinetics without inhibitor?
(A) Line 1 (B) Line 2
(C) Line 3 (D) Line 4

[GATE 2005]

48. Which line represents kinetics of non-competitive inhibition?
(A) Line 1 (B) Line 2
(C) Line 3 (D) Line 4

Statement for Linked Answer Questions 106 & 107:

The following fragments are isolate on partial hydrolysis of a nonapeptide X:

Val-Arg-Pro-Gly. Lys-Phe-Val-Arg. Ala-Gly-Ser-Lys

[GATE 2005]

49. The correct sequence of X is
(A) Ala-Gly-Ser-Lys-Ala-Pro-Val-Arg-Gly
(B) Val-Arg-Gly-Lys-Phe-Val-Arg-Ala-Pro
(C) Lys-Phe-Val-Arg-Ala-Gly-Ser-Pro Gly
(D) Ala-Gly-Ser-Lys-Phe-Val-Arg-Pro-Gly

[GATE 2005]

50. The number of fragments obtained when X is digested with trypsin is
(A) 0 (B) 2
(C) 3 (D) 4

[GATE 2006]

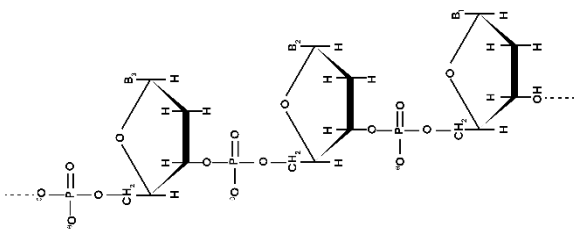
51. Which of the following amino acids does NOT contribute to fluorescence of a protein?
(A) Tyrosine (B) Phenylalanine
(C) Cysteine (D) Tryptophan

[GATE 2006]

52. The main function of the pentose phosphate pathway is to
(A) Supply ribose 5-phosphate and NADPH
(B) Supply NADH and ATP
(C) Provide a mechanism to use the carbon skeletons of excess amino acids
(D) Provide carbon skeletons for oxidation of fatty acids

[GATE 2006]

53. The polymer shown below is a component of



(A) Polysaccharide
(B) Polyribonucleotide
(C) Polyketide
(D) Polydeoxyribonucleotide

[GATE 2006]

54. The double-reciprocal transformation of the Michaelis-Menten equation, also called the Lineweaver-Burk plot, is given by $1/V_0 = K_m/(V_{max}[S]) + 1/V_{max}$ To determine K_m from a double reciprocal plot, you would
(A) Take the reciprocal of the y-axis intercept
(B) Take the reciprocal of the x-axis intercept
(C) Multiply the reciprocal of the x-axis intercept by-1
(D) Multiply the reciprocal of the y-axis intercept by -1

[GATE 2006]

55. Incubation of a cell extract containing all enzymes of glycolysis with [$\gamma -^{32}$ P] ATP and unlabeled inorganic phosphate results in the formation of which of the following labeled compounds (assume that pyruvate kinase is inactivated)?
1. Glucose-6-^{32}Phosphate
2. (3-^{32}P)-Phosphoglycerate
3. (1-Phospho-3-^{32}Phospho)-Bisphosphoglycerate
4. (1-Phospho-6-^{32}Phospho)-Fructose bisphosphate
(A) 1 and 3 (B) 1, 2 and 3
(C) 2 and 4 (D) only 4

[GATE 2006]

56. Identify the correct pairs for the primary functions of the different enzyme classes
P. Kinases
Q. Lyases
R. Synthases
S. Phosphatases
1. Cleave bonds by elimination
2. Make large molecules from small molecules
3. Transfer phosphate group to biomolecules
4. Remove phosphate group from biomolecules
(A) P-4, Q-2, R-3, S-1
(B) P-3, Q-1, R-2, S-4
(C) P-4, Q-1, R-2, S-3
(D) P-3, Q-2, R-1, S-4

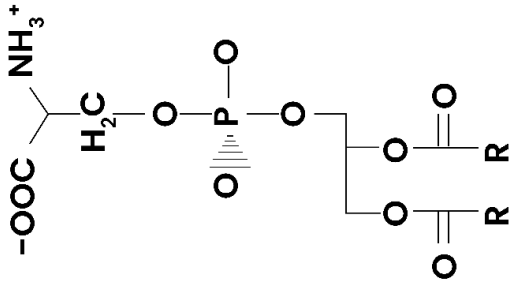
[GATE 2006]

57. Which of the following statements about the mitochondrial proton gradient and membrane potential is correct?

(A) Either of them is sufficient to make ATP from ADP + P_i
(B) Both are required to make ATP
(C) Usually cancel one another since the system is at equilibrium
(D) Neither of them is required for ATP synthesis

[GATE 2006]

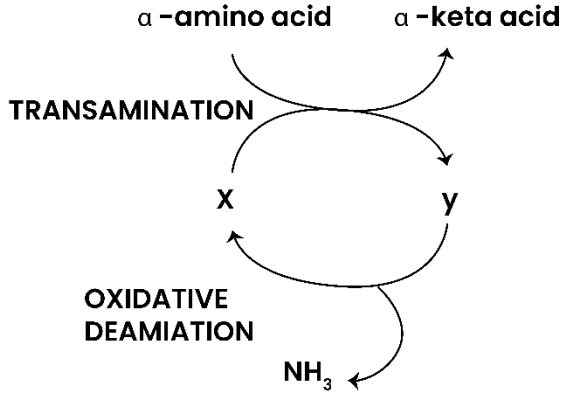
58. The molecule shown is:



(A) Phosphatidylserine
(B) Phosphatidylcholine
(C) Phosphatidylethanolamine
(D) Phosphatidylinositol

[GATE 2006]

59. Part of the overall flow in amino acid catabolism is shown in the figure. Identify X and Y.



(A) X: L-Glutamate; Y: α-Ketoglutarate
(B) X: α -ketoglutarate: Y: L-Glutamate
(C) X: α -ketoglutamate: Y: L-Glutamine
(D) X: α -ketoglutarate: Y: D-Glutamate

[GATE 2007]

60. Deamination of cytosine produces
(A) Uracil (B) Pseudouracil
(C) Hypoxanthine (D) 5-Methyluracil

[GATE 2007]

61. One of the carbon atoms of a glucose molecule is [^{14}C]-labelled. If $^{14}C0_2$ is released during the conversion of pyruvate to acetyl coenzyme-A, which carbon atom of glucose was radiolabelled?
(A) C3 but not C4 (B) C3 or C4
(C) C1 or C6 (D) C1 but not C6

[GATE 2007]

62. The maximum number of hydrogen bonds that a molecule of water can form is
(A) 1 (B) 2
(C) 3 (D) 4

[GATE 2007]

63. The total radioactivity in 1 ml solution containing 0.25 mg of glycine is 1 mCi. The specific activity (mCi/millimole) of radiolabelled glycine will be
(A) 300 (B) 18.75
(C) 3000 (D) 1875

[GATE 2007]

64. Folate derivatives are required for the synthesis of which deoxynucleotides?
(A) Adenylate and guanylate
(B) Cytidylate and thymidylate
(C) Adenylate, guanylate and thymidylate
(D) Adenylate, guanylate and cytidylate

[GATE 2007]

65. Cytochrome *c* reductase, also called as Complex III or cytochrome bc_1 complex, localized on the inner mitochondrial membrane receives electrons from ubiquinol and donates to cytochrome *c*. In one cycle
(A) Two cytochrome *c* molecules are reduced
(B) One ubiquinol is oxidized
(C) Two ubiquinols are oxidized and one ubiquinone is reduced
(D) One cytochrome *c* is reduced

[GATE 2007]

66. Which of the following enzyme activities can be detected in the supernatant obtained by centrifugation of liver homogenate at 100,000 g for 1 hr at 4°C? (Not verified yet)
(A) Succinate dehydrogenase
(B) Glyceraldehyde 3-phosphate dehydrogenase
(C) Glycogen synthetase
(D) Aconitase

[GATE 2007]

67. Which of the following statements about the enzyme complexes of the electron transport system is correct?
(A) They interact with one another via mobile electron carriers
(B) They are located in the mitochondrial matrix
(C) They cannot be separated from one another in a functional form
(D) They all have cytochromes

[GATE 2007]

68. F_1F_0-ATPase in chloroplasts is located on the
    (A) Inner chloroplast membrane with F_1 facing the stroma
    (B) Inner chloroplast membrane with F_1 facing the inter-membrane space
    (C) Thylakoid membrane with F_1 facing the stroma
    (D) Thylakoid membrane with F_1 facing the thylakoid lumen

Common Data Questions Common Data for Questions 69, 70:

The number of protons translocated by the various vectorial proteins localized on the inner mitochondrial membrane of an organism was determined. They are as follows: NADH dehydrogenase: 4, cytochrome bc_1 complex: 2, cytochrome aa_3 complex: 4 and F_1 F_0 -ATPase: One proton is also required for the transport of inorganic phosphate into the mitochondrial matrix

[GATE 2007]

69. The number of ATP molecules that can be synthesized by the oxidation of one NADH molecule is
    (A) 2 (B) 2.5
    (C) 3 (D) 3.3

[GATE 2007]

70. If the cytosolic NADH is transported to the matrix by the glyceraldehyde 3-phosphate shuttle, then the number of ATPs synthesized is
    (A) 1.5 (B) 2
    (C) 2.5 (D) 3.3

Statement for Linked Answer Question 88 & 89:

$\Delta G^{0\prime}$ is the symbol used to denote standard free energy change of a chemical reaction in biological system. The standard conditions are T = 298 K, concentration of water = 55.5 M, pH = 7, and the reactants and products (other than water and proton) are initially present at 1 M concentration.

