GATE - 2016

(BIOTECHNOLOGY)

AIR 6

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Education for Life...

Pathfinder Academy

GATE Biotechnology

Year – 2016

General aptitude

Questions 01 to 05 carry *one* mark each.

01. The volume of a sphere of diameter 1 unit is _____ than the volume of a cube of side 1 unit.

a. least
b. less
c. lesser
d. low

02. The unruly crowd demanded that the accused be _____ without trial.

a. hanged
b. hanging
c. hankering
d. hung

03. Choose the statement(s) where the underlined word is used *correctly*:

P. A prone is a dried plum.
Q. He was lying prone on the floor.
R. People who eat a lot of fat are prone to heart disease.

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

04. Fact: If it rains, then the field is wet.

Read the following statements:

P. It rains.
Q. The field is not wet.
R. The field is wet.
S. It did not rain.

Which one of the options given below is *not* logically possible, based on the given fact?

a. If R, then S
b. If P, then R
c. If P, then Q
d. If Q, then S

05. A window is made up of a square portion and an equilateral triangle portion above it. The base of the triangular portion coincides with the upper side of the square. If the perimeter of the window is 6 m, the area of the window in m^2 is _____.

a. 1.43
b. 2.06
c. 2.68
d. 2.88

Questions 06 to 10 carry *two* marks each.

06. Students taking an exam are divided into two groups, P and Q such that each group has the same number of students. The performance of each of the students in a test was evaluated out of 200 marks. It was observed that the mean of group P was 105, while that of group Q was 85. The standard deviation of group P was 25, while that of group Q was 5. Assuming that the marks were distributed on a normal distribution, which of the following statements will have the highest probability of being *true*?

a. No student in group Q scored less marks than any student in group P.

b. No student in group P scored less marks than any student in group Q.

c. Most students of group Q scored marks in a narrower range than students in group P.

d. The median of the marks of group P is 100.

07. A smart city integrates all modes of transport, uses clean energy and promotes sustainable use of resources. It also uses technology to ensure safety and security of the city, something which critics argue, will lead to a surveillance state.

Which of the following can be logically inferred from the above paragraph?

P. All smart cities encourage the formation of surveillance states.

Q. Surveillance is an integral part of a smart city.

R. Sustainability and surveillance go hand in hand in a smart city.

S. There is a perception that smart cities promote surveillance.

a. P and S only

b. Q and R only

c. S only

d. P only

08. Find the missing sequence in the letter series.

B, FH, LNP, _ _ _ _.

a. SUWY

b. TUVW

c. TVXZ

d. TWXZ

09. The binary operation □ is defined as a □ b = ab + (a + b), where a and b are any two real numbers. The value of the identity element of this operation, defined as the number x such that a □ x = a, for any a, is _____.

a. 0

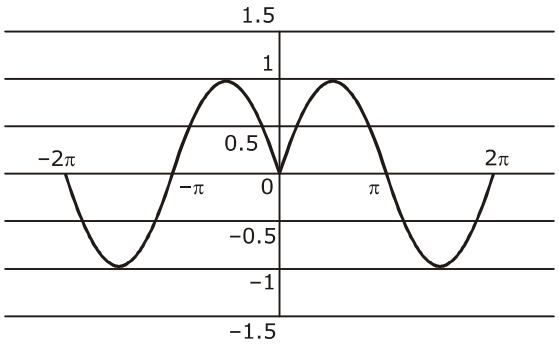
b. 1

c. 2

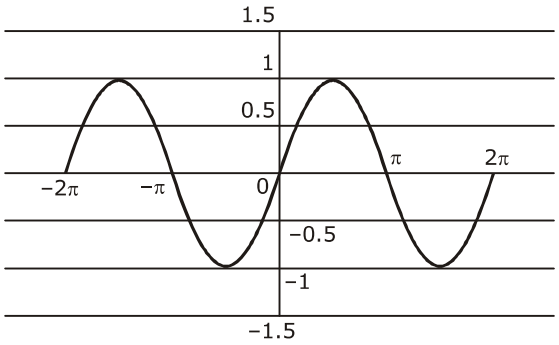
d. 10

10. Which of the following curves represents the function $y = \ln(|e^{[|\sin(|x|)|]}|)$ for $|x| < 2\pi$? Here, x represents the abscissa and y represents the ordinate.

