IIT-JAM Biotechnology

Model Paper

PART - A

Questions 1 to 10 carry *one* mark each.

1. Isoelectric point of the enzyme ribonuclease is 9.3. It was observed that at this point there are 10 positively charged and 10 negatively charged side chains of amino acids. When the enzyme solution was titrated with HCl to give a pH of 3, it was observed that 2 ionized glutamic acid and 1 ionized aspartic acid side chain got protonated. The net charge on the enzyme at pH 3 would, therefore, be

   a. +2 b. +3

   c. +7 d. +97

2. Multiple RNA polymerase transcribes a DNA template, unwinding about 1.5 turns of DNA template per transcription bubble. From the structural information of classical B-DNA, how many transcription bubbles are possible for a 180 base pair DNA molecule?

   a. 12 b. 27

   c. 6 d. 270

3. A glycogen chain comprised of four glucose molecules is completely converted to pyruvic acid in the glycolytic pathway. How many ATPs will be gained during this conversion?

   a. 8 b. 11

   c. 12 d. 9

4. Initial density of a culture of bacteria with a generation time of 30 minutes was 1×10^5 cells/ml. After 5 hours of incubation, what serial dilution will you have to plate out to get ~100 colonies per ml?

   a. 10^3 b. 10^4

   c. 10^5 d. 10^6

5. A mammalian cell has an outstretched double-stranded DNA of 1.2 metres which duplicates in 4 hr. If it duplicates at the rate of 20 micrometres/min, how many origins of replication are there in the DNA?

   a. 2500 b. 250

   c. 25 d. 1

6. How large would you expect the gene for a 40000-dalton protein in a eukaryote to be if each amino acid weighs about 100 daltons; there is five times as much intron as exon sequence in the gene? (Ignore the contribution of the promoter and the 5′ and 3′ untranslated regions).

   a. ~ 1200 bp b. > 1200 bp

   c. ~ 2400 bp d. ~ 7200 bp

7. Two point charges repel each other with a force of 100N. One of the charges is increased by 20% and other is reduced by 20%. The new force of repulsion at the same distance would be

   a. 100 N b. 144 N

   c. 96 N d. none of these

8. The drift current in a p-n junction is
   a. from the n-side to the p-side
   b. from the p-side to the n-side
   c. from the n-side to the p-side if the junction is forward biased and in the opposite direction if it is reverse biased
   d. from the p-side to the n-side if the junction is forward-biased and in the opposite direction if it is reverse biased

9. In diamond crystal each carbon atom is linked with carbon atoms. The number of carbon atoms linked is
   a. 2
   b. 4
   c. 3
   d. 1

10. A value of $\sqrt{i} + \sqrt{-i}$ is
   a. 0
   b. $\sqrt{2}$
   c. –i
   d. i

Questions 11 to 30 carry *two* marks each.

11. Which of the following statements are *correct*?
   P. Polarity of water makes it an excellent solvent.
   Q. Water has high tensile strength.
   R. Cohesive property of water is due to H-bonding.
   S. Water has high dielectric constant.
   a. P and S
   b. Q and R
   c. Q, R and S
   d. P, Q, R and S

12. If phosphoglyceride A has a higher T_m than phosphoglyceride B, which of the following differences between A and B may exist? (In each case only one parameter–either chain length or double bonds– is compared.)
   P. A has shorter fatty acid chains than B.
   Q. A has longer fatty acid chains than B.
   R. A has more unsaturated fatty acid chains than B.
   S. A has more saturated fatty acid chains than B.
   a. P and Q are correct
   b. only Q is correct
   c. Q and S are correct
   d. R and S are correct

13. Which of the following statements are *correct* about collagen?
   P. Extremely rich in proline and glycine.
   Q. A double helix, where two α-chains are wrapped around one another in a rope-like structure.
   R. A triple helix formed by three extended protein chains that wrap around each other.
   S. In the lumen of the ER, selected proline and lysine residues are hydroxylated to form hydroxyproline and hydroxylysine, respectively.
   a. P and Q
   b. P, Q and S
   c. P, R and S
   d. Q, R and S