[GATE 2007]

71. Suppose ΔG denotes the free-energy change for the reaction $A + B \rightleftharpoons C + H$ at pH 5, all other conditions being the same as the standard conditions specified above. Then
    (A) $\Delta G = \Delta G^{0\prime}$
    (B) $\Delta G = \Delta G^{0\prime} + 11.5\ RT$
    (C) $\Delta G = \Delta G^{0\prime} + 4.6\ RT$
    (D) $\Delta G = \Delta G^{0\prime} + 16.1\ RT$

[GATE 2007]

72. If $\Delta G^{0\prime}$ for the reaction is - 11. 7 kJ/mol and R = 8.314 kJ/mol, the reaction is
    (A) Endergonic at both 37°C and 25°C
    (B) Endergonic at 37°C and exergonic at 25°C
    (C) Exergonic at both 37°C and 25°C
    (D) Exergonic at 37°C and endergonic at 25°C

[GATE 2008]

73. Which of the following inhibitor uncouples electron transport and oxidative phosphorylation?
    (A) Azide (B) Dinitrophenol
    (C) Oligomycin (D) Rotenone

[GATE 2008]

74. The catalytic efficiency of an enzyme is represented by
    (A) V_{max} (B) K_M
    (C) k_{cat} (D) k_{cat}/K_m

[GATE 2008]

75. Match the function of following cofactors

	Column-I		Column-II
P.	Thiamine pyrophosphate	1.	Acyl group transfer
Q.	Coenzyme A	2.	Transfer of one carbon component
R.	Pyridoxal phosphate	3.	Group transfer to or from amino acid
S.	Tetrahydrofolate	4.	Aldehyde transfer

    (A) P-4, Q-3, R-1, S-2 (B) P-4, Q-3, R-2, S-1
    (C) P-4, Q-1, R-3, S-2 (D) P-3, Q-1, R-4, S-2

[GATE 2008]

76. Match the enzymes in Column I with their metabolic pathways in Column II.

	Column-I		Column-II
P.	Succinyl CoA synthetase	1.	Oxidation
Q.	Acyl CoA dehydrogenase	2.	Calvin cycle
R.	Transketolase	3.	Tricarboxylic acid cycle
S.	Ribulose 1, 5-bisphosphate carboxylase	4.	Pentose phosphate pathway

    (A) P-1, Q- 2, R-3, S-4 (B) P-3, Q- 1, R-2, S-4
    (C) P-2, Q- 4, R-1, S-3 (D) P-3, Q- 1, R-4, S-2

[GATE 2008]

77. Glycolysis and gluconeogenesis are reciprocally coordinated. Which of the following will activate pyruvate carboxylase in gluconeogenesis?

(A) Acetyl CoA
(B) Fructose 2,6-bisphosphate
(C) ADP
(D) ATP

[GATE 2008]

78. The following four different solutions are prepared by mixing the components of electron transport chain. Which among them is expected to cause a net transfer of electrons to cytochrome c?
(A) Reduced ubiquinone and reduced cytochrome c.
(B) Reduced ubiquinone, cytochrome bc_1 complex and reduced cytochrome c.
(C) Oxidized ubiquinone and oxidized cytochrome c.
(D) Reduced ubiquinone, cytochrome bc_1 complex and oxidized cytochrome c.

[GATE 2008]

79. The atoms of pyrimidine ring are derived from
(P) Carbamoyl phosphate
(Q) Inosine mono phosphate
(R) Aspartate
(S) Glutamate
(A) P, Q (B) P, R
(C) P, S (D) Q, R

[GATE 2009]

80. Pernicious anemia is due to.
(A) blockage of vitamin B_{12} absorption.
(B) blockage of vitamin A absorption
(C) deficiency of vitamin C
(D) deficiency of vitamin B_2

[GATE 2009]

81. Generally, the rate-limiting step of major metabolic pathways is a reaction
(A) In which the availability of the substrate is limited
(B) Catalyzed by an allosteric enzyme.
(C) Catalyzed by an enzyme with very low K_m.
(D) Whose products are not readily consumed by the subsequent step of the pathway

[GATE 2009]

82. Phospholipases A1 and A2,
(A) Play no role in phospholipids synthesis.
(B) hydrolyze phosphatidic acid to diglycerate.
(C) Remove fatty acid from S_N1 and S_N2 of phospholipids.
(D) Are involved in biosynthesis of phosphatidyl ethanolamine.

[GATE 2009]

83. The formation of ATP from ADP and P_i is not a spontaneous reaction. A reason for this is
(A) ATP readily ionizes.
(B) Electrostatic repulsion in ATP is lower than that in ADP.
(C) ATP is better hydrated than the total hydration levels of ADP and Pi.
(D) Resonance stabilization of P-O bonds in P_i is higher than that in ATP.

[GATE 2009]

84. Choose the correct pair from the followings.

a. Isocitrate lyase	i. Conversion of amino acids into glucose
b. PEP carboxykinase	ii. Biotin
c. Pyruvate dehydrogenase complex	iii. Synthesis of glucose from acetate
d. Phosphofructokinase	iv. Lipoic acid
e. Pyruvate carboxylase	v. An allosteric enzyme

(A) a-i, b-ii, c-iv, d-v, e-iii
(B) a-iii, b-i, c-iv, d-v, e-ii
(C) a-iii, b-i, c-iv, d-ii, e-v
(D) a-ii, b-v, c-i, d-iv, e-iii

[GATE 2009]

85. In mammals, the second messenger Nitric Oxide (NO) is produced from
(A) Ammonium nitrate
(B) Arginine
(C) Urea
(D) Nitrous acid

[GATE 2010]

86. In the two-half reaction
Acetaldehyde
$+ 2H^+ + 2e^- \rightarrow Ethanol\ \Delta E^0 = -0.16\ V$
$NADH + H \rightarrow NAD^+ + 2H^+ + 2e^- \Delta E^0 = -0.32\ V$
$(F = 23{,}063\ cal/V)$
The ΔG^o for coupled reaction will be\
(A) +7,400 cal
(B) -7,400 cal
(C) -22,200 cal
(D) +22,200 cal

[GATE 2010]

87. Match the metabolic pathways in Group 1 with the corresponding enzymes in Group 2.

Group 1	Group 2
P. β-Oxidation	1. Ribulose bisphosphate carboxylase
Q. Glycolysis	2. Phosphofructokinase I
R. Gluconeogenesis	3. Phosphoenol pyruvate carboxykinase
S. Calvin cycle	4. Thiolase
	5. Phosphofructokinase 2

(A) P-4, Q-2, R-3, S-5 (B) P-3, Q-2, R-4, S-1
(C) P-3, Q-1, R-5, S-2 (D) P-4, Q-2, R-3, S-1

[GATE 2010]

88. Match the parameters in Group 1 with the correct options in Group 2.

Group 1	Group 2
P. K_M	1. Catalytic efficiency of the enzyme
Q. K_{cat}/K_M	2. Affinity of enzyme to the inhibitor
R. pK_a	3. Affinity of enzyme to the substrate
S. K_I	4. Maximum buffering capacity

(A) P-3, Q-I, R-2, S-4 (B) P-3, Q-1, R-4, S-2
(C) P-1, Q-2, R-4, S-3 (D) P-1, Q-4, R-2, S-3

[GATE 2010]

89. Lineweaver-Burk plot is a plot of
(A) $\frac{1}{V_0}\ Vs\ \frac{1}{[S]}$ (B) $V_0\ vs\ [S]$
(C) $V_0\ vs\ \frac{1}{[S]}$ (D) $\frac{1}{V_0}vs\ [S]$

[GATE 2010]

90. Amino acids responsible for *N*-linked and *O*-linked glycosylation of proteins are
(A) Asparagine and Aspartic acid
(B) Glutamine and Serine
(C) Glutamic acid and Serine
(D) Asparagine and Threonine

[GATE 2010]

91. The metabolic disorders, Alkaptonuria and Phenylketonuria are caused by defects in the enzymes
P. Glucose-6-phosphatase
Q. Phenylalanine hydroxylase
R. Homogentisate 1,2-dioxygenase
S. Tyrosinase
(A) Q, R (B) P, R
(C) P, Q (D) Q, S

[GATE 2011]

92. Which one of the following enzymes fixes CO_2 into organic form?
(A) Ribulose 5-phosphate kinase
(B) Ribulose 1,5-bisphosphate carboxylase
(C) Pyruvate dehydrogenase
(D) Carbonic anhydrase

[GATE 2011]

93. Cyanide poisoning is due to its direct inhibition of.
(A) Electron transport chain
(B) Fatty acid biosynthesis
(C) Fatty acid oxidation
(D) Nucleic acid biosynthesis

[GATE 2011]

94. In humans, the largest energy reserve is
(A) Liver glycogen
(B) Blood glucose
(C) Muscle glycogen
(D) Adipose tissue triacylglycerol

[GATE 2011]

95. In the following enzyme catalyzed reaction which follows Michaelis-Menten kinetics

$$E + S \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ES \xrightarrow{k_2} E + P$$

K_m is equals to
(A) $k_{-1}/(k_1,k_2)$ (B) $(k_1, k_2)/k_{-1}$
(C) $k_1/(k_2 + k_{-1})$ (D) $(k_2 + k_{-1})/k_1$

[GATE 2012]

96. Which one of the following compounds does NOT block electron transport?
(A) Cyanide (B) Rotenone
(C) Oligomycin (D) Antimycin A

[GATE 2012]

97. An amino-acid has one proton donating group in the side chain (R). The pK_{COOH}, pK_{NH2} 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

[GATE 2012]

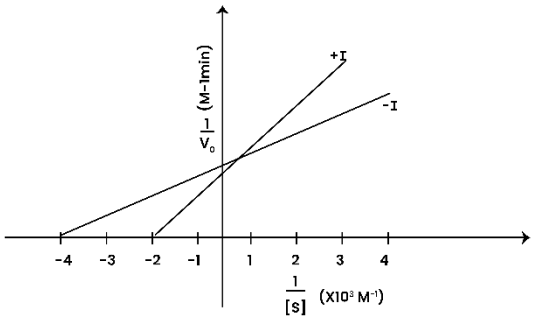
98. β-oxidation of a 16-carbon fatty acid and a 17 carbon fatty acid leads to formation of
    (A) (8 Acetyl CoA) and (8 Acetyl CoA + CO_2), respectively
    (B) (5 Propionyl CoA + 1 CO_2) and (5 Propionyl CoA +1 Acetyl CoA), respectively
    (C) (5 Propionyl CoA + 1 CO_2) and (5 Propionyl CoA + 2 CO_2), respectively
    (D) (8 Acetyl CoA) and (7 Acetyl CoA + 1 Propionyl CoA), respectively

[GATE 2012]

99. The actual free energy change of a given biochemical reaction carried out under standard conditions with 1 M initial concentration of each of the reactants and products will be
    (A) equal to zero
    (B) equal to standard free energy change for the reaction
    (C) less than the standard free energy change for the reaction
    (D) greater than the standard free energy change for the reaction

[GATE 2012]

100. The kinetics of an enzyme in the presence (+I) or absence (-I) of a reversible inhibitor is described in the following graph.