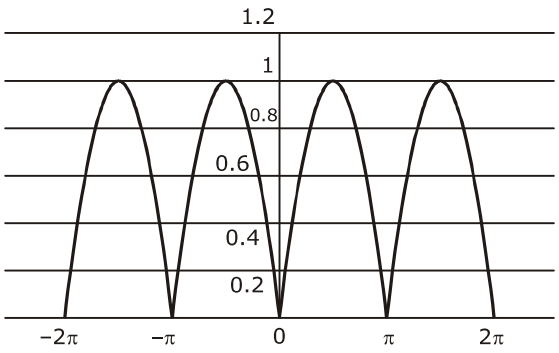
a.



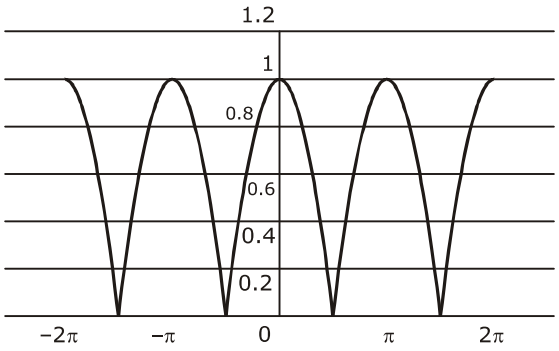
b.



c.



d.



Biotechnology

Questions 11 to 35 carry *one* mark each.

11. Bacteria with two or more flagella at one or both ends are called

    a. amphitrichous
    b. peritrichous
    c. lophotrichous
    d. atrichous

12. Which family of viruses has single stranded DNA?

    a. Herpesviridae
    b. Poxviridae
    c. Retroviridae
    d. Parvoviridae

13. What will be the binding status of regulatory proteins in *lac* operon when concentrations of both lactose and glucose are very low in the culture medium?

    a. Only the repressor remains bound to the operator.
    b. Only the cyclic AMP-Catabolic Activator Protein (cAMP-CAP) complex remains bound to the CAP binding site.
    c. Neither the repressor nor cAMP-CAP complex remain bound to their respective binding sites.
    d. Both the repressor and cAMP-CAP complex remain bound to their respective binding sites.

14. Which of the following are *true* for *Treponema pallidum*?

    P. It is the causative agent of syphilis.
    Q. It is a spirochete.
    R. It is a non-motile bacterium.
    S. It is generally susceptible to penicillin.

Choose the *correct* combination.

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

15. In a typical mitotic cell division cycle in eukaryotes, M phase occurs immediately after the

a. G_0 phase
b. S phase
c. G_1 phase
d. G_2 phase

16. Which one of the following is *not* a therapeutic agent based on nucleic acid for the treatment of genetic disorders?

a. Antisense oligonucleotide
b. Ribozyme
c. Aptamer
d. Avidin

17. ATP biosynthesis takes place utilizing the H^+ gradient in mitochondria and chloroplasts. Identify the *correct* sites of H^+ gradient formation.

a. Across the outer membrane of mitochondria and across the inner membrane of chloroplast.
b. Across the inner membrane of mitochondria and across the thylakoid membrane of chloroplast.
c. Within the matrix of mitochondria and across the inner membrane of chloroplast.
d. Within the matrix of mitochondria and within the stroma of chloroplast.

