IIT-JAM BIOTECHNOLOGY 2023

SECTION-A

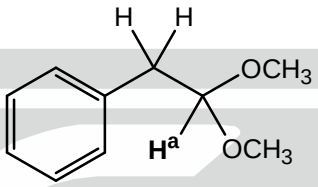
[Multiple Choice Questions (MCQ)]

1. Rain is falling vertically with a speed of 40 ms^{-1}. Wind starts blowing with a speed of 16 ms^{-1} in the west to east direction. How should a person, who is standing, hold his umbrella to avoid getting wet?
   (a) At an angle of about 22º with vertical towards east
   (b) At an angle of about 66º with vertical towards west
   (c) At an angle of about 22º with vertical towards west
   (d) At an angle of about 66º with vertical towards east
2. Which one of the following is NOT a plant vascular tissue?
   (a) Periderm (b) Xylem (c) Phloem (d) Stele
3. Which one of the following does NOT belong to the fresh water ecosystem?
   (a) Estuary (b) Lentic (c) Wetland (d) Lotic
4. Which one of the following pairs of antibodies contains 'J-chain' in their multimeric form?
   (a) IgD and IgG (b) IgA and IgM (c) IgD and IgE (d) IgA and IgE
5. Arrange the following elements in increasing order of their electronegativity according to the Pauling scale C, Na, Be and Br
   (a) Na, C, Be, Br (b) Na, Be, C, Br (c) Be, Na, C, Br (d) Br, C, Na, Be
6. Which one of the following compounds inhibits the polymerization of tubulin to microtubules in animal cells?
   (a) Taxol (b) ATP (c) Vinblastine (d) Thymosin
7. A growing shoot of a germinating seedling encounters an underground obstacle. Which one of the following hormones elicits "triple response" to the underground obstacle?
   (a) Auxin (b) Gibberellins (c) Ethylene (d) Cytokinin
8. Given the following sets:
   $A = \{2, 4, 6, 8, 10, 12\}$
   $B = \{8, 10, 12, 14, 16, 18\}$
   $C = \{7, 8, 9, 10, 11, 12, 13\}$
   $(A \cap B) \cup (B \cap C)$ is
   (a) {8, 10, 12, 14} (b) {8, 10, 12}
   (c) {4, 6, 7, 8, 10, 11, 12, 13} (d) {7, 8, 10, 11, 12, 13, 14}
9. Restriction enzymes that recognize the same nucleotide sequence but cleave at different positions are called
   (a) neoschizomers (b) isoschizomers
   (c) isocaudomers (d) heterohypekomers
10. Which one of the following is transcribed by RNA polymerase III in eukaryotes?
    (a) 28S rRNA (b) tRNA (c) miRNA (d) 18S rRNA

11. Tetracycline binds to the
    (a) 50S subunit and blocks exit of growing polypeptide chain
    (b) 30S subunit and prevents codon:anticodon interactions
    (c) 50S subunit and inhibits aminoacyl-tRNA binding
    (d) 30S subunit and inhibits aminoacyl-tRNA binding

12. Which one of the following statements about the G_1 checkpoint of eukaryotic cell division cycle is INCORRECT?
    (a) Cell assures the existence of favorable extracellular environment
    (b) Cell assures the DNA has no damage
    (c) Cell assures the damaged DNAs are directed for repair mechanism
    (d) Cell assures complete replication of DNA

13. What is the splitting pattern of proton **H^a** of the following compound in its ^{1}H NMR spectrum?

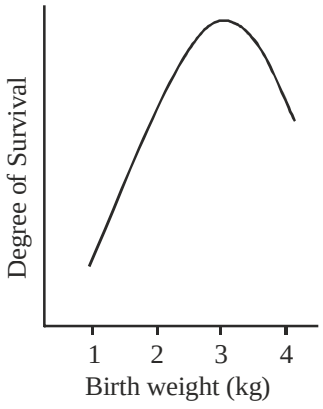


    (a) Doublet (b) Triplet (c) Multiplet (d) Doublet of doublet

14. The inability in humans to taste capsaicin resides in a single gene difference between two alleles P and *p*. The allele *P* for tasting is dominant over the nontasting allele. In a population of 400 individuals in Hardy-Weinberg equilibrium. 64 are nontasters. How many individuals are heterozygous for the gene?
    (a) 64 (b) 128 (c) 192 (d) 144