If concentration of the reversible inhibitor in +I experiment was equal to 3.0×10^{-3} M, then the dissociation constant for the enzyme-inhibitor complex is
    (A) 1×10^{-3} M (B) 2×10^{-3} M
    (C) 3×10^{-3} M (D) 4×10^{-3} M

[GATE 2012]

101. Leguminous plants maintain a very low concentration of free oxygen in their root nodules because
    (A) The nitrogen fixing bacteria living in the root nodules are anaerobic
    (B) Of binding of oxygen to leg-hemoglobin
    (C) Reductase enzyme of the nitrogenase complex helps in removal of O_2
    (D) Nitrogenase enzyme of the nitrogenase complex helps in removal of O_2

[GATE 2013]

102. Which one of the following statements is **TRUE** when a cell is kept in a hypotonic solution?
    (A) Water moves out of the cell
    (B) Size of the cell remains same
    (C) No movement of water takes place
    (D) Size of the cell increases

[GATE 2013]

103. The order n for a given substrate concentration in an enzyme catalyzed reaction following Michaelis-Menten kinetics, is
    (A) $n = 1$ (B) $n = 0$
    (C) n is not defined (D) $0 \leq n \leq 1$

[GATE 2013]

104. The terminal electron acceptor during mitochondrial respiration is
    (A) O_2 (B) FAD^+
    (C) NAD^+ (D) ATP

[GATE 2013]

105. During the biosynthesis of urea in the urea cycle, the two nitrogen atoms are derived from
    (A) Two free ammonium groups
    (B) Free ammonium group and aspartate
    (C) Both nitrogen atoms are derived from arginine
    (D) One nitrogen atom is derived from citrulline and one from glutamate.

[GATE 2013]

106. An enzyme has two binding sites for an inhibitor molecule. When the inhibitor binds to the first site, the dissociation constant of the inhibitor for the second site increases, leading to negative co-operativity. The Hill coefficient for such an inhibitor is
    (A) equal to one (B) greater than one
    (C) less than one (D) less than zero

[GATE 2013]

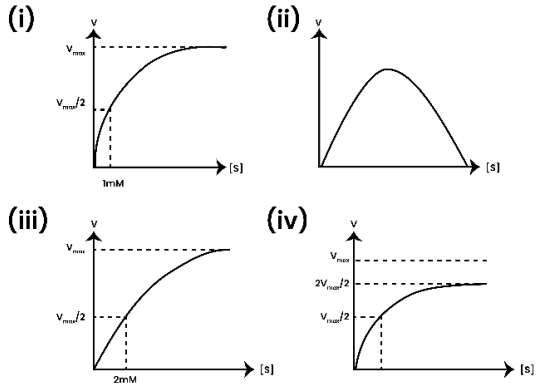
107. You have prepared 1.0 liter of 0.5 M acetate buffer (pH=5.0). The dissociation constant of acetic acid is 1.7×10^{-5} M. What would be the acetate ion concentration in the buffer?

(A) 0.1M (B) 0.25 M
(C) 0.315 M (D) 0.415 M

[GATE 2013]

108. The following figures show the plot of reaction rate versus substrate concentration (mM) for an enzyme catalyzed reaction in the presence and absence of an inhibitor. Match the possible reaction types with the plots.

(P) Competitive inhibition
(Q) Substrate inhibition
(R) Michaelis-Menten
(S) Non-competitive inhibition



(A) P – i, Q – iii, R – ii, S – iv
(B) P – iii, Q – ii, R – i, S – iv
(C) P – iii, Q – iv, R – i, S – ii
(D) P – iv, Q – ii, R – i, S – iii

[GATE 2013]

109. Arrange the following in the increasing order of amount of ATP generated by metabolism of one molecule of the following compounds.

(i) Anaerobic catabolism of starch with 300 glucose units
(ii) Aerobic catabolism of glucose
(iii) Aerobic catabolism of acetate
(iv) Aerobic catabolism of palmitate

(A) (ii), (iv), (iii), (i) (B) (iii), (ii), (i), (iv)
(C) (iv), (ii), (i), (iii) (D) (iii), (ii), (iv), (i)

[GATE 2013]

110. Match the following enzymes with their regulatory mechanism

(a) Phosphofructokinase
(b) Glycogen synthase
(c) β-galactosidase
(d) Lactate dehydrogenase

1. Product inhibition
2. Control of enzyme synthesis
3. Allosteric interaction
4. Covalent modification

(A) (a)-3, (b)-2, (c)-1, (d)-4
(B) (a)-3, (b)-4, (c)-2, (d)-1
(C) (a)-4, (b)-3, (c)-1, (d)-4
(D) (a)-4, (b)-1, (c)-2, (d)-3

[GATE 2013]

111. An enzyme of 40 kDa is added to a substrate solution in a molar ratio of 1:3. The concentration of the enzyme in the mixture is 12 mg/ml. What would be the corresponding substrate concentration?

(A) 0.4 mM (B) 0.12 mM
(C) 0.9 mM (D) 0.3 mM

[GATE 2014]

112. During an enzyme catalyzed reaction, the equilibrium constant

(A) Increases
(B) Decreases
(C) Remains unchanged
(D) Can increase or decrease, depending on the enzyme

[GATE 2014]

113. Which one of the following molecules is an allosteric activator of phosphofructokinase-1?

(A) Fructose 1,6-bisphosphate
(B) Fructose 2,6-bisphosphate
(C) Glucose 6-phosphate
(D) Citrate

[GATE 2015]

114. Which one of the following small molecules is a prerequisite for fatty acid oxidation?

(A) Inositol (B) Choline
(C) Carnitine (D) Glycerol

[GATE 2015]

115. Oxidation of one molecule of glucose via the glycerol-phosphate shuttle produces

(A) 32 molecules of ATP
(B) 32 molecules of NADPH
(C) 30 molecules of ATP
(D) 30 molecules of NADPH

[GATE 2015]

116. Ribulose-5-phosphate epimerase is involved in which one of the following processes?

(A) Glycolysis
(B) TCA cycle
(C) Glycosylation
(D) Pentose phosphate pathway

[GATE 2015]

117. Proteolytic enzymes are usually biosynthesized as large, inactive precursors known as
(A) holoenzymes (B) ribozyme
(C) zymogens (D) apoenzymes

[GATE 2015]

118. The formation of a carbocation, also called an oxonium ion, occurs during the reaction catalyzed by
(A) aldolase (B) lysozyme
(C) ribonuclease A (D) carboxypeptidase

[GATE 2015]

119. Match the entries in Column-1 with those in Column-2

Column-1	**Column-2**
P. Vitamin B_1	1. Thiamine pyrophosphate
Q. Carboxypeptidase	2. Aconitase
R. TCA cycle	3. Sucrose
S. Reducing sugar	4. Zn^{2+}
	5. Riboflavin
	6. Lactose

(A) P-1; Q-4; R-2; S-6
(B) P-5; Q-1; R-2; S-3Aconitase catalyzes the second step of TCA cycle to
(C) P-1; Q-4; R-5; S-6
(D) P-5; Q-2; R-1; S-6

[GATE 2016]

120. Inter-conversion of UDP-glucose and UDP-galactose is catalyzed by
(A) an oxidase (B) a kinase
(C) an epimerase (D) a mutase

[GATE 2016]

121. Four groups of metabolites are given below. Choose the group in which all the compounds contain at least one bond whose ΔG'° of hydrolysis is ≤ −7.0 kcal/mole.
(A) Glucose 1-phosphate, Adenosine triphosphate, Fructose 1,6-bisphosphate
(B) Creatine phosphate, Acetyl phosphate, Succinyl CoA
(C) Glycerol 3-phosphate, Acetyl CoA, 1,3-Bisphosphoglycerate
(D) Glucose 6-phosphate, Phosphoenolpyruvate, Adenosine diphosphate

[GATE 2016]

122. The ΔG'° for the malate dehydrogenase catalyzed step of Krebs cycle is +7.1 kcal/mole. Nevertheless, the conversion of malate to oxaloacetate *in vivo* proceeds spontaneously because the subsequent reaction that consumes oxaloacetate has a ΔG'° of
(A) −3.0 kcal/mole (B) +3.0 kcal/mole
(C) −7.7 kcal/mole (D) +7.7 kcal/mole

[GATE 2016]

123. When freshly isolated intact mitochondria were incubated with ADP and inorganic phosphate neither the oxygen consumption nor the ATP synthesis could be detected. Addition of succinate resulted in increased oxygen consumption as well as ATP synthesis with time. Subsequent addition of cyanide to this system will result in which one of the following?
(A) Both oxygen consumption and ATP synthesis are inhibited
(B) Oxygen consumption continues but ATP synthesis is inhibited
(C) Oxygen consumption is inhibited but ATP synthesis continues
(D) Both oxygen consumption and ATP synthesis continue

[GATE 2016]

124. Aspartate residues are found in the active sites of many enzymes. The pK_α for the β −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

[GATE 2016]

125. Kinetic parameters for the enzyme fumarase with three different substrates are given below.

Substrate	$K_M(\mu M)$	$K_{cat}(sec^{-1})$
Fluorofumarate	**27**	**2700**
Fumarate	**5**	**800**
Chlorofumarate	**111**	**20**

The specificity of fumarase for the substrates decreases in the order
(A) Fluorofumarate > Fumarate > Chlorofumarate
(B) Chlorofumarate > Fluorofumarate > Fumarate
(C) Fumarate > Fluorofumarate > Chlorofumarate
(D) Fumarate > Chlorofumarate > Fluorofumarate

[GATE 2017]

126. Which one of the enzymes is responsible for arsenic toxicity?
(A) Pyruvate kinase
(B) Aldolase
(C) Phosphofructokinase
(D) Pyruvate dehydrogenase

[GATE 2017]

127. Which one is TRUE for Calvin cycle?
(A) Glycerol 3-phosphate is generated in this cycle
(B) CO_2 is not consumed in this cycle
(C) This is a reductive pentose phosphate cycle
(D) Ribose 5-phosphate is a carboxylation substrate in this cycle

[GATE 2017]

128. Administration of primaquine causes severe hemolytic anemia because it
(A) Increases the demand for NADPH to a level that cells cannot meet
(B) Decreases the demand for NADPH
(C) Inactivates glutathione peroxidase of erythrocytes
(D) Increases reduced glutathione level of erythrocytes

[GATE 2017]