18. Which one of the following is *not* an algorithm for building phylogenetic trees?

a. Maximum parsimony
b. Neighbor joining
c. Maximum likelihood
d. Bootstrap

19. Cesium chloride density gradient centrifugation is commonly used for the separation of DNA molecules. The buoyant density, ρ, of a double stranded Cs^+DNA is given by the equation $\rho = 1.66 + 0.098\ X_{G+C}$; where X_{G+C} denotes

a. total number of G and C
b. mole fraction of G + C
c. number of GC repeats
d. ratio of G + C to A + T content

20. Disaccharide molecules that contain $\beta(1 \rightarrow 4)$ glycosidic linkage are

a. sucrose and maltose
b. sucrose and isomaltose
c. maltose and isomaltose
d. lactose and cellobiose

21. Junctional diversity of antibody molecules results from

a. the addition of switch region nucleotides
b. the addition of N and P nucleotides
c. the joining of V, D and J segments
d. mutations in complementarity-determining regions

22. Which one of the following is *not* used for the measurement of cell viability in animal cell culture?

a. Trypan blue dye exclusion
b. Tetrazolium (MTT) assay
c. LDH activity in the culture medium
d. Coulter counter

23. Which one of the following techniques relies on the spin angular momentum of a photon?

a. CD spectroscopy
b. Fluorescence spectroscopy
c. IR spectroscopy
d. Raman spectroscopy

24. Which one of the following statements is *not* true?

a. In competitive inhibition, substrate and inhibitor compete for the same active site of an enzyme.
b. Addition of a large amount of substrate to an enzyme cannot overcome uncompetitive inhibition.
c. A transition state analogue in enzyme catalyzed reaction increases the rate of product formation.
d. In non-competitive inhibition, K_m of an enzyme for its substrate remains constant as the concentration of the inhibitor increases.

25. Based on their function, find the odd one out.
    a. miRNA
    b. siRNA
    c. shRNA
    d. snRNA

26. Prandtl number is the ratio of
    a. thermal diffusivity to momentum diffusivity.
    b. mass diffusivity to momentum diffusivity.
    c. momentum diffusivity to thermal diffusivity.
    d. thermal diffusivity to mass diffusivity.

27. Fed batch cultivation is suitable for which of the following?
    P. Processes with substrate inhibition.
    Q. Processes with product inhibition.
    R. High cell density cultivation.
    a. P and Q only
    b. P and R only
    c. Q and R only
    d. P, Q and R

28. A biological process is involved in the _____ treatment of industrial effluent.
    a. primary
    b. secondary
    c. tertiary
    d. quaternary

29. In dead-end filtration, rate of filtration is
    a. directly proportional to the square root of pressure drop across the filter medium.
    b. inversely proportional to the pressure drop across the filter medium.
    c. inversely proportional to the viscosity of the solution.
    d. inversely proportional to the square of viscosity of the solution.

30. The power required for agitation of non-aerated medium in fermentation is _____ kW.
    Operating conditions are as follows:
    Fermentor diameter = 3 m
    Number of impellers = 1
    Mixing speed = 300 rpm
    Diameter of the Rushton turbine = 1 m
    Viscosity of the broth = 0.001 Pa.s
    Density of the broth = 1000 $kg.m^{-3}$
    Power number = 5

31. Which one of the following is the most suitable type of impeller for mixing high viscosity (viscosity > 10^5 cP) fluids?
    a. Propeller
    b. Helical ribbon
    c. Paddle
    d. Flat blade turbine

32. Runs scored by a batsman in five one-day matches are 55, 75, 67, 88 and 15. The standard deviation is _____.

33. The positive eigenvalue of the following matrix is _____.

$$\begin{bmatrix} 2 & 1 \\ 5 & -2 \end{bmatrix}$$

34. The Laplace transform F(s) of the function f(t) = cos (at), where a is constant, is _____.

a. $\frac{s^2}{s^2+a^2}$ b. $\frac{a}{s^2+a^2}$

c. $\frac{s}{s^2+a^2}$ d. $\frac{s}{s^2-a^2}$

35. The value of the integral $\int_0^{0.9} \frac{dx}{(1-x)(2-x)}$ is _____.

Questions 36 to 65 carry *two* marks each.