15. In the "Southern blot" technique, which of the following reagents is used to detect the presence of a desired DNA fragment?
    (a) DNase (b) Ethidium bromide
    (c) Silver nitrate (d) DNA probe

16. The relationship between birth weight and degree of survival $\left(\log\left[\frac{survivors}{non-survivors}\right]\right)$ in 6908 human births in an obstetric hospital is shown in the figure below. The mode of selection for birth weight is



    (a) disruptive (b) directional (c) stabilizing (d) diversifying

17. Determine the correctness or otherwise of the following **Assertion [a]** and the **Reason [r]**.

Assertion [a]: The cardiovascular organization called double circulation provides vigorous flow of blood to the brain, muscles, and other organs.

Reason [r]: The blood is pumped a second time after it loses pressure in the capillary beds of the lungs or skin.

(a) Both [a] and [r] are true but [r] is not the correct reason for [a]
(b) Both [a] and [r] are false
(c) [a] is true but [r] is false
(d) Both [a] and [r] are true and [r] is the correct reason for [a]

18. Match the microorganisms in **Group-I** with the human disease in **Group-II**

Group-I	**Group-II**
P) *Treponema pallidum*	1) Sleeping sickness
Q) *Trypanosoma cruzi*	2) Whooping cough
R) *Trypanosoma gambiense*	3) Chagas disease
S) *Bordetella pertussis*	4) Syphilis

(a) P-2, Q-1, R-3, S-4 (b) P-1, Q-2, R-4, S-3
(c) P-3, Q-1, R-2, S-4 (d) P-4, Q-3, R-1, S-2

19. Class II MHC molecules are NOT expressed by

(a) T-cells (b) macrophages (c) B-cells (d) dendritic cells

20. Match the type of DNA repair mechanism in **Group-I** with the enzyme(s) involved in **Group-II**

Group-I	**Group-II**
P) Mismatch repair	1) DNA glycosylase
Q) Base excision repair	2) UvrA, UvrB, UvrC and UvrD
R) Nucleotide excision repair	3) RecA
S) Double strand break repair	4) MutL, MutS and MutH

(a) P-4, Q-1, R-3, S-2 (b) P-4, Q-1, R-2, S-3
(c) P-2, Q-1, R-4, S-3 (d) P-4, Q-2, R-1, S-3

21. Which one of the following statements about photoproteins in plants is INCORRECT?

(a) Cryptochromes are sensitive to blue light
(b) Phytochromes are activated by red light
(c) Phytochromes are inactivated by far-red light
(d) Phototropins are insensitive to blue light

22. Which one of the following statements is ***correct*** about solute transport across membranes?

(a) All ABC transporters do not have nucleotide binding domain
(b) The direction in which a charged solute tends to move spontaneously across a membrane does not depend on the electrical gradient across the membrane
(c) Passive transporters decrease the activation energy and does not facilitate the transport of polar compounds
(d) P-type ATPases get reversibly phosphorylated as a part of transport cycle

23. Which one of the following is ***correct*** in the case of conjugation of a high frequency recombination (Hfr) strain with F^- strain of *E. coli*?
    (a) Recombination frequency is low, F factor transfer frequency is high
    (b) Recombination frequency is high, F factor transfer frequency is low
    (c) Recombination frequency is high, F factor transfer frequency is high
    (d) Recombination frequency is low, F factor transfer frequency is low

24. A genetic linkage map represents the
    (a) relative locations of genes on a chromosome
    (b) accurate physical distances among loci
    (c) phylogenetic linkage among organisms
    (d) distribution of the mutational hotspots

25. Determine the correctness or otherwise of the following **Assertion [a]** and the **Reason [r]**.
    Assertion [a]: Nitric oxide is involved in transient paracrine and autocrine signaling.
    Reason [r]: Nitric oxide is highly reactive, with a lifetime of few seconds, yet can diffuse freely across membranes
    (a) Both [a] and [r] are false
    (b) Only [a] is true but [r] is false
    (c) Both [a] and [r] are true and [r] is the correct reason for [a]
    (d) Both [a] and [r] are true but [r] is not the correct reason for [a]