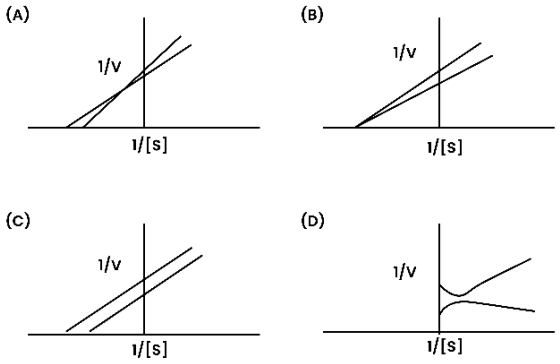
129. Match the following enzymes in column I with their cofactors in column II

Column I	**Column II**
(P) Pyruvate decarboxylase	i. Biocytin
(Q) Glyceraldehyde 3-phosphate dehydrogenase	ii. $NADP^+$
(R) Pyruvate carboxylase	iii. NAD^+
(S) Glucose-6-phosphate dehydrogenase	iv. Thiamine pyrophosphate

(A) P-ii; Q-i; R-iv; S-iii
(B) P-iv: Q-iii; R-i; S-ii
(C) P-i: Q-ii; R-iii; S-iv
(D) P-iii; Q-i; R-iv; S-ii

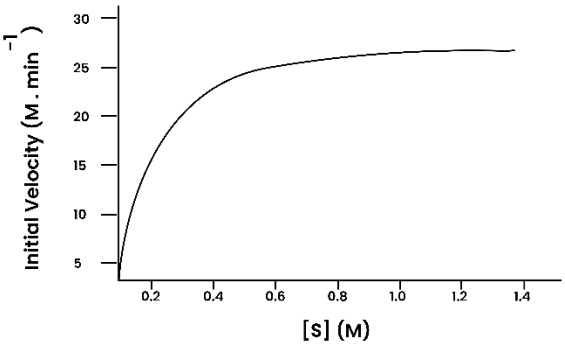
[GATE 2017]

130. In an *in vitro* dehydrogenation reaction of succinate catalyzed by succinate dehydrogenase, malonate is added. Which one of the following curves represents the effect of malonate on the catalysis of succinate dehydrogenase?



[GATE 2018]

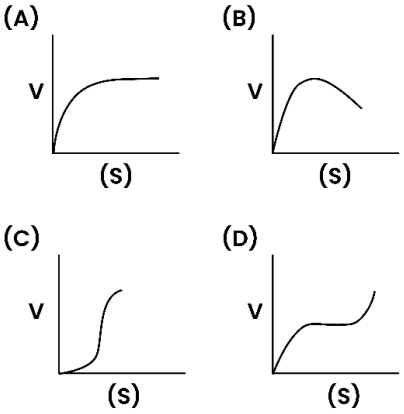
131. The substrate saturation profile of an enzyme that follows Michaelis-Menten kinetics is depicted in the figure. What is the order of the reaction in the concentration range between 0.8 to 1.4 M?



(A) Zero (B) Fraction
(C) First (D) Second

[GATE 2018]

132. Which one of the following profiles represent the phenomenon of cooperativity?



[GATE 2018]

133. The movement of protons through the F_oF_1-ATPase during mitochondrial respiration is required for ____
(A) The increase in pH of mitochondrial matrix.
(B) Changing the conformation of F_oF_1-ATPase to expel the ATP.
(C) Importing P_i from inter membrane space.
(D) Decreasing the affinity of ADP to F_oF_1-ATPase.

[GATE 2018]

134. Which one the following reaction mechanisms drives the conversion of low energy 3-phosphoglyceraldehyde to high energy 1,3-bisphosphoglycerate?
(A) Oxidation without anhydride bond formation
(B) Oxidation coupled with anhydride bond formation
(C) Substrate level phosphorylation
(D) Formation of carboxylate

[GATE 2019]

135. The example of substrate level phosphorylation in glycolysis is
(A) Conversion of Glucose to Glucose-6-phosphate
(B) Conversion of Glyceraldehyde-3-phosphate to 1,3-Bisphosphoglycerate
(C) Conversion of 1,3-Bisphosphoglycerase to 3-Phosphoglycerate
(D) Conversion of Dihydroxyacetone phosphate to Glyceraldehyde-3-phosphate

[GATE 2019]

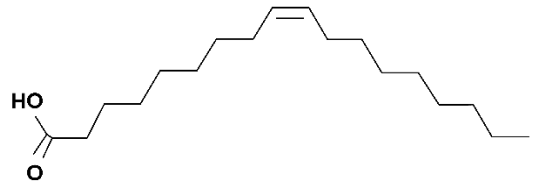
136. The light-harvesting pigment **NOT** used by Cyanobacteria for photosynthesis is
(A) Rhodopsin (B) Phycobilin
(C) Phycoerythrobilin (D) Phycocyanobilin

[GATE 2019]

137. Slow intravenous infusion of ethanol is a therapy to treat methanol poisoning. The underlying chemical reaction is an example of
(A) Competitive inhibition
(B) Non-competitive inhibition
(C) Mixed inhibition
(D) Enzyme activation

[GATE 2019]

138. The enzyme **NOT** involved in oxidation of the molecule shown below is



(A) Δ^3, Δ^2 - Enoyl –CoA isomerase
(B) Propionyl-CoA caboxylase
(C) Acyl CoA dehydrogenase
(D) Enoyl CoA hydratase

[GATE 2019]

139. Pernicious anemia is due to
(A) Blockage of vitamin B_{12} absorption
(B) Blockage of vitamin A absorption
(C) Deficiency of vitamin C
(D) Deficiency of vitamin B_2

[GATE 2020]

140. Which one of the following bonds is NOT present in ATP?
(A) β-Glycosidic (B) Phosphoanhydride
(C) Phosphoester (D) α-Glycosidic

[GATE 2020]

141. The prosthetic groups/cofactors involved in both $1e^-$ and $2e^-$ transfer in the mitochondrial electron transport chain are
(A) NAD and NADP (B) Coenzyme Q and FMN
(C) NAD and FAD (D) Heme and FMN

[GATE 2021]

142. The high energy compound(s) is/are:
(A) 1,3-Bisphosphoglycerate
(B) Phosphoenol pyruvate
(C) Adenosine monophosphate
(D) Vitamin K

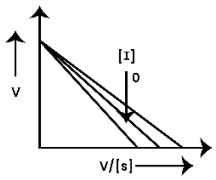
[GATE 2021]

143. The non-coenzyme vitamin is _____
(A) Nicotinic acid (B) Folic acid
(C) Ascorbic acid (D) Thiamine

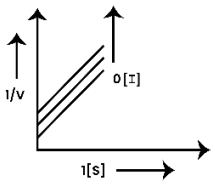
[GATE 2021]

144. Given below are four plots obtained from separate experiments on enzyme inhibition kinetics. The velocity (v) of the reaction is plotted at varying concentrations of substrate (s) and inhibitor (I). The plot(s) corresponding to competitive inhibition is/are

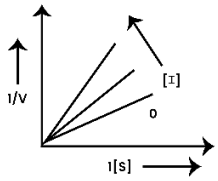
i)



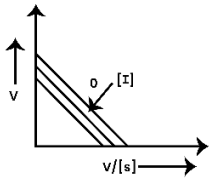
iii)



ii)



iv)



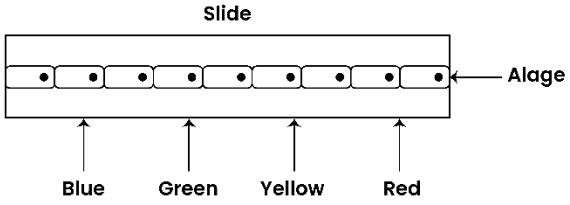
(A) (ii) (B) (iii)
(C) (iv) (D) (i)

[GATE 2022]

145. Which one of the following enzymes converts testosterone to estradiol?
(A) 3β-hydroxysteroid dehydrogenase
(B) 5α-reductase
(C) Aromatase
(D) 17β-hydroxysteroid dehydrogenase

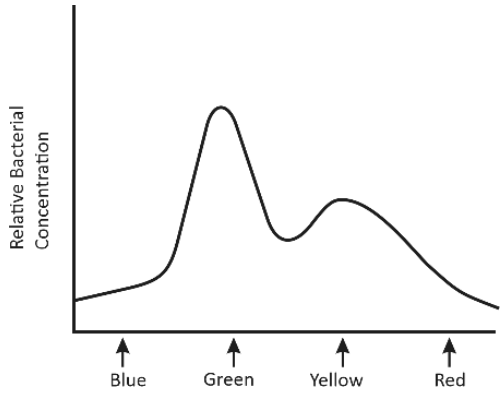
[GATE 2022]

146. Filamentous photosynthetic algae were placed on a microscopic slide and illuminated with light of different colors as illustrated.

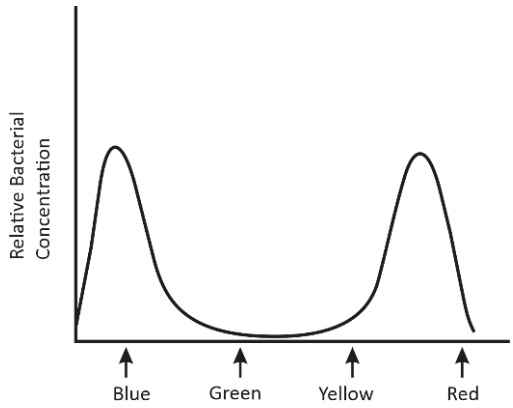


The bacteria that are known to migrate towards the region of high O_2 were also added uniformly on the slide. Which one of the following options illustrates the distribution of bacteria along the length of the microscopic slide after illumination?

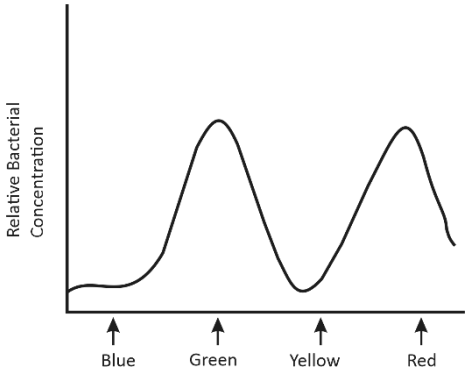
A.