36. Which combination of the following statements is *correct* for cyanobacteria?

P. They can perform oxygenic photosynthesis.

Q. Usually filamentous forms are involved in nitrogen fixation.

R. Nitrogen fixation occurs in heterocysts.

S. They cannot grow in a mineral medium exposed to light and air.

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

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

37. Which set of the following events occurs during the elongation step of translation?

1. Attachment of mRNA with the smaller subunit of ribosome.
2. Loading of correct aminoacyl-tRNA into the A site.
3. Formation of a peptide bond between the amino acyl-tRNA in the A site and the peptide chain that is attached to the peptidyl-tRNA in the P site.
4. Dissociation of the ribosomal subunits.
5. Translocation of peptidyl-tRNA from the A site to the P site of the ribosome.

a. 1, 2 and 3 b. 1, 2 and 5

c. 2, 3 and 5 d. 3, 4 and 5

38. A DNA sequence, 5'-ATGGACGTGCTTCCCAAAGCATCGGGC-3', is mutated to obtain

1. 5'-ATGGACGTGCTTC**a**CAAAGCATCGGGC-3'
2. 5'-ATGGACGTGCTTCCC**g**AAAGCATCGGGC-3'
3. 5'-ATGGACGTGCTTCC-AAAGCATCGGGC-3'
4. 5'-ATGGACGTGCTTCCCAA**t**GCATCGGGC-3'
5. 5'-ATGGACG**a**GCTTCCCAAAGCATCGGGC-3'

[Point mutations are shown in the lower case or '-' within the sequences]

Which of the above mutant sequences *do not* have frame-shift?

a. 1, 2 and 4 b. 1, 4 and 5

c. 2, 3 and 4 d. 2, 4 and 5

39. Which of the following events occur during the stationary phase of bacterial growth?

1. Rise in cell number stops.
2. Spore formation in some Gram-positive bacteria such as *Bacillus subtilis*.
3. Cell size increases in some Gram-negative bacteria such as *Escherichia coli*.
4. Growth rate of bacterial cells nearly equals their death rate.
5. Decrease in peptidoglycan crosslinking.

a. 1, 2 and 4 only b. 1, 4 and 5 only

c. 2, 3 and 4 only d. 1, 3 and 5 only

40. Select the *correct* combination of genetic components that are essential for the transfer of T-DNA segment from *Agrobacterium tumefaciens* to plant cells.

a. Border repeat sequences and oncogenes.
b. Border repeat sequences and *vir* genes.
c. Opine biosynthetic genes and *vir* genes.
d. Opine biosynthetic genes and oncogenes.

41. Match the secondary metabolites (Column-I) with the corresponding plant species (Column-II).

Column-I	Column-II
P. Morphine	1. *Datura stramonium*
Q. Pyrethrins	2. *Catharanthus roseus*
R. Scopolamine	3. *Papaver somniferum*
S. Vincristine	4. *Tagetes erecta*

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

42. A variety of genetic elements are used in the transgenic plant research. Match the genetic elements (Column-I) with their corresponding source (Column-II).

Column-I	Column-II
P. *Ubiquitin 1* promoter	1. *Agrobacterium tumefaciens*
Q. *Nos* transcriptional terminator	2. *Streptomyces hygroscopicus*
R. *bar* selection marker gene	3. *Escherichia coli*
S. *gus* reporter gene	4. *Zea mays*

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

43. Match the type of chromosomal inheritance (Column-I) with the corresponding genetic disease or trait (Column-II).

Column-I	Column-II
P. Autosomal recessive inheritance	1. Huntington disease
Q. Autosomal dominant inheritance	2. Hairy ears
R. X-linked inheritance	3. Cystic fibrosis
S. Y-linked inheritance	4. Hemophilia

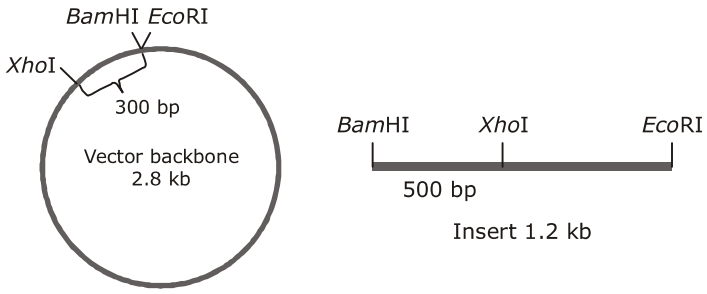
a. P-1, Q-4, R-3, S-2
b. P-4, Q-3, R-2, S-1
c. P-3, Q-1, R-4, S-2
d. P-4, Q-2, R-3, S-1

44. A crossing was performed between the genotypes DdEeFfgg and ddEeFfGg. Assuming that the allelic pairs of all genes assort independently, the proportion of progeny having the genotype ddeeffgg is expected to be _____%.