14. Which of the following statements is/are *incorrect* about the acid hydrolysis of various lipids?

P. A cerebroside will release two fatty acids and one monosaccharide per mole of cerebroside.

Q. Phosphatidylcholine will release two fatty acids and one glycerol molecule per mole of phosphatidylcholine.

R. Sphingomyelin and phosphatidylcholine will release equivalent molar amounts of choline and phosphoric acid.

S. Cerebrosides and sphingomyelin will each release one mole of sphingosine.

a. Only P
b. Only R
c. Q and S
d. P, Q and R

15. Which of the following are *correct* about caspases?

P. They are cysteine proteases.

Q. They cleave their target proteins at C-terminal to specific aspartate residues.

R. They are serine proteases.

S. They are synthesized in the form of inactive procaspases.

a. P and Q
b. Q and S
c. P, Q and S
d. P, R and S

16. DNA was isolated from three samples of normal human cells. In each of these samples, cells were at different stages of cell division.

Sample 1: Cells were in G2 phase.

Sample 2: Cells were in anaphase.

Sample 3: Cells were in telophase.

DNA isolated from which of these samples conforms to Chargaff's rules?

a. Only samples 1 and 2
b. Only samples 1 and 3
c. Only samples 2 and 3
d. Samples 1, 2 and 3

17. In a tissue, cells are bound together by physical attachment between cell to cell or between cell to extracellular matrix. Following are some of the characteristics of cell junctions:

1. Tight junctions are cell-cell junctions connecting intermediate filament in one cell with that in the next cell.
2. Desmosomes are cell-matrix anchoring junctions connecting actin filament in one cell to extracellular matrix.
3. Gap junctions are channel forming junctions allowing passage of small water soluble molecules from cell to cell.
4. Tight junctions are occluding junctions, which seal gap between two cells.
5. Hemidesmosomes are cell-matrix anchoring junctions connecting intermediate filament in one cell to extracellular matrix.

Which of the following combination of statements is *not* correct?

a. 1 and 2
b. 1 and 3
c. 3 and 4
d. 4 and 5

18. If the number of alleles in a population is n, then

P. n different homozygous genotypes are possible.

Q. $n(n - 1)/2$ different heterozygous genotypes are possible.

R. $n(n + 1)/2$ different genotypes are possible.

S. $n(n + 1)$ different genotypes are possible.

a. Q, R and S
b. P, Q and R
c. Q and R
d. P, Q, R and S

19. Four genes, *J*, *K*, *L* and *M*, reside on the same chromosome. Given that the crossover frequency between *K* and *J* is 3, between *K* and *L* is 8, between *J* and *M* is 12, and between *L* and *M* is 7, what is the order of the genes on the chromosome?

a. *J K L M*
b. *J K M L*
c. *K J L M*
d. *K J M L*

20. In a transformation experiment, an $a^+ b^+ c^+$ strain is used as the donor and an $a^- b^- c^-$ strain as the recipient. One hundred a^+ transformants are selected and then replica-plated to determine whether b^+ and c^+ are present. What can you conclude about the relative positions of the genes, based on the listed genotypes?

$a^+ b^- c^-$ 21
$a^+ b^- c^+$ 69
$a^+ b^+ c^-$ 3
$a^+ b^+ c^+$ 7

a. The order is *a c b,* and *c* is closer to *a*.
b. Genes *c* and *a* are cotransformed 76% of the time.
c. *a*-*b* cotransduction is 10%.
d. All are correct.