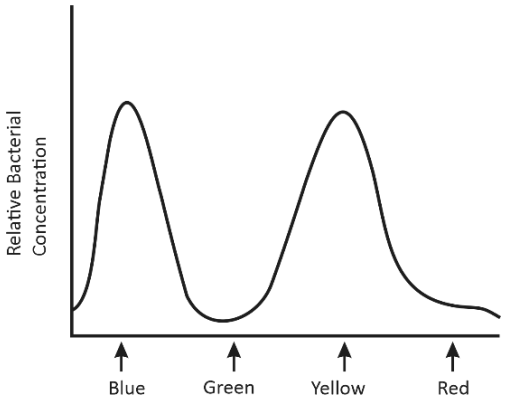
B.



C.



D.



[GATE 2022]

147. Which of the following statements about endogenous synthesis of insulin are correct?
P. Insulin is synthesized as pre-proinsulin.
Q. Pre-proinsulin is converted to proinsulin.
R. Single-site cleavage of proinsulin eliminates C chain.
S. Mature insulin consists of disulphide-linked A and B chains.
(A) P, Q, and R (B) P, Q, and S
(C) Q, R, and S. (D) P, R, and S

[GATE 2022]

148. Which one of the following enzymes is located in the outer mitochondrial membrane?
(A) Succinate dehydrogenase
(B) Fumarase
(C) Monoamine oxidase
(D) Citrate synthase

[GATE 2023]

149. Determine the correctness or otherwise of the following Assertion [a] and the Reason [r].
Assertion [a]: On a per carbon basis, palmitic acid yields more ATP than glucose.
Reason [r]: Carbons in palmitic acid are more reduced than those in glucose.

(A) Both [a] and [r] are true and [r] is the correct reason for [a]
(B) Both [a] and [r] are true but [r] is not the correct reason for [a]
(C) [a] is true but [r] is false
(D) [a] is false but [r] is true

[GATE 2023]

150. Given below are four reactions of the glycolytic pathway catalyzed by the enzymes E1, E2, E3, and E4, as indicated. Which of these enzymes is/are NOT part of the gluconeogenesis pathway?

(i) Fructose 6-phosphate $\xrightarrow{E1}$ Fructose 1, 6-bisphosphate
(ii) Fructose 1,6-bisphosphate $\xrightarrow{E2}$ Dihydroxyacetone phosphate + Glyceraldehyde 3-phosphate
(iii) 3-Phosphoglycerate $\xrightarrow{E3}$ 2-Phosphoglycerate
(iv) Phosphoenolpyruvate $\xrightarrow{E4}$ Pyruvate

(A) E1 (B) E2
(C) E3 (D) E4

[GATE 2023]

151. Intracellular concentrations of ATP, ADP, and inorganic phosphate in four cell types are given below. Which one of these cell types has the most negative ΔG for ATP hydrolysis?

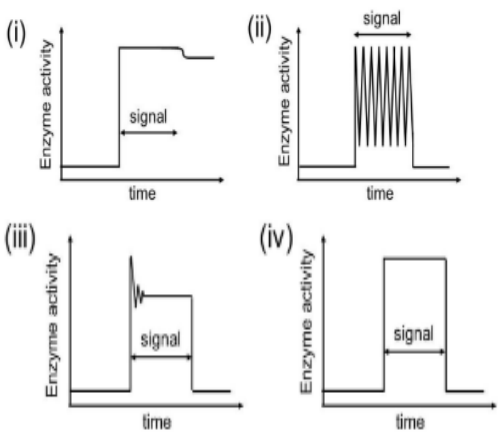
Cell Type	ATP (mM)	ADP (mM)	Inorganic Phosphate (mM)
L	3.0	1.8	5.0
K	3.9	1.3	3.0
B	2.7	0.7	2.7
M	7.2	0.9	8.0

(A) L (B) K
(C) B (D) M

[GATE 2023]

152. Enzyme activity profiles as a function of time in the absence or presence of different types of feedback mechanisms are shown in the figure below. Match the following feedback mechanisms with the corresponding profiles in the figure.

(p) No feedback mechanism
(q) Negative feedback mechanism with short delay
(r) Negative feedback mechanism with long delay
(s) Positive feedback mechanism



(A) (p) – (i); (q) – (ii); (r) – (iii); (s) – (iv)
(B) (p) – (iv); (q) – (iii); (r) – (ii); (s) – (i)
(C) (p) – (iv); (q) – (ii); (r) – (iii); (s) – (i)
(D) (p) – (i); (q) – (iii); (r) – (ii); (s) – (iv)

[GATE 2024]

153. Which one of the following metabolic intermediates is common to glycolysis, nucleotide synthesis and glycogen synthesis?

(A) Citrate
(B) Oxaloacetate
(C) Glucose 6-phosphate
(D) Glycerol 3-phosphate

[GATE 2024]

154. Which one or more of the following statements is/are correct regarding the electromotive force generated by electron transfer chain?

(A) It is used for the synthesis of ATP
(B) It is not used for active transport process.
(C) It includes a pH gradient component.
(D) It does not include an electrical potential gradient component.

NAT

[GATE 2014]

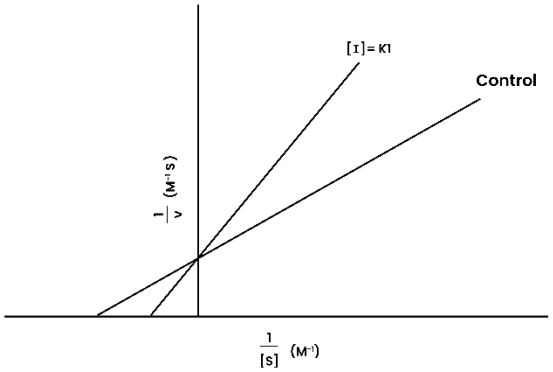
1. For a single substrate enzyme, a reaction is carried out at a substrate concentration four times the value of *Km*. The observed initial velocity will be _____ % of *Vmax*.

[GATE 2014]

2. Consider the following biochemical reaction: Fructose 6-phosphate + ATP → Fructose 1,6-bisphosphate + ADP The equilibrium constant under biochemical standard conditions (K'_{eq}) for the above reaction is 254. The standard free energy change ($\Delta G'°$) for the conversion of fructose 6-phosphate is _____kJ/mol.

GATE 2014]

3. The kinetic data for a single substrate enzyme is shown below. The concentration of inhibitor [I] used in the reaction was equal to the K_i of the inhibitor. The K_m value of an uninhibited reaction is 2×10^{-5} M. In the presence of the inhibitor, the observed K_m value is _____$\times 10^{-5}$ M.



4. The number of ATP molecules required for the complete assimilation of one molecule of CO_2 in Calvin cycle is _____.

5. The half-maximal velocity of an enzyme catalyzed reaction was found at a substrate concentration of 0.5×10^{-6} M. This enzyme follows Michaelis-Menten kinetics. In the presence of a competitive inhibitor, the half-maximal velocity was found at a substrate concentration of 1.5×10^{-6} M. Given that the enzyme-inhibitor pair has a dissociation constant of 2×10^{-7}M, the concentration of the competitive inhibitor in μM, rounded off to one place of decimal, was _____.

6. The pK_a values of the carboxylic and amino groups of an amino acid with a non-ionizable side chain are 2.17 and 9.13, respectively. The isoelectric point (rounded off to two places of decimals) of this amino acid is _____.

7. The standard free energy changes for conversion of phosphoenol pyruvate (PEP) to pyruvate, and ATP synthesis are shown below.

$$\text{PEP} + \text{H}_2\text{O} \rightleftharpoons \text{pyruvate} + \text{P}_\text{i} \qquad \Delta\text{G}'^\circ = -61.9\ \text{kJ} \cdot \text{mol}^{-1}$$

$$\text{ADP} + \text{P}_\text{i} \rightleftharpoons \text{ATP} + \text{H}_2\text{O} \qquad \Delta\text{G}'^\circ = 30.5\ \text{kJ} \cdot \text{mol}^{-1}$$

The starting concentrations of PEP, ADP, pyruvate, and ATP are 25, 25, 50 and 50 mM, respectively. The value of universal gas constant (R) is 8.315 $\text{J} \cdot \text{mol}^{-1}\text{K}^{-1}$. The actual free energy change in $\text{kJ} \cdot \text{mol}^{-1}$ for the reaction $\text{PEP} + \text{ADP} \rightarrow \text{pyruvate} + \text{ATP}$ carried out at 37 °C will be (rounded off to one place of decimal).

[GATE 2016]

8. Phosphoglucose isomerase was incubated with 0.2 M of glucose 6-phosphate. On reaching equilibrium, 55% of glucose 6-phosphate was converted to fructose 6-phosphate. The equilibrium constant for this reaction is _____.

[GATE 2017]

9. In an enzyme catalyzed reaction, the initial reaction velocity is only one fourth of its maximum velocity. If the substrate concentration is 3.0 x 10^{-3} mM, the value of K_m in micro molar (μM) will be .....

[GATE 2018]

10. The number of $NADP^+$ molecules required to completely oxidize one molecule of glucose to CO_2 through pentose phosphate pathway is ____ (correct to integer number).

[GATE 2018]

11. An enzyme follows Michaelis-Menten kinetics with substrate S. The fraction of the maximum velocity (V_{max}) will be observed with the substrate concentration [S] = $4K_m$ is _____ (correct to one decimal place). (K_m is Michaelis-Menten constant)

[GATE 2018]

12. The standard free energy ($\Delta G^{0'}$) values of reactions catalyzed by citrate lyase and citrate synthetase are -670 and -8192 cal/mol, respectively.

$$\text{Citrate} \xrightleftharpoons{\text{Citrate lyase}} \text{Acetate} + \text{Oxaloacetate} \quad \Delta G_1' = -670\ \text{cal/mole}$$

$$\text{Acetyl-CoA} + \text{Oxaloacetate} + \text{H}_2\text{O} \xrightleftharpoons{\text{Citrate synthetase}} \text{Citrate} + \text{CoA} \quad \Delta G_2' = -8192\ \text{cal/mole}$$

The standard free energy (in cal/mol) of acetyl-CoA hydrolysis is ___ (correct to integer number).

[GATE 2019]

13. You are given a 0.1M solution of Glucose (stock solution). The stock solution required to make 0.5 ml of 0.005M Glucose solution (rounded off to three decimal places) in ml is _____.

