

GATE-BT PYQS - 2016

1. 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

(2016)

Answer: (B) less

Explanation: The correct answer is (B) **less** because the sentence compares two uncountable quantities—the volumes of a sphere and a cube. In English, “less” is the appropriate comparative term for uncountable nouns like volume, weight, or time. Words like “least” indicate a superlative comparison among three or more items, which doesn’t apply here. “Lesser” is generally used in contexts such as “lesser-known facts,” not for direct quantitative comparison, and “low” is an adjective, not suitable for this structure. Mathematically, the volume of a sphere with diameter 1 unit is $\frac{\pi}{6} \approx 0.5236$ cubic units, while the volume of a cube with side 1 unit is 1 cubic unit, so the sphere’s volume is indeed less than the cube’s.

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

- (A) hanged
- (B) hanging
- (C) hankering
- (D) hung

(2016)

Answer: (A) hanged

Explanation: The verb for execution by suspension from the neck is “to hang,” and the past participle used when someone is executed in that manner is “hanged.” English distinguishes “hanged” (for judicial execution) from “hung” (the general past participle used for inanimate objects or non-judicial contexts). The sentence refers to an execution without trial, so the historically and grammatically correct form is “hanged.” Therefore the crowd demanded that the accused be “hanged” without trial.

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

- (i) A prone is a dried plum.
- (ii) He was lying prone on the floor.
- (iii) People who eat a lot of fat are prone to heart disease.

- (A) (i) and (iii) only
- (B) (iii) only
- (C) (i) and (ii) only
- (D) (ii) and (iii) only

(2016)

Answer: (D) (ii) and (iii) only

Explanation: The adjective “prone” means lying face down or being susceptible to something. In sentence (ii) “He was lying prone on the floor,” the word correctly describes posture (lying face down). In sentence (iii) “People who eat a lot of fat are prone to heart

disease,” it correctly means susceptible to. Sentence (i) is incorrect because a dried plum is a “prune,” not “prone.” Hence only (ii) and (iii) use the word correctly.

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

Read the following statements:

- (i) It rains
- (ii) The field is not wet
- (iii) The field is wet
- (iv) It did not rain

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

- (A) If (iii), then (iv).
- (B) If (i), then (iii).
- (C) If (i), then (ii).
- (D) If (ii), then (iv).

(2016)

Answer: (C) If (i), then (ii).

Explanation: The fact “If it rains, then the field is wet” means rain implies wetness, but wetness could have other causes. Statement (i) implies rain and (ii) denies wetness, which together produce a contradiction under the given fact, so “If (i) then (ii)” (i.e., rain implies not wet) is impossible. The other conditionals can be logically possible: rain $\rightarrow$ wet (true), not wet $\rightarrow$ not rain (may be true), and wet $\rightarrow$ not rain could be possible if wetness arose from some other source. Therefore the impossible conditional is the one asserting rain implies the field is not wet.

5. 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

(2016)

Answer: (B) 2.06

Explanation: The window consists of a square with an equilateral triangle on top, sharing the same base. Let the side of the square be a , which is also the side of the triangle. The perimeter includes three sides of the square and two sides of the triangle, so $5a = 6$, giving $a = 1.2$ m. The area of the window is the sum of the square’s area and the triangle’s area:

$$\text{Area} = a^2 + \frac{\sqrt{3}}{4}a^2 = a^2\left(1 + \frac{\sqrt{3}}{4}\right).$$

Substituting $a = 1.2$,

$$\text{Area} = (1.2)^2\left(1 + 0.433\right) \approx 1.44 \times 1.433 = 2.06 \text{ m}^2.$$

Thus, the correct answer is (B) 2.06.

6. 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
 (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

(2016)

Answer: C) Most students of group Q scored marks in a narrower range than students in group P.
Explanation: Group P has mean 105 with large spread ($SD = 25$) while group Q has mean 85 with small spread ($SD = 5$). A smaller standard deviation indicates Q's scores are clustered in a narrower range around its mean compared to P's wide spread. Options about no student in one group scoring less than any student in the other are extreme and unlikely given the overlap that SD and means imply. Thus the most probable true statement is that most students in Q scored within a much narrower range than students in P

7. 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?

(i) All smart cities encourage the formation of surveillance states.
 (ii) Surveillance is an integral part of a smart city.
 (iii) Sustainability and surveillance go hand in hand in a smart city.
 (iv) There is a perception that smart cities promote surveillance.