26. Match the recombinant DNA products in **Group-I** with its application in **Group-II**

Group-I	**Group-II**
P) Tissue plasminogen activator	1) Emergency treatment of heart attack
Q) Erythropoietin	2) Treatment of anemia
R) Superoxide dismutase	3) Prevents tissue damage
S) Interferon	4) Stimulates cells to inhibit viral replication

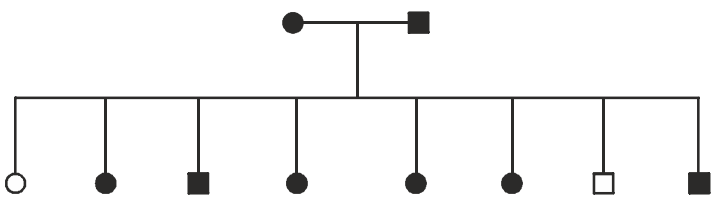
    (a) P-3, Q-1, R-4, S-2
    (b) P-4, Q-3, R-1, S-2
    (c) P-1, Q-2, R-3, S-4
    (d) P-1, Q-3, R-4, S-2

27. Match the molecules in **Group-I** with the type of bonds present in them, in **Group-II**

Group-I	**Group-II**
P) NaCl	1) Coordination bond
Q) H_2	2) Polar covalent bond
R) Pd-P bond in $Pd(PPh_3)_4$	3) Covalent bond
S) C-Cl bond in CH_3Cl	4) Ionic bond

    (a) P-4, Q-3, R-1, S-2
    (b) P-4, Q-1, R-3, S-2
    (c) P-4, Q-3, R-2, S-1
    (d) P-2, Q-3, R-1, S-4

28. The pedigree given below shows individuals affected (shaded circles/rectangles) by chronic hypertension. Assuming 100% penetrance, the inheritance of this trait is



(a) autosomal dominant (b) sex-linked recessive
(c) sex-linked dominant (d) autosomal recessive

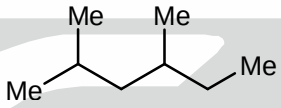
29. In mice, a trait is determined by a dominant allele *Y* and recessive allele *y*. What proportion of the offspring from a *YY* × *yy* cross is expected to be homozygous recessive in F_1 generation?
(a) 0 (b) 0.5 (c) 0.25 (d) 1

30. Which one of the following enzymes is required to ensure the replication of a negative-sense or negative-strand RNA virus?
(a) DNA-dependent RNA polymerase (b) RNA-dependent RNA polymerase
(c) RNA-dependent DNA polymerase (d) DNA polymerase

SECTION-B

[Multiple Select Questions (MSQ)]

31. Which of the following statement(s) is/are ***correct*** for the following compound?



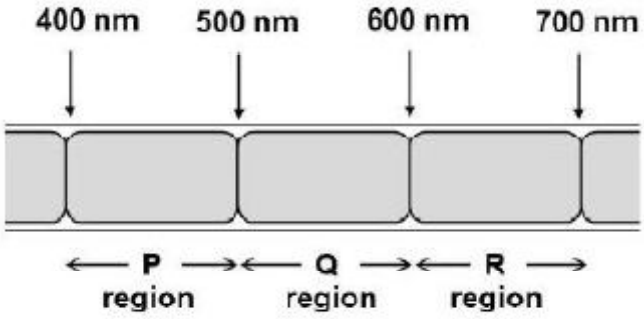
(a) It can have a maximum of four stereoisomers
(b) It is a chiral compound
(c) It is an achiral compound
(d) It can have a maximum of two stereoisomers

32. The characteristic morphological change(s) in cells undergoing apoptosis is/are
(a) formation of blebs on cell surface
(b) collapse of the cytoskeleton
(c) swelling and bursting of cells
(d) condensation and fragmentation of nuclear chromatin