[GATE 2020]

14. When one glucose unit from glycogen gets converted to lactate in the muscle, the net number of ATP molecules produced is _____

[GATE 2020]

15. An enzyme obeying Michaelis-Menten kinetics shows a reaction velocity (v) of 10 μmol/min when the substrate concentration [S] equals its K_m. The maximal velocity V_{max} for this enzyme is _____ μmol/min (correct to integer number). (K_m is Michaelis-Menten constant)

[GATE 2020]

16. The enzyme glucose isomerase catalyzes the inter-conversion of glucose and fructose as shown.

    Glucose $\leftrightarrow$ Fructose

    The ΔG_0 for this reaction is zero kcal/mol. After adding glucose isomerase to a 0.12 M glucose solution and allowing the reaction to attain equilibrium, the final concentration of fructose in the reaction mixture will be _____ mM.

[GATE 2024]

17. In Michaelis-Menten's equation, if [S] = 15 *Km*, then the ratio max is _____.
    (Round off to three decimal places).

ANSWER KEY									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
B	D	C	D	B	C	D	-	C	-
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	B	A	D	C	D	C	A	A	C
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
D	C	A	-	C	A	C	C	C	A
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
A	D	A	D	C	A	B	B	B	D
41	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
A	C	D	D	B	A	A	C	D	B
51	**52**	**53**	**54**	**55**	**56**	**57**	**58**	**59**	**60**
C	A	D	C	B	B	B	A	B	A
61	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**
B	D	A	C	A	C	A	C	B	A
71	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**
B	A	B	D	C	D	A	D	B	A
81	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**
B	C	D	B	B	A	D	B	A	D
91	**92**	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**
A	B	A	D	D	C	A	D	B	C
101	**102**	**103**	**104**	**105**	**106**	**107**	**108**	**109**	**110**
B	D	D	A	B	C	C	B	D	B
111	**112**	**113**	**114**	**115**	**116**	**117**	**118**	**119**	**120**
C	C	B	C	C	D	C	B	A	C
121	**122**	**123**	**124**	**125**	**126**	**127**	**128**	**129**	**130**
B	C	A	C	C	D	C	A	B	A
131	**132**	**133**	**134**	**135**	**136**	**137**	**138**	**139**	**140**
A	C	B	B	C	A	A	B	A	D
141	**142**	**143**	**144**	**145**	**146**	**147**	**148**	**149**	**150**
B	A, B	*	B, D	C	B	B	C	A	A,D
151	**152**	**153**	**154**						
C	B	C	A,C						

NTA									
1	2	3	4	5	**6**	**7**	**8**	**9**	**10**
80 TO 80	13.6 TO 13.8	4 TO 4	3 ATP	0.4	5.65	-28.1 to -27.8	1.20 TO 1.24	-9 TO -9	12 TO 12
11	**12**	**13**	**14**	**15**	**16**	**17**			
0.8 TO 0.8	-8862 TO -8862	0.024 TO 0.026	3 TO 3	20	60	0.9380			

:: EXPLANATIONS ::

1. **Topic:** Photosynthesis

   Answer (B)

   Explanation: Cyclic photo-phosphorylation uses photosystem I (P_{700}). During this process, there is no production of NADPH and oxygen and no photolysis of water takes place.

2. **Topic:** Carbohydrate metabolism

   Answer (D)

   Explanation: Glycogen storage diseases occur due to genetic deficiency of enzymes of glycogen metabolism. Glycogen synthetase is the key regulatory enzyme of glycogen synthesis.

3. **Topic:** Enzyme kinetics

   Answer (C)

   Explanation: K_{cat} is the measure of the number of substrate molecules "turned over" by enzyme per second. The unit of K_{cat} is in 1/sec. The higher the K_{cat} is, the more substrates get turned over in one second. Also, as saturating substrate concentrations $V_0 = V_{max}$. Also, $V_{max} = K_{cat}$ X E_T. So, as to have the same velocity we have to take DNA polymerase 6.7 times that of chymotrypsin.

4. **Topic:** Enzyme kinetics

   Answer (D)

   Explanation: Enzymes cannot convert non-spontaneous reaction into a spontaneous reaction but enzymes decreases the activation energy of the reaction so that the enzyme reaches its transition state quickly.

5. **Topic:** Enzyme inhibition

   Answer (B)

   Explanation: DIPF inhibits the activity of the enzyme trypsin by binding to the hydroxyl group present in the side chain of serine residue present at the active site of trypsin.

6. **Topic:** Amino acid metabolism

   Answer (C)

   Explanation: Pyridoxal phosphate (PLP) acts as cofactor during transamination reaction and it forms a schiff's base using its carbonyl group and ε-NH_2, group of lysine.

7. **Topic:** Vitamins

   Answer (D)

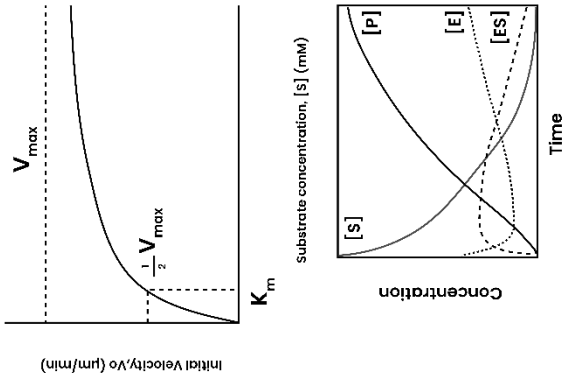
   Explanation: Calciol undergoes first hydroxylation reaction in the liver at its 25th position to become calcidiol. Calcidiol further undergoes hydroxylation at 1st position in kidney to form calcitriol.

8. **Explanation**

   (A) 2-keto-3-deoxy-6-phosphate aldolase act upon 2-keto-3-deoxy-6-phosphogluconate to produce pyruvate and glyceraldehyde-3-phosphate.

   (B) Unit of rate constant for first order reaction is s^{-1} and for second order reaction is $M^{-1}s^{-1}$. Putting these values in above equation, unit of K_m = M.

   (C) Arsenate resembles phosphate and replaces it from glyceraldehyde-3-phosphate to produce 1-arseno-3-phosphoglycerate which readily undergoes hydrolysis to produce arsenate and 3-phosphoglycerate. No substrate level phosphorylation occur but ADP-arsenate is produced in the presence of ADP and arsenate. This ADP-arsenate hydrolyze quickly and results in uncoupling of oxidative phosphorylation mechanism.



   (E) IPTG is active in its native form and it can directly cross the cell membrane to bind the lac repressor but lactose needs to be converted into 1,6-allolactose by β-galactosidase which can bind to lac repressor and therefore there is a lag before the enzymes of lactose operon are synthesised when lactose is used as an inducer.

   (F) Yes, If $^{18}O_2$ were added to C_3 plants on a bright sunny day, the glycine subsequently isolated from the leaves would be labelled. The reason is RuBisCo can catalyze both carboxylation and oxygenation of RuBP. When RuBisCo catalyze oxygenase activity, 3-phosphoglecerate and 2-phosphoglycolate are produced. 2-phosphoglycolate undergoes photorespiration and in peroxisome glycine is produced which would be labelled with $^{18}O_2$.

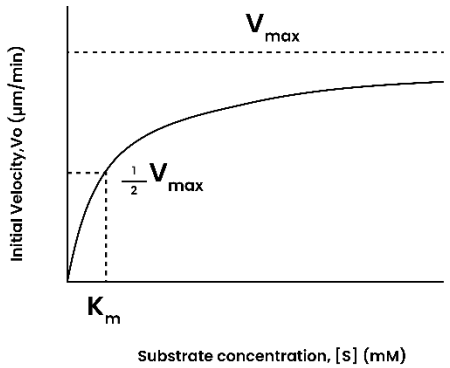
9. **Topic:** Metabolism

Answer (C)

Explanation: Ionophores are small molecules which are specific for certain cations and help in their movement through the membrane. Gramicidin A is an antibiotic which act as an ionophore and forms a monovalent cation channel in bacterial cell membranes. Ouabain is a cardiotonic steroid and it inhibits the activity of NA^{+}-K^{+} ATPase. Malonate is a competitive inhibitor of the enzyme succinate dehydrogenase and it competes with succinate to bind at the active site of the enzyme. Alkaptonuria is genetic disorder which occur due to defect in tyrosine degradation. The enzyme homogentisic acid oxidase, is defective in Alkaptonuria disease. Cathepsins are protein hydrolyzing enzymes.

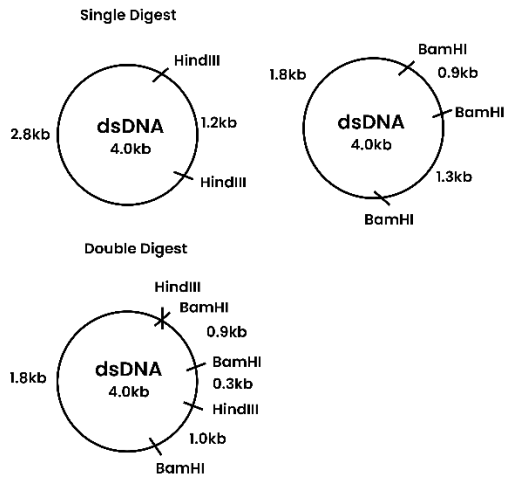
10. **Explanation:**

(A) According to Michaelis-Menten approach, the graph plotted against V_o Versus $[S]$ follows hyperbolic curve.



At sufficiently high substrate concentration with respect to K_m, almost all of the active sites are saturated with the substrate and in that case, a further increase in the substrate concentration do not cause further increase in the velocity.

(B)



(C) Isozymes are the enzymes which are encoded by different genes, have different amino acid sequence but they catalyze the same biochemical reaction. They differ in their kinetic properties. For example, hexokinase have four different isozymes, and all of them catalyze the phosphorylation of hexose sugar.

11. **Topic:** Carbohydrate metabolism

Answer (C)

Explanation: Avidin is a protein which binds very tightly to biotin, the co-enzyme which act as mobile carboxyl group carrier and it is required during carboxylation reaction. Conversion of pyruvate to PEP occurs in two steps. The first step converts pyruvate to oxaloacetate by the action of enzyme pyruvate carboxylase which requires biotin as prosthetic group. Therefore, in the presence of avidin, conversion of pyruvate to PEP will not occur.

12. **Topic:** Cell signalling

Answer (B)

Explanation: In its inactive state, PKA has two catalytic subunits and two regulatory subunits. cAMP binds to the regulatory subunits of PKA and induces conformational change in the enzyme and results in the dissociation of regulatory subunits from PKA and hence catalytic subunits of PKA become active.