21. Arrange the following oxides according to their decreasing basic nature.

a. Na_2O, MgO, Al_2O_3, CuO
b. CuO, Al_2O_3, MgO, Na_2O
c. Al_2O_3, CuO, MgO, Na_2O
d. CuO, MgO, Na_2O, Al_2O_3

22. A mixture of 50.0 mL of NH_3 and 60.0 mL of O_2 gas reacts as $4NH_3(g) + 5O_2(g) \longrightarrow 4NO + 6H_2O(g)$. If all the gases are at the same temperature and pressure and the reaction continues until one of the gases is completely consumed, what volume of water vapour is produced?

a. 48 mL
b. 60.0 mL
c. 72 mL
d. 75.0 mL

23. Identify the *correct* order of boiling points of the following compounds:

1. $CH_3CH_2CH_2CH_2OH$
2. $CH_3CH_2CH_2CHO$
3. $CH_3CH_2CH_2COOH$

a. 1 > 2 > 3
b. 3 > 1 > 2
c. 1 > 3 > 2
d. 3 > 2 > 1

24. How many ions per mole present in $Cu_2[Fe(CN)_6]$ in their solution?

a. 3 mole
b. 2 mole
c. 9 mole
d. 8 mole

25. The dissociation constant of weak acid is 1.0×10^{-5}. The equilibrium constant for the reaction with strong base is

a. 1.0×10^{-5}
b. 1.0×10^{9}
c. 1.0×10^{7}
d. 1.0×10^{14}

26. 10,000 alpha particles per minute are passing through a straight tube of radius *r*. The resulting electric current is approximately

a. 0.5×10^{-16} amp
b. 2×10^{12} amp
c. 0.5×10^{12} amp
d. 2×10^{-12} amp

27. Consider following statements:

P. spontaneous processes involving macroscopic objects proceed with a decrease in potential energy.

Q. expansion of an ideal gas is a spontaneous process in which there is no change of energy at all.

R. for a spontaneous process in an isolated system, the change in entropy is positive.

Select *correct* statements

a. P and Q
b. P and R
c. Q and R
d. P, Q and R

28. If the lines $\frac{x-1}{2}=\frac{y+1}{3}=\frac{z-1}{4}$ and $\frac{x-3}{1}=\frac{y-k}{2}=\frac{z}{1}$ intersect, then the value of k is

a. 3/2
b. 9/2
c. –2/9
d. –3/2

29. A function *f* from the set of natural numbers to integers defined by $f(n)=\begin{cases}\frac{n-1}{2}, & \text{when n is odd}\\ -\frac{n}{2}, & \text{when n is even}\end{cases}$

a. onto but not one-one
b. one-one and onto both
c. neither one-one nor onto
d. one-one but not onto

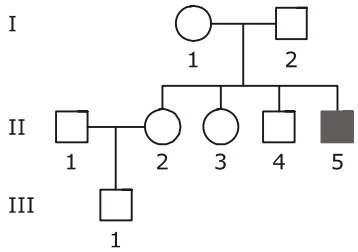
30. If in a ΔABC, the altitudes from the vertices A, B, C on opposite sides are in H.P. then sinA, sinB, sinC are in

a. arithmetic-Geometric progression
b. H.P.
c. G.P.
d. A.P.

PART - B

Questions 31 to 40 carry *two* marks each.

31. In the following pedigree, the affected male II-5 is affected with a genetic condition due to a rare recessive allele (the symbols *A* and *a* denote the dominant and recessive alleles respectively).



a. The genotype of II-5 is aa.
b. The genotypes of I-1 and I-2 are Aa.
c. The probability that II-2 is heterozygous is 2/3.
d. Assuming that II-1 has genotype AA, the probability that III-1 will be heterozygous is 1/3.

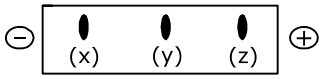
32. Cystic fibrosis is an autosomal recessive human disease caused by one gene with two alleles (CF dominant to cf). A man who has a sibling with cystic fibrosis has children with a woman who also has a sibling with cystic fibrosis. Neither the man nor the woman has cystic fibrosis, nor do any of their parents. Which of the following is *true*?

a. The probability that the man is a carrier and that the woman is not a carrier is 1/9.
b. The probability that they will have a child who has cystic fibrosis is 4/9.
c. The probability that they will have a child who has cystic fibrosis is 1/9.
d. The probability that either parent is a carrier is 2/3.