33. Which of the given statement(s) about synthetic oligonucleotides is/are ***correct***?
(a) Chemical synthesis extends the DNA chain from $3' \rightarrow 5'$ end
(b) Chemical synthesis extends the DNA chain from $5' \rightarrow 3'$ end
(c) They can be utilized for site-directed mutagenesis
(d) They can be utilized as radiolabeled probes

34. Which of the following statement(s) is/are ***correct*** about telophase?
(a) Daughter chromosomes are yet to form
(b) Nuclear membrane disappears
(c) Division of cytoplasm begins
(d) New nuclear envelop starts to reassemble

35. Different segments of a photosynthetic filamentous alga are exposed to different wavelengths of light as shown below. After a period of time, bacteria known to migrate towards high oxygen concentration, is spread on the surface of the alga. Which region(s) of the alga will have maximum bacterial congregation?



(a) Only Q (b) P and R (c) Only P (d) P and Q

36. Hyperventilation (breathing rapidly and deeply) causes which of the following event(s) in the arterial blood?

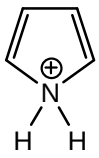
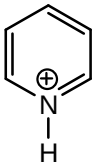
(a) Decrease in CO_2 concentration (b) Increase in pH

(c) Decrease in proton concentration (d) Increase in O_2 concentration

37. Which of the following option(s) represent(s) the evolutionary relationship between the bird and bat wings as structures for flying?

(a) homologous (b) convergence (c) divergence (d) analogous

38. Which of the following compound(s) is/are aromatic?

(a)  (b)  (c)  (d) 

39. Which of the following is/are essential feature(s) of high-fidelity DNA polymerases used in polymerase chain reaction?

(a) $5' \rightarrow 3'$ exonuclease activity (b) Optimum temperature for activity $\geq 72^{o}C$

(c) $3' \rightarrow 5'$ exonuclease activity (d) Endonuclease activity

40. A species of fish living in a lake are separated by drying up of the lake into two separate lakes. After several hundreds of years of separation, the two groups are unable to mate. These groups are now considered to be different _____

(a) species (b) communities (c) organisms (d) populations

SECTION-C

[Numerical Answer Type (NAT)]

41. Among *i*-$BuNH_2$, NH_3, Me_2NH, $EtNH_2$ the number of compound(s) more basic than $MeNH_2$ is/are ___

42. A restriction endonuclease has a recognition site of 3 bases. Assuming random arrangement of nucleotides, the probability that this endonuclease will cut a piece of DNA is _____

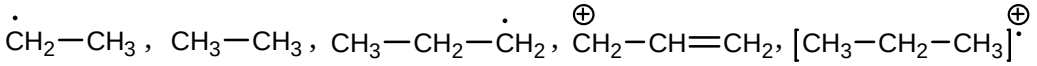
(rounded off to three decimal places)

43. The net number of molecule(s) of NADH formed from one molecule of glucose in glycolysis under aerobic conditions is/are _____

44. The number of possible unique combination(s) of linear tetrapeptides that can be made from four different amino acids using each amino acid only once in the chain is/are _____

45. The value of $\lim_{x\to -3}\frac{(2x+6)}{(x+3)}$ is _____

46. Among the five fragments given below,



the number of fragment(s) accelerated to the analyzer tube in mass spectrometer with electron ionization is/are _____

47. Among K^+, Li^+, Rb^+, Cs^+, the number of cation(s) having ionic radii more than Na^+ is/are _____

48. The order of differential equation $\frac{d^3y}{dx^3}+2\frac{d^2y}{dx^2}-3\frac{dy}{dx}+6x^4y=0$ is _____

49. Whales can dive under sea to depths of 2 km. The pressure on the whale at this depth (ignoring atmospheric pressure) is _____$\times 10^6$ Pa.
(Use Density of sea water = 1g cm^{-3} and g = 10 ms^{-2})

50. A massless ideal spring is hanging vertically. A sphere of mass of 500 g, suspended from the spring, stretches the spring from its initial position by 50 cm when it reaches equilibrium. The force constant of the spring is _____ Nm^{-1}. (Use g = 10 ms^{-2})

51. A protein solution of 1 μM has transmission of 40% at 280 nm, when measured in a 1 cm cuvette using a UV-Visible spectrophotometer. The transmission of the same solution, when measured using a 2 cm cuvette is _____%. (rounded off to the nearest integer)

52. A random variable X and its probability distribution is given below. The value of P(X < 5) is _____ (rounded off to one decimal place).