13. **Topic**: Carbohydrate metabolism

Answer (A)

Explanation:

β-Amylase catalyzes the exohydrolysis of 1,4-α-glycosidic linkages in polysaccharides, resulting in the successive liberation of maltose units from the non-reducing ends of the chains.

14. **Topic:** Lipid metabolism

Answer (D)

Explanation: Lipids have higher calorific value than carbohydrates and produces much more energy upon oxidation as compared to carbohydrates. Glycogen and glucose are carbohydrates while triacylglycerol is lipid.

15. **Topic:** Glycolysis

Answer (C)

Explanation: The enzyme hexokinase converts glucose to glucose-6-phosphate and it requires Mg^{2+} as cofactor.

16. **Topic:** Oxidative phosphorylation

Answer (D)

Explanation: DNP act as uncoupler of ETC and ATP synthesis. ATP causes decreased synthesis of ATP and loss of potential energy which is dissipated as heat.

17. **Topic:** Nucleic acid metabolism

Answer (C)

Explanation: Methotrexate is a chemotherapeutic agent which inhibit the activity of dihydrofolate reductase and hence inhibit the *de novo* synthesis of purines.

18. **Topic:** Amino acid

Answer (A)

Explanation: Both valine and isoleucine are branched chain amino acids and have similar biochemical properties. Therefore, substitution of valine to isoleucine is a conservative substitution.

19. **Topic:** circulatory system

Answer (A)

Explanation: Clustering of thrombocytes is called platelet aggregation. It is initiated at the site of injury and the fundamental reaction in the clotting of blood is conversion of soluble plasma protein fibrinogen to insoluble fibrin.

20. **Topic:** Amino acid

Answer (C)

Explanation: Pyridoxal phosphate is acting as a coenzyme in the absorptive process for L-tyrosine. Glutamic acid and aspartic acid in low concentrations are absorbed *in vivo* by means of a transamination reaction, for which pyridoxal phosphate is required. Thus, pyridoxal phosphate is a known cofactor in all three of these reactions. So, oral administration of large amounts of tyrosine may interfere with the intestinal absorption of aspartate.

21. **Topic:** Enzyme kinetics

Answer (D)

Explanation: For an enzyme catalyzed reaction, the Michaelis-Menten equation is

$V_0 = \frac{V_{max} \times [S]}{K_m + [S]}$

Km is the substrate concentration at which the rate of reaction is half of its maximum value. Therefore, $K_m = [S]$. Substituting this value in Michaelis-Menten equation, we get:

$V_0 = \frac{Vmax}{2}$

22. **Topic:** Metabolism

Answer (C)

Explanation: BMR is the amount of energy per unit time required by an individual to perform basic functions when the individual is at rest. For a warm-blooded animal, it is the rate of energy expenditure per unit time when the animal is at rest.

23. **Topic:** Lipid metabolism

Answer (A)

Explanation: The excess of dietary carbohydrates and proteins are converted into fats and lipids inside the liver.

24. **Explanation:**

(A) The enzyme preparation is diluted 10 times. Therefore, the concentration of enzyme becomes 0.3 mg/ml. To perform the experiment, 10 µL of enzyme preparation was taken. 10 µL contains 3 mg enzyme.

Therefore, velocity (µmoles of product/min/mg)= $\frac{30 \times 10^{-3}}{3 \text{ x } 10^{-3}} = 10 \quad \mu mol/min/mg$

(B) It denotes the specific activity. Specific activity of the enzyme = activity in Units/amount of enzyme (mg). Specific activity can be used to measure the increase in fold purity that is obtained following the protein purification protocol.

(C) Turnover number = moles of product formed per unit time/moles of enzyme

Moles of enzyme = $\frac{\text{amount of enzyme in g}}{\text{molecular weight of the enzyme}} = \frac{3 \text{ X } 10^{-6}}{3 \text{ X } 10^{4}} = 10^{-10}\ moles$

Turnover number= $\frac{30 \times 10^{-9} \text{ mol/min}}{10^{-10} \text{ mol}} = 300 \text{ min}^{-1}$

25. **Topic:** Enzyme classification

Answer (C)

Explanation: Oxidoreductases catalyze redox reactions. During redox reactions, oxidation of one group is accompanied by reduction of another group therefore these enzymes are collectively known as oxidoreductases. Some examples of this class of enzyme are dehydrogenases, oxygenases and oxidases.

26. **Topic:** Vitamin

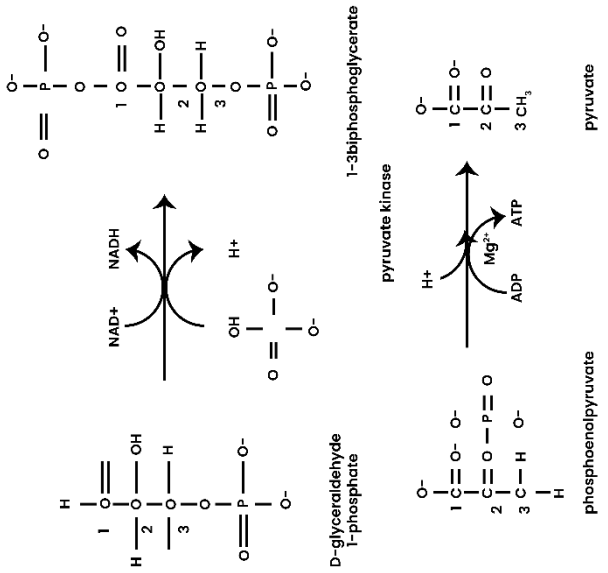
Answer (A)

Explanation: Vitamin D is a lipid soluble vitamin. Vitamin D_3 is formed in the skin from 7-dehydrocholestrol in the presence of UV light.

27. **Topic:** Glycolysis

Answer (C)

Explanation: ATP is generated at two steps during the 'pay-off' phase of glycolysis which are shown as:



28. **Topic:** Protein glycosylation

Answer (C)

Explanation: O- linked glycosylation occurs inside golgi apparatus. O-linked sugars are attached to the hydroxyl group of serine or threonine via N-acetylgalactosamine.O-linked sugars are generally short oligosaccharides containing 3 to 4 sugar residues only. These sugars are added one a time, and different enzymes participate during the addition of subsequent sugar moiety.

29. **Topic: Photosynthesis**

Answer (C)

Explanation: PSII act as strong oxidant and it can oxidize water molecule but it is a weak reductant.

30. **Topic:** Mechanism of enzyme catalysis

Answer (A)

Explanation: RNase are a group of enzymes that catalyzes the hydrolysis of phosphodiester bond in RNA molecules. RNase contains His^{12}, Lys^{41} and His^{119} as a catalytic triad which act as acid-base catalysts. His^{12} act as general base catalyst and absorb a proton from 2'-OH group of ribose producing a nucleophilic alkoxide anion which attacks the nearby phosphorous atom.

31. **Topic:** Citric acid cycle

Answer (A)

Explanation: No carbon would be labeled in succinate because labeled carbon would get eliminated as carbon dioxide by oxidative decarboxylation.

32. **Topic:** Enzyme kinetics

Answer (D)

Explanation: From the given Lineweaver-Burk plot, the value of $-1/K_m = -0.5$. Therefore, Km = 1/0.5 = 2mM.

33. **Topic:** Bioenergetics

Answer (A)

Explanation: $\Delta G° = -RT \ln K_{eq}$

R=2 cal deg^{-1} mol^{-1}, T=300K and $K_{eq} = 10^{-3}$

$\Delta G° = -(2)(300)\ln(10^{-3}) = 4140 \frac{cal}{mol} = 4.1 kcal/mol$

34. **Topic:** Co-enzyme

Answer (D)

Explanation: Biotin act as mobile carboxyl group carrier during carboxylation reactions.

35. **Topic:** Oxidative phosphorylation

Answer (C)

Explanation: Cyanide binds with complex IV and inhibit the terminal transfer of electrons to oxygen.

36. **Topic:** glycolysis

Answer (A)

Explanation: During the preparatory phase of glycolysis, 2 molecules of ATP are consumed to convert one molecule of glucose into two molecules of glyceraldehyde-3-phosphate.

37. **Topic:** Citric acid cycle

Answer (B)

Explanation: Citric acid cycle occurs in mitochondrial matrix. The net result of citric acid cycle is that one molecule of acetyl-CoA gets converted into two molecules of carbon dioxide.

38. **Topic:** Lipid synthesis

Answer (B)

Explanation: All these enzymes are used during lipid synthesis. **β**-ketoacyl-ACP synthase condenses acyl and malonyl groups. **β**-ketoacyl-ACP reductase reduces **β**-keto group to **β**-hydroxy group and the enzyme uses NADPH. Enoyl-ACP-reducatse is the last enzyme which is used during the elongation of fatty acid chain. ACP catalyzes the addition of thioester to a phosphopantetheine moiety.

39. **Topic:** Protein modification

Answer (B)

Explanation: The reaction is catalyzed by oligosaccharide-protein transferase. The enzyme uses Asn-x-Thr or Asn-x-Ser as substrate.

40. **Topic:** Light reaction

Answer (D)

Explanation: PSII is a pigment protein complex which contains many proteins and cofactors. It contains pheophytin-quinone type reaction center. Photochemical reaction center contains Chl which is called P_{680}. PSII is bound to the protein containing Mn^{2+} ions, as a part of oxygen evolving complex.

41. **Topic:** Cell signaling
Answer (A)
Explanation: Activated PKC causes phosphorylation of hydroxyl group of serine or threonine residues of proteins not tryptophan.

42. **Topic:** Lipid metabolism
Answer (C)
Explanation: Site of **β**-oxidation is mitochondrial matrix but fatty acyl groups cannot cross inner-mitochondrial membrane therefore fatty acyl molecule get converted to fatty acyl carnitine by the action of enzyme carnitine acyl transferase I which is present in intermembrane space and in this form it can cross the inner mitochondrial membrane. Once it reaches inside the mitochondrial matrix, the carnitine is removed from fatty acyl molecule by the action of enzyme carnitine acyl transferase II.

43. **Topic:** Lipids
Answer (D)
Explanation: Melting point of a molecule increases with increase in carbon chain length but unsaturation decreases the melting point. Therefore, stearic acid has the higher melting point as compared to palmitic acid.

44. **Topic:** Carbohydrate metabolism
Answer (D)
Explanation: Glycogen is a polysaccharide made up of glucose. When the patient is on carbohydrate free diet then source of glucose in the urine is the increased breakdown of glycogen.