45. The equilibrium potential of a biological membrane for Na^+ is 55 mV at 37°C. Concentration of Na^+ inside the cell is 20 mM. Assuming the membrane is permeable to Na^+ only, the Na^+ concentration outside the membrane will be _____ mM.

(Faraday constant: 23062 $cal.V^{-1}.mol^{-1}$, Gas constant: 1.98 $cal.mol^{-1}.K^{-1}$)

46. A 1.2 kb DNA fragment was cloned into *Bam*HI and *Eco*RI sites located on a 2.8 kb cloning vector. The *Bam*HI and *Eco*RI sites are adjacent to each other on the vector backbone. The vector contains an *Xho*I site located 300 bp upstream of the *Bam*HI site. An internal *Xho*I site is present in the gene sequence as shown in the figure. The resultant recombinant plasmid is digested with *Eco*RI and *Xho*I and analyzed through 1% agarose gel electrophoresis. Assuming complete digestion with *Eco*RI and *Xho*I, the DNA fragments (in base pairs) visible on the agarose gel will correspond to:



a. 2800, 700 and 500
b. 2800, 700 and 800
c. 2500, 700 and 800
d. 2500, 1200 and 300

47. Find the *incorrect* combination.
a. Surface immunoglobulins — B cell antigen receptor.
b. Affinity maturation — isotype switching.
c. Fc region of antibodies — binding to complement proteins.
d. Spleen, the secondary lymphoid organ — no connection with the lymphatic system.

48. Which of the following statement(s) is/are *correct* for antigen activated effector T-cells?
P. $CD4^+$ cells make contact with macrophages and stimulate their microbicidal activity.
Q. $CD4^+$ cells make contact with B-cells and stimulate them to differentiate into plasma cells.
R. $CD8^+$ cells make contact with B-cells and stimulate them to differentiate into plasma cells.
S. $CD8^+$ cells make contact with virus infected cells and kill them.
a. Q only
b. Q and S only
c. P, Q and S only
d. P, Q, R and S

49. Which one of the following statements regarding G proteins is *incorrect*?
a. GDP is bound to G protein in the resting stage.
b. GTP bound α-subunit cannot reassemble with $\beta\gamma$-dimer.
c. All G proteins are trimeric.
d. Activation of G protein may result in activation or inhibition of the target enzymes.

50. In animal cell culture, a CO_2 enriched atmosphere in the incubator chamber is used to maintain the culture pH between 6.9 and 7.4. Which one of the following statements is *correct*?
a. Higher the bicarbonate concentration in the medium, higher should be the requirement of gaseous CO_2.
b. Lower the bicarbonate concentration in the medium, higher should be the requirement of gaseous CO_2.
c. Higher the bicarbonate concentration in the medium, lower should be the requirement of gaseous CO_2.
d. CO_2 requirement is independent of bicarbonate concentration in the medium.

51. Choose the *correct* combination of True (T) and False (F) statements about microcarriers used in animal cell culture.
P. Higher cell densities can be achieved using microcarriers.
Q. Microcarriers increase the surface area for cell growth.
R. Microcarriers are used for both anchorage- and nonanchorage-dependent cells.
S. Absence of surface charge on microcarriers enhances attachment of cells.
a. P-T, Q-F, R-T and S-F
b. P-T, Q-T, R-F and S-F
c. P-F, Q-F, R-T and S-T
d. P-F, Q-T, R-F and S-T

52. In an assay of the type II dehydroquinase of molecular mass 18 kDa, it is found that the V_{max} of the enzyme is 0.0134 μmol.min^{-1} when 1.8 μg enzyme is added to the assay mixture. If the K_m for the substrate is 25 μM, the k_{cat}/K_m ratio will be _____ × 10^4 $M^{-1}.s^{-1}$.