X	0	1	2	3	4	5
$P(X)$	0	k	$2k$	$3k$	$6k$	$8k$

53. The $\Delta G'$ and K'_{eq} values of ATP hydrolysis are –32.34 kJ mol^{-1} and 4.6×10^5, respectively. The $\Delta G'$ and K'_{eq} values of enzymatic hydrolysis of glucose-6-phosphate to glucose and phosphate are –13.18 kJ mol^{-1} and 203.8, respectively. The $\Delta G'$ value of reaction of glucose-6-phosphate formation from glucose and ATP by hexokinase is _____ kJ mol^{-1} (rounded off to 2 decimal places).
[All reactions are carried out at pH 7.0 and 25°C].

54. If a bacterial culture with a doubling time of 30 minutes starts with two cells, then the number of cells after 4 hours are _____

55. The heat required to convert 2 kg of water at 20°C in a calorimeter to steam at 100°C and at atmospheric pressure (1 atm) is _____ kJ. (Specific heat capacity of water is 4.2 kJ kg^{-1} K^{-1} and latent heat of steam is 2256 kJ kg^{-1}).

56. Consider a first order reaction $A \rightarrow B$. The initial concentration of A is 100 mol L^{-1} and the value of first order rate constant is 0.01 min^{-1}. The concentration of A after 10 min of reaction is _____ mol L^{-1} (rounded off to one decimal place).

57. An electron is accelerated from rest through a potential difference of 200 V. The de-Broglie wavelength associated with this electron is _____ nm. (Rounded off to 2 decimal places)
(Planck's constant = 6.6×10^{-34} Js, 1eV = 1.6×10^{-19} J, mass of an electron = 9.1×10^{-31} kg)

58. Given data consists of distinct values of x_i occurring with frequencies f_i. The mean value for the data is ____

x_i	5	6	8	10
f_i	8	10	10	12

(rounded off to one decimal place)

59. The rate of transcription in a bacterium is 50 nucleotides/min and the average molecular weight of an amino acid is 110 Da. Time taken for synthesis of the mRNA of a protein with molecular weight of 110 kDa is _____ min. (rounded off to one decimal place)
Assume no abortive transcriptions and no sequences upstream of the start codon.

60. K_m and V_{max} of an enzyme preparation are 5 μM and 30 μM min^{-1} respectively. Considering, K_i value of competitive inhibitor is 60 μM, the velocity (V_0) of this enzyme-catalyzed reaction in the presence of 200 μM of substrate and 600 μM of competitive inhibitor is _____ μM min^{-1}
(rounded off to two decimal places).

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ANSWER KEY

SECTION-A

1. (c)	**2.** (a)	**3.** (a)	**4.** (b)	**5.** (b)
6. (c)	**7.** (c)	**8.** (b)	**9.** (a)	**10.** (b)
11. (d)	**12.** (d)	**13.** (b)	**14.** (c)	**15.** (d)
16. (c)	**17.** (d)	**18.** (d)	**19.** (a)	**20.** (b)
21. (d)	**22.** (d)	**23.** (b)	**24.** (a)	**25.** (c)
26. (c)	**27.** (a)	**28.** (a)	**29.** (a)	**30.** (b)

SECTION-B

31. (b, d)	**32.** (a, b, d)	**33.** (a, c, d)	
34. (c, d)	**35.** (b)	**36.** (a, b, c)	
37. (b, d)	**38.** (b, d)	**39.** (b, c)	**40.** (a)

SECTION-C

41. (3)	**42.** (1/64)	**43.** (2)	**44.** (24)
45. (2)	**46.** (2)	**47.** (3)	**48.** (3)
49. (20)	**50.** (10)	**51.** (16)	**52.** (0.60)
53. (–19.16)	**54.** (512)	**55.** (5184)	**56.** (90.5)
57. (0.09)	**58.** (7.5)	**59.** (60)	**60.** (23.53)