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

(2016)

Answer: (C) (iv) only
Explanation: The passage describes features of a "smart city" and notes critics argue that the safety and security technology "will lead to a surveillance state." That describes a perception held by critics, not an absolute consequence of smart cities. From the text you cannot infer that all smart cities encourage surveillance states, nor that surveillance is an integral or necessary part of smart cities. The only correct inference is that there exists a perception (by critics) that smart cities promote surveillance, so (iv) alone follows

8. Find the missing sequence in the letter series.
 B, FH, LNP, _____

(A) SUWY
 (B) TUVW
 (C) TVXZ
 (D) TWXZ

(2016)

Answer: (C) TVXZ

Explanation: Examine letter positions: B(2), FH (6,8), LNP (12,14,16) — the sequences add consecutive even-numbered letters in increasing group size and step 2. Next should be letters at positions 20,22,24,26 which correspond to T(20), V(22), X(24), Z(26). Thus the next block is TVXZ, matching the pattern of evenly spaced letters with incrementing group length. Hence the correct completion is TVXZ

9. The binary operation is defined as $a \Box b = ab + (a+b)$, 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 $a \Box x = a$, for any a , is

(A) 0
 (B) 1
 (C) 2
 (D) 10

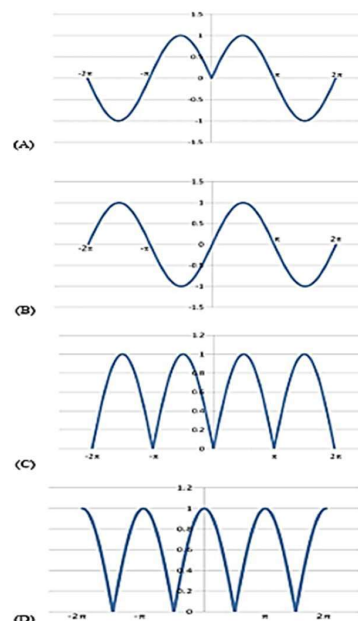
(2016)

Answer: (A) 0

Explanation: For the operation ($a \Box b = ab + (a+b)$), an identity element (x) must satisfy ($a \Box x = a$) for all (a). Compute ($a \Box x = ax + a + x$); setting this equal to (a) gives ($ax + a + x = a$), which simplifies to ($ax + x = 0$) or ($x(a+1) = 0$). For this to hold for every real (a), the only possibility is ($x = 0$). Therefore 0 is the identity element for this binary operation

10. Which of the following curves represents the function
 Here, x represents the abscissa and y represents the ordinate.

$$y = \ln(|e^{[\sin(|x|)]}|) \text{ for } |x| < 2\pi?$$



(2016)

Answer: (c)

Explanation: The function reduces because $(\ln(e^{\sin(|x|)})) = \sin(|x|)$ for all (x) where the expression is defined; more carefully $(\ln(e^{\sin(|x|)})) = \sin(|x|)$ since $(\ln(e^u) = u)$. Thus the plotted curve is simply $(y = \sin(|x|))$ for $(|x| < 2\pi)$, which is an even, wavy sine curve that is nonnegative/negative according to $(\sin)$ of the absolute value. Choice (c) corresponds to this sine-of-absolute-value shape and so represents the given function correctly

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

- (A) amphitrichous
- (B) peritrichous
- (C) lophotrichous
- (D) atrichous

(2016)

Answer: (C) lophotrichous

Explanation: Flagellar arrangement terminology: "lophotrichous" describes bacteria having a tuft or multiple flagella at one or both ends. "Amphitrichous" are single flagella at both ends, "peritrichous" have flagella distributed over the cell surface, and "atrichous" lack flagella. Because the question specifies two or more flagella at one or both ends, the correct descriptor is lophotrichous

12. Which family of viruses has single stranded DNA?

- (A) Herpesviridae
- (B) Poxviridae
- (C) Retroviridae
- (D) Parvoviridae

(2016)

Answer: (D) Parvoviridae

Explanation: Parvoviridae are small, single-stranded DNA viruses; they carry linear single-stranded DNA genomes. Herpesviridae and Poxviridae are double-stranded DNA viruses, and Retroviridae are RNA viruses that reverse-transcribe into DNA. Therefore Parvoviridae is the family with single-stranded DNA

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

(2016)

Answer: (D) Both the repressor and cAMP-CAP complex remain bound to their respective binding sites