53. The molar extinction coefficients of Trp and Tyr at 280 nm are 5690 and 1280 $M^{-1}.cm^{-1}$, respectively. The polypeptide chain of yeast alcohol dehydrogenase (37 kDa) contains 5 Trp and 14 Tyr residues. The absorbance at 280 nm of a 0.32 mg.mL^{-1} solution of yeast alcohol dehydrogenase measured in a cuvette of 1 cm pathlength will be _____.

(Assume that the molar extinction coefficient values for Trp and Tyr apply to these amino acids in the yeast alcohol dehydrogenase).

54. The activity of lactate dehydrogenase can be measured by monitoring the following reaction:

Pyruvate + NADH ⟶ Lactate + NAD^+

The molar extinction coefficient of NADH at 340 nm is 6220 $M^{-1}.cm^{-1}$. NAD^+ does not absorb at this wavelength. In an assay, 25 μL of a sample of enzyme (containing 5 μg protein per mL) was added to a mixture of pyruvate and NADH to give a total volume of 3 mL in a cuvette of 1 cm pathlength. The rate of decrease in absorbance at 340 nm was 0.14 min^{-1}. The specific activity of the enzyme will be _____ μmol.min^{-1}.mg^{-1}.

55. Analysis of a hexapeptide using enzymatic cleavage reveals the following result:

- Amino acid composition of the peptide is: 2R, A,V, S, Y.
- Trypsin digestion yields two fragments and the compositions are: (R, A, V) and (R, S, Y).
- Chymotrypsin digestion yields two fragments and the compositions are: (A, R, V, Y) and (R, S)
- Digestion with carboxypeptidase A yields no cleavage product.

Given: Trypsin cleaves at carboxyl side of R.

Chymotrypsin cleaves at carboxyl side of Y.

Carboxypeptidase A cleaves at amino side of the C-terminal amino acid (except R and K) of the peptide.

The *correct* amino acid sequence of the peptide is

a. RSYRVA
b. AVRYSR
c. SRYVAR
d. SVRRYA

56. The empirical formula for biomass of an unknown organism is $CH_{1.8}O_{0.5}N_{0.2}$. To grow this organism, ethanol (C_2H_5OH) and ammonia are used as carbon and nitrogen sources, respectively. Assume no product formation other than biomass. To produce 1 mole of biomass from 1 mole of ethanol, the number of moles of oxygen required will be _____.

57. *Saccharomyces cerevisiae* is cultured in a chemostat (continuous fermentation) at a dilution rate of 0.5 h^{-1}. The feed substrate concentration is 10 g.L^{-1}. The biomass concentration in the chemostat at steady state will be _____ g.L^{-1}.

Assumptions: Feed is sterile, maintenance is negligible and maximum biomass yield with respect to substrate is 0.4 (g biomass per g ethanol).

Microbial growth kinetics is given by $\mu = \frac{\mu_m s}{K_s + s}$; where μ is specific growth rate (h^{-1}), μ_m = 0.7 h^{-1}, K_s = 0.3 g.L^{-1} and s is substrate concentration (g.L^{-1}).

58. Decimal reduction time of bacterial spores is 23 min at 121°C and the death kinetics follow first order. One liter medium containing 10^5 spores per mL was sterilized for 10 min at 121°C in a batch sterilizer. The number of spores in the medium after sterilization (assuming destruction of spores in heating and cooling period is negligible) will be _____ × 10^7.

59. A bioreactor is scaled up based on equal impeller tip speed. Consider the following parameters for small and large bioreactors:

Parameters	*Small bioreactor*	*Large bioreactor*
Impeller speed	N_1	N_2
Diameter of impeller	D_1	D_2
Power consumption	P_1	P_2

Assuming geometrical similarity and the bioreactors are operated in turbulent regime, what will be P_2/P_1?

a. $(D_1/D_2)^2$ b. $(D_2/D_1)^2$

c. $(D_1/D_2)^5$ d. $(D_2/D_1)^5$

60. An enzyme converts substrate A to product B. At a given liquid feed stream of flow rate 25 $L.min^{-1}$ and feed substrate concentration of 2 $mol.L^{-1}$, the volume of continuous stirred tank reactor needed for 95% conversion will be _____ L.