33. Glucose labeled with ^{14}C in C-3 and C-4 is completely converted to acetyl-CoA via glycolysis and the pyruvate dehydrogenase complex. What percentage of the acetyl-CoA molecules formed will be labeled with ^{14}C, and in which position of the acetyl moiety will the ^{14}C label be found?
    a. 100% of the acetyl-CoA will be labeled at C-1 (carboxyl).
    b. 100% of the acetyl-CoA will be labeled at C-2.
    c. 50% of the acetyl-CoA will be labeled, all at C-2 (methyl).
    d. No label will be found in the acetyl-CoA molecules.

34. Plasmid A and plasmid B were digested with BamHI and analyzed by agarose gel electrophoresis. If plasmid A gave two fragments and plasmid B gave three fragments, then which of the following inferences are *correct*?
    a. Plasmid A has three sites and is circular.
    b. Plasmid B has three sites and is circular.
    c. Plasmid A has two sites and is linear.
    d. Plasmid B has two sites and is linear.

35. In an electrophoresis experiment at pH 5 (shown below) x, y and z refer respectively to



    a. lysine, alanine and aspartic acid
    b. alanine, aspartic acid and lysine
    c. lysine, aspartic acid and alanine
    d. aspartic acid, alanine and lysine

36. At high pressure the following reaction is zero order.

$$2NH_3(g) \xrightarrow[\text{Platinum catalyst}]{1130\ K} N_2(g) + 3H_2(g)$$

    a. Rate of reaction is equal to rate constant.
    b. Rate of the reaction depends on concentration of ammonia.
    c. Rate of decomposition of ammonia will remain constant until ammonia disappears completely.
    d. Further increase in pressure will change the rate of reaction.

37. Which of the following statements are correct?
    a. Mixing two oppositely charged sols neutralises their charges and stabilises the colloid.
    b. Presence of equal and similar charges on colloidal particles provides stability to the colloids.
    c. Any amount of dispersed liquid can be added to emulsion without destabilising it.
    d. Brownian movement stabilises sols.

38. A particle, moving in a plane, is acted upon by a force of constant magnitude that is always perpendicular to the velocity of the particle. Pick out the *correct* statement from the following:
    a. Acceleration is constant.
    b. Kinetic energy is constant.
    c. Velocity is constant.
    d. The particle moves in a circular path.

39. A sphere is rolled on a rough horizontal surface. It gradually slows down and stops. The force of friction tries to
    a. decrease the linear velocity
    b. increase the angular velocity
    c. increase the linear momentum
    d. decrease the linear momentum

40. If $z_1 = 0$, $z_2 = a - i$ and $z_3 = -1 + ib$ are the vertices of an equilateral triangle, then the values of a and b are respectively

a. $-2+\sqrt{3}, -2+\sqrt{3}$ b. $-2-\sqrt{3}, -2-\sqrt{3}$

c. $-2+\sqrt{3}, -2-\sqrt{3}$ d. $-2-\sqrt{3}, -2+\sqrt{3}$

SECTION - C

Questions 41 to 50 carry *one* mark each.

41. An X-linked recessive gene produces red-green color blindness in humans. A woman with normal color vision whose father was colorblind marries a colorblind man. What is the probability that their son will be colorblind?

42. A peptide has the sequence Glu-His-Trp-Ser- Gly- Leu-Arg-pro-Gly. What is the net charge of the molecule at pH 11?

43. How many numbers of optically active isomers are possible for $CH_3-\underset{\underset{|}{OH}}{CH}-\underset{\underset{|}{OH}}{CH}-\underset{\underset{|}{OH}}{CH}-CH_3$?

44. For the reaction $PCl_5 \rightleftharpoons PCl_3 + Cl_2$ in gaseous phase, $K_c = 4$. In a 2 litre flask, there are 2 mol each of PCl_3 and Cl_2 and 0.5 mol of PCl_5. What is the equilibrium concentration of PCl_5?