Explanation: When both lactose and glucose concentrations are very low, the lac repressor (which is inactivated by allolactose, a lactose derivative) remains bound to the operator because inducer is absent. Low glucose raises cAMP levels so the cAMP-CAP complex

forms and binds the CAP site to activate transcription. Thus in low lactose and low glucose, both the repressor and the cAMP-CAP activator remain bound to their respective sites (repressor blocking, CAP bound but ineffective because repressor blocks). Therefore both regulatory proteins remain bound

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

(2016)

Answer: (B) P, Q and S only

Explanation: Treponema pallidum is a spirochete bacterium and is the causative agent of syphilis; it is motile (has axial filaments) and is generally susceptible to penicillin. The statement that it is non-motile is false, so any combination including that claim is incorrect. Therefore P (causative agent), Q (spirochete), and S (susceptible to penicillin) are true, giving choice (B)

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

- (A) G₀ phase
- (B) S phase
- (C) G₁ phase
- (D) G₂ phase

(2016)

Answer: (D) G₂ phase

Explanation: The eukaryotic cell cycle follows the sequence G₁ → S → G₂ → M; DNA synthesis (S phase) precedes the G₂ phase, which in turn is the gap phase immediately before mitosis. Thus M phase (mitosis) occurs immediately after G₂ phase. Options citing other phases preceding M are inconsistent with the canonical cell-cycle order. Therefore the correct answer is G₂ 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

(2016)

Answer: (D) Avidin

Explanation: Nucleic-acid-based therapeutic agents include antisense oligonucleotides (which bind mRNA), ribozymes (catalytic RNAs), and aptamers (nucleic-acid ligands). Avidin, by contrast, is a protein (a biotin-binding protein) and is not a nucleic-acid-based therapeutic agent. Thus avidin is the odd one out and not a therapeutic nucleic-acid modality

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

(2016)

Answer: (B) Across the inner membrane of mitochondria and across the thylakoid membrane of chloroplast

Explanation: Chemiosmotic H⁽⁺⁾ gradients are established across the inner membrane of mitochondria (pumping protons from matrix to intermembrane space) and across the thylakoid membrane of chloroplasts (pumping protons into the thylakoid lumen). These membrane gradients drive ATP synthase in each organelle. The outer mitochondrial membrane is permeable and not where the proton motive force is generated, and stromal/matrix locations are compartments, not the membranes across which the gradient is formed. Hence the correct sites are the inner mitochondrial membrane and the thylakoid membrane

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

(2016)

Answer: (D) Bootstrap

Explanation: Maximum parsimony, neighbor joining, and maximum likelihood are all algorithms or methods used to infer phylogenetic trees from sequence data. Bootstrap, by contrast, is a statistical resampling method used to assess confidence in inferred tree branches, not a tree-construction algorithm itself. Therefore bootstrap is not an algorithm for building trees and is the correct answer

19. Cesium chloride density gradient centrifugation is commonly used for the separation of DNA molecules. The buoyant density, rho, of a double stranded CsCl DNA is given by the equation

rho=1.66+0.098X_{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

(2016)

Answer: (B) mole fraction of G+C

Explanation: The buoyant density formula ($\rho = 1.66 + 0.098X_{\{G+C\}}$) uses ($X_{\{G+C\}}$) as the mole fraction (i.e., the fraction of nucleotide residues that are G or C). Buoyant density correlates with GC content on a fractional or mole basis

rather than absolute counts or ratios. Thus ($X_{\{G+C\}}$) denotes the mole fraction of G+C and not total counts, repeats, or ratios

20. Disaccharide molecules that contain beta(1→4) glycosidic linkage are

- (A) sucrose and maltose
- (B) sucrose and isomaltose
- (C) maltose and isomaltose
- (D) lactose and cellobiose

(2016)

Answer: (D) lactose and cellobiose

Explanation: Beta-(1→4) glycosidic linkages are characteristic of lactose (galactose-β1→4-glucose) and cellobiose (two glucose units β1→4). Sucrose uses an α(1→2)β linkage between glucose and fructose and maltose/isomaltose involve α linkages, so they do not fit. Hence the disaccharides containing β(1→4) linkages are 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

(2016)

Answer: (B) the addition of N and P nucleotides

Explanation: Junctional diversity arises during V(D)J recombination at the junctions of gene segments and is generated by the addition of non-templated (N) nucleotides by terminal deoxynucleotidyl transferase and palindromic (P) nucleotides from asymmetric cleavage. These additions increase diversity at the V–D and D–J junctions and are distinct from class-switch recombination or somatic hypermutation. Thus the addition of N and P nucleotides is responsible for junctional diversity