Given the rate equation: $-r_A = \dfrac{0.1C_A}{1+0.5C_A}$

where $-r_A$ is the rate of reaction in $mol.L^{-1}.min^{-1}$ and C_A is the substrate concentration in $mol.L^{-1}$.

Assumptions: Enzyme concentration is constant and does not undergo any deactivation during the reaction.

61. A protein is to be purified using ion-exchange column chromatography. The relationship between HETP (Height Equivalent to Theoretical Plate) and the linear liquid velocity of mobile phase is given by:

$$H = \frac{A}{u} + Bu + C$$

where H is HETP (m) and *u* is linear liquid velocity of mobile phase ($m.s^{-1}$). The values of A, B and C are 3×10^{-8} $m^2.s^{-1}$, 3 s and 6×10^{-5} m, respectively. The number of theoretical plates based on *minimum* HETP for a column of 66 cm length will be _____.

62. An enzyme is immobilized on the surface of a non-porous spherical particle of 2 mm diameter. The immobilized enzyme is suspended in a solution having bulk substrate concentration of 10 mM. The enzyme follows first order kinetics with rate constant 10 s^{-1} and the external mass transfer coefficient is 1 $cm.s^{-1}$. Assume steady state condition wherein rate of enzyme reaction ($mmol.L^{-1}.s^{-1}$) at the surface is equal to mass transfer rate ($mmol.L^{-1}.s^{-1}$). The substrate concentration at the surface of the immobilized particle will be _____ mM.

63. $\dfrac{d^2y}{dx^2} - y = 0$. The initial conditions for this second order homogeneous differential equation are y(0) = 1 and dy/dx = 3 at x = 0. The value of y when x = 2 is _____.

64. The value of determinant A given below is _____.

$$A = \begin{pmatrix} 5 & 16 & 81 \\ 0 & 2 & 2 \\ 0 & 0 & 16 \end{pmatrix}$$

65. Consider the equation $V = \dfrac{aS}{b + S + \dfrac{S^2}{c}}$

Given a = 4, b = 1 and c = 9, the positive value of S at which V is maximum, will be _____.

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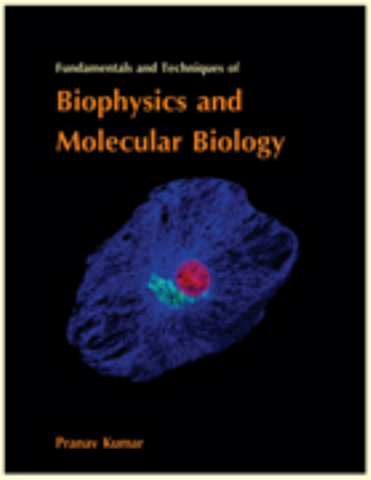

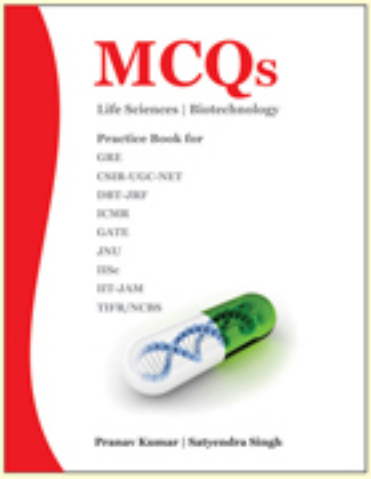

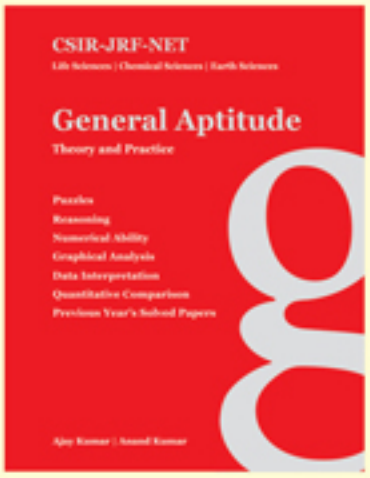

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