45. At 80°C, distilled water (H_3O^+) concentration is equal to 1×10^{-6} mol/litre. What is the value of K_w at the same temperature?

46. Two plane mirrors are inclined to one another at an angle of 40°. A point object is placed in between them. How many numbers of images formed due to reflection at both mirrors?

47. The length of a simple pendulum executing simple harmonic motion is increased by 21%. The percentage increase in the time period of the pendulum of increased length is _____.

48. The sum of the digits in the unit place of all the numbers formed with the help of 3, 4, 5, 6, taken all at a time, is _____.

49. The number of real roots of $3^{2x^2-7x+7} = 9$ is _____.

50. The number of terms with integral coefficients in the expansion of $(7^{1/3} + 5^{1/2}\, x)^{600}$ is _____.

Questions 51 to 60 carry *two* marks each.

51. In the following reaction:

$Pyruvate + NADH + H^+ \longrightarrow Lactate + NAD^+$

The half-cell reactions are:

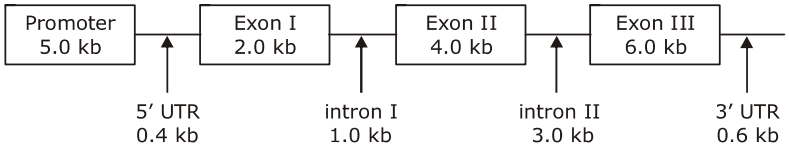
$Pyruvate + 2H^+ + 2e^- \longrightarrow Lactate$ $\quad E'_0 = -0.19$ V

$NAD^+ + H^+ + 2e^- \longrightarrow NADH$ $\quad E'_0 = -0.32$ V

What will be the value of $\Delta G°'$?

52. In a cross involving polygenic inheritance where three gene pairs control plant height, the shortest and tallest plants are 6 cm and 24 cm, respectively. What height should all F_1 display if homozygous 12 cm and 24 cm plants are crossed, assuming their environments are the same?

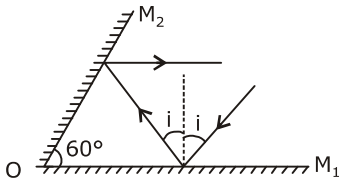
53. The organization of an eukaryotic gene expressed at high levels in liver is diagrammatically represented below:



The size of the mature mRNA generated by the transcription followed by normal splicing of this gene will be (assume that this mRNA is *not* polyadenylated; 5′UTR and 3′UTR refer to the 5′ and 3′ untranslated regions, respectively) _____.

54. A primer with the sequence ATCGGTAACGATTACATTC is to be used in a PCR reaction. Using the formula: $T_m = 2°\ (A + T) + 4°(G + C)$, what is the T_m of this oligonucleotide?

55. Two plane mirrors are inclined to one another at an angle of 60°. A ray is incident on mirror M_1 at an angle 'i'. The reflected ray from mirror M_2 is parallel to mirror M_1 as shown in figure. The angle of incidence 'i' is _____.



56. A particle had a velocity of 18 m/s in +x direction and 2.4 s later its velocity was 30 m/s in the opposite direction. The average acceleration of the particle during this 2.4 s interval will be _____.

57. In resonance column, first and second resonances are obtained at depths 22.7 cm and 70.2 cm respectively. The third resonance will be obtained at a depth _____.

58. For the following equilibrium $N_2O_4 \rightleftharpoons 2NO_2$ in gaseous phase, NO_2 is 50% of the total volume when equilibrium is set-up. Hence, percent of dissociation of N_2O_4 is _____.

59. A person standing on the bank of a river observes that the angle of elevation of the top of a tree on the opposite bank of the river is 60° and when he retires 40 meters away from the tree the angle of elevation becomes 30°. The breadth of the river is _____.

60. $\lim_{x\to 0} \frac{\sin(\pi \cos^2 x)}{x^2}$ equals _____.