45. **Topic:** Amino acid
Answer (B)
Explanation: pI of lysine = $\frac{pK_a(\alpha-\mathrm{NH3+})+\mathrm{pKa}\ (\varepsilon-\mathrm{NH3+})}{2}$ = $\frac{9.0+10.0}{2}=\frac{19}{2}=9.5$

46. **Topic:** Metabolism
Answer (A)
Explanation: Oxidative decarboxylation of pyruvate produces acetyl-CoA. The reaction is catalyzed by pyruvate dehydrogenase complex which requires five different co-enzymes which are TPP, lipoic acid, coenzyme A, FAD and NAD^+.

47. **Topic:** Enzyme kinetics
Answer (A)
Explanation: This is Lineweaver-Burk plot which is used to find out the value of K_m and V_{max} for an enzyme catalyzed reaction. In the presence of competitive inhibitor, value of K_m increases but V_{max} remains unchanged, making the slope steeper. Hence, line 1 represents the kinetics in the absence of inhibitor which will be a reference to assess the effects of various inhibitors. While line 2 represents the presence of competitive inhibitor. Line 3 represents the non-competitive inhibition as V_{max} has lowered, while K_m remains same. And, line 4 represents the mixed inhibition as V_{max} has lowered, and K_m has increased

48. **Topic:** Enzyme kinetics
Answer (C)
Explanation: During non-competitive inhibition, K_m remains same but V_{max} decreases. Therefore, Line 3 represents the presence of non-competitive inhibitor with reference to line 1.

49. **Topic:** Protein sequencing
Answer (D)
Explanation: The sequence of nonapeptide can be obtained by comparing and overlapping the shorter fragments with the larger fragments. The first fragment shows first two residues common to second fragment's last two residues. And, the second fragment's first residue is common to last residue of fragment third. Therefore, the correct sequence is Ala-Gly-Ser-Lys-Phe-Val-Arg-Pro-Gly.

50. **Topic:** protein sequencing
Answer (B)
Explanation: Trypsin cleaves the peptide bond on the carboxyl side of lysine and arginine which is not followed by proline residue. Therefore option (B) is correct.

51. **Topic:** Amino acids
Answer (C)
Explanation: Intrinsic fluorescence is the property of aromatic amino acids which are: phenylalanine, tyrosine, and tryptophan. These amino acids contain aromatic ring which contributes for fluorescence. Cysteine is not an aromatic amino acid therefore it does not act as an intrinsic flurophore.

52. **Topic:** Pentose phosphate pathway
Answer (A)

Explanation: Pentose phosphate pathway is an alternative pathway for oxidation of glucose. Main functions of pentose phosphate pathway are: 1) to provide NADPH for reductive biosynthesis and 2) to provide ribose-5-phosphate for nucleotide synthesis.

53. **Topic:** Nucleic acids

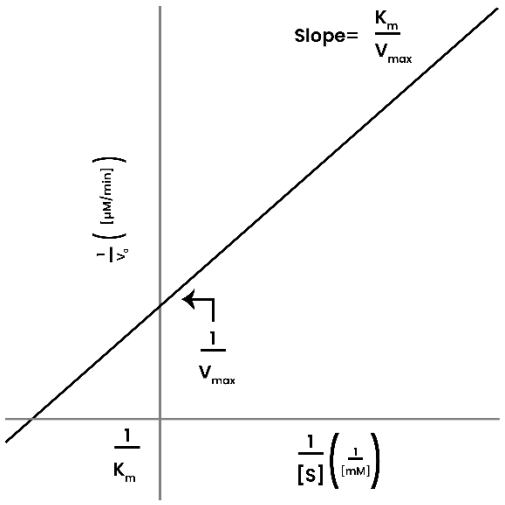
Answer (D)

Explanation: When a nitrogenous base is covalently joined to ribose sugar, nucleoside is formed. Nucleic acids contain two types of riboses. DNA contains 2'-deoxy-D-ribose and RNA contains D-ribose sugar. The difference between 2'-deoxy-D-ribose and D-ribose is that former has hydrogen attached to 2' carbon of sugar while latter has hydroxyl group (-OH) attached to 2' carbon of sugar. Therefore, the given molecule contains deoxyribose sugar. When nucleoside is linked to phosphoric acid at C-5 position of sugar moiety, a nucleotide is formed. Nucleotides are joined together by phosphodiester bonds to form polydeoxynucleotide.

54. **Topic:** Enzyme kinetics

Answer (C)

Explanation: Lineweaver-Burk plot is shown below:



Slope of the double reciprocal plot is K_m/V_{max} while the value of intercept on Y-axis is $1/V_{max}$ and on X-axis is $-1/K_m$. Hence, to find the value of K_m, multiply the reciprocal of $-1/K_m$ by (-1).

55. **Topic:** Glycolysis

Answer (B)

Explanation: The $[\gamma -^{32} P]$ ATP is transferred to glucose to give glucose-6-phosphate, and to fructose-6-phosphate to give fructose-1,6-bisphosphate in the energy investment steps, due to which both of the phosphates are radiolabelled. While one of the phosphate in 1,3-bisphosphoglycerate comes from P_i instead of ATP, which will not be radiolabelled.

56. **Topic:** Enzymes classification

Answer (B)

Explanation: There are six classes of enzymes which are: oxidoreductases, transferases, hydrolases, lyases, isomerases and ligases. Kinase belongs to the class transferases and catalyzes the transfer of phosphate group to biomolecules. Lyases catalyze bond cleavage. Synthases belongs to the class lyases. Phosphatases belong to the class hydrolases and catalyze the removal of phosphate group from biomolecules.

57. **Topic:** Oxidative phosphorylation

Answer (B)

Explanation: During the process of oxidative phosphorylation, mitochondria pump protons across their inner membrane to generate mitochondrial membrane potential ($\Delta\psi$) and pH gradient (ΔpH) both of which are required to synthesize ATP.

58. **Topic:** Lipids

Answer (A)

Explanation: Phosphatidylserine is a glycerophospholipid because it contains a glycerol backbone to which two fatty acyl chains are attached and a phosphate to which one alcohol is covalently linked. The given molecule is phosphatidylserine because the attached alcohol is serine.

59. **Topic:** Amino acid metabolism

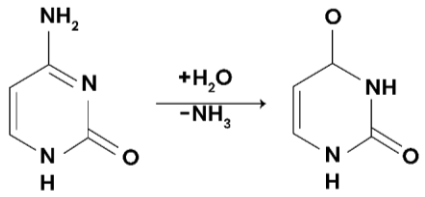
Answer (B)

Explanation: During transamination reaction, transfer of amino group occurs from one amino acid to a keto acid such that the amino acid itself get converted into a keto acid by removal of amino group and the keto acid which receives an amino group becomes an amino acid. Here, α-keto acid is converted into an α-amino acid therefore, X must be a keto acid which by accepting amino group will become an α-amino acid. Therefore, X is α – ketoglutarate and Y is L-Glutamate.

60. **Topic:** Nucleic acids

Answer (A)

Explanation: Cytosine undergoes spontaneous deamination to produce uracil.



Dearnination Of Cytosine To Uracil

61. **Topic:** Metabolism

Answer (B)

Explanation: When six carbon glucose molecule undergo glycolysis, it gets converted into three carbon pyruvate. Given table shows labelling of carbons of glucose and their fate:

Carbon labeled in glucose	Carbon which got labeled in pyruvate
1st or 6th	3rd
2nd or 5th	2nd
3rd or 4th	1st

Pyruvate undergoes oxidative decarboxylation to get converted into acetyl-CoA and its carbon number 1 would be removed as carbon dioxide. Therefore, if $^{14}C0_2$ is released during the conversion of pyruvate to acetyl coenzyme-A, carbon 3 or carbon 4 of glucose was radiolabelled.

62. **Topic:** water

Answer (D)

Explanation: One water molecule can form maximum 4 hydrogen bonds with neighbouring water molecules. However, at room temperature, water only form 3.4 hydrogen bonds with other water molecules because its molecules are disordered and are in continuous motion. In ice, water molecules are properly organised and form 4 hydrogen bonds with each other.

63. **Topic:** Radioactivity

Answer (A)

Explanation: Specific activity of glycine = 1/0.25 = 4 mCi/mg

Molecular weight of glycine= 75 mg per millimole

So specific activity of radiolabeled glycine = 4×75 = 300 mCi/millimole

64. **Topic:** Nucleic acid metabolism

Answer (C)

Explanation: N^{10}-formyl THF is required for the synthesis of adenylate, guanylate in the purine synthesis pathway. Pyrimidines, do not require folate for biosynthetic reactions except thymidylate which require N^5, N^{10}-methylene tetrahydrofolate.

65. **Topic:** Oxidative phosphorylation

Answer (A)

Explanation: During first half of Q cycle, two protons are pumped from complex III to intermembrane space with the removal of two electrons from QH_2 pool. Out of these two electrons, one electron move out of complex III and reduce cytochrome c but another electron partially reduces the oxidized ubiquinone to semi-uniquinone. Then during second half of the Q cycle, again same mechanism occurs and out of two electrons removed, one reduces cytochrome c molecule while other reduces semi-ubiquinone to ubiquinol.

66. **Topic:** Metabolism

Answer (C)

67. **Topic:** Oxidative phosphorylation

Answer (A)

Explanation: Complex I and complex II of ETC transport electron from NADH and $FADH_2$ respectively to complex III with the help of coenzyme Q which is an electron carrier. Coenzyme Q is a lipid soluble, non-protein bound prosthetic group. Then electrons are transported from coenzyme to cytochrome c. cytochrome c is located between complex III and complex IV. Hence, ETC complexes interact with one another via mobile electron carriers.

68. **Topic:** Light reaction

Answer (C)

Explanation: ATP synthesis in chloroplast: Electrons move from water via photosystem II, $cytb_6f$ complex, Photosystem I and ultimately to $NADP^+$. H^+ are pumped into the thylakoid lumen by the flow of electrons through $cytb_6f$ between photosystem II and photosystem I. Protons again enter into chloroplast stroma via proton channels formed by F_0 portion of ATP synthase. F_1 subunit which is facing the stroma, catalyzes the synthesis of ATP.

69. **Topic:** Oxidative phosphorylation

Answer (C)

Explanation: Minimum three protons are required for the synthesis of one molecule of ATP. Oxidation of one molecule of NADH leads to pumping of 10 protons against the electrochemical gradient with the help of electron transport chain complexes. One proton is required for transport of inorganic phosphate into the mitochondrial matrix. Therefore