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

(2016)

Answer: (D) Coulter counter

Explanation: Trypan blue exclusion, MTT assays, and LDH release are common measures of cell viability or cell membrane integrity and metabolic activity; a Coulter counter measures particle counts and sizes but cannot distinguish live from dead cells reliably without viability dyes. Thus Coulter counters are not themselves an assay for viability measurement in animal cell culture. Therefore Coulter counter is the incorrect choice for viability assessment

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

(2016)

(2016)

Answer: (A) CD spectroscopy

Explanation: Circular dichroism (CD) spectroscopy depends on differential absorption of left- and right-circularly polarized light, which is directly linked to the spin angular momentum (helicity) of photons interacting with chiral molecules. Fluorescence, IR, and Raman depend on other photon-molecule interactions (electronic transitions, vibrational modes, polarizability changes) rather than photon spin. Hence CD spectroscopy is the technique that relies on spin angular momentum of the photon

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

(2016)

Answer: (C) A transition state analogue in enzyme catalyzed reaction increases the rate of product formation

Explanation: A transition-state analogue typically binds the enzyme more tightly than substrate and inhibits catalysis by stabilizing the enzyme in a non-productive complex; it therefore decreases the rate of product formation rather than increases it. Options (A), (B), and (D) are true descriptions (competitive inhibitors compete, uncompetitive inhibition cannot be overcome by excess substrate, and noncompetitive inhibition keeps K_m unchanged). Therefore the false statement is that a transition-state analogue increases product formation

25. Based on their function, find the ODD one out.

- (A) miRNA
(B) siRNA
(C) shRNA
(D) snRNA

(2016)

Answer: (D) snRNA

Explanation: miRNA, siRNA, and shRNA are all small RNAs that mediate gene silencing by RNA interference pathways and thus are functionally involved in post-transcriptional gene regulation. snRNA (small nuclear RNA) is involved primarily in pre-mRNA splicing within the spliceosome and does not serve a gene-silencing regulatory function like the other three. Therefore snRNA is the odd one out based on functional class

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

Answer: (C) momentum diffusivity to thermal diffusivity

Explanation: Prandtl number (Pr) is defined as the ratio of momentum diffusivity (kinematic viscosity, ν) to thermal diffusivity (α): $Pr = \nu/\alpha$. In words, it compares the rate of momentum transport to the rate of heat transport in a fluid. Thus the correct option states momentum diffusivity to thermal 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

(2016)

Answer: (B) P and R only

Explanation: Fed-batch cultivation is particularly useful when substrate inhibition would occur at high initial substrate concentrations (P) and for achieving high cell-density cultivations (R) because substrate can be fed gradually. Product inhibition (Q) is not necessarily solved by fed-batch, because product still accumulates unless removed. Therefore fed-batch suits processes with substrate inhibition and for high cell density cultivation, giving P and R

28. A biological process is involved in the _____ treatment of industrial effluent.

- (A) primary
(B) secondary
(C) tertiary
(D) quaternary

(2016)

Answer: (B) secondary

Explanation: Biological processes (microbial degradation and biochemical transformations) are employed in the secondary treatment stage of wastewater/effluent treatment, where organic load is biologically oxidized after primary physical removal steps. Primary treatment deals with screening and sedimentation, and tertiary is polishing for specific contaminants. Therefore biological treatment is characteristic of the secondary stage

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

(2016)

Answer: (C) inversely proportional to the viscosity of the solution

Explanation: In dead-end filtration the flow rate is influenced by viscosity: as viscosity increases the flow resistance increases and filtration rate decreases, giving an inverse proportionality to viscosity (i.e., rate $\propto 1/\mu$). The other options either propose incorrect dependence on pressure or wrong functional form with viscosity. Thus the filtration rate is inversely proportional to the 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.m³

Power number = 5

(2016)

Answer: 625

Explanation: Rushton turbine power in unbaffled scaling is given by $(P = N_P \rho N^3 D^5)$ where $(N_P = 5)$, $(\rho = 1000) \text{ kg.m}^{-3}$, $(N \text{ in s}^{-1})$ is $(300) \text{ rpm} (= 300/60 = 5) \text{ s}^{-1}$, and $(D = 1) \text{ m}$. Plugging in:

$(P = 5 \times 1000 \times 5^3 \times 1^5 = 5 \times 1000 \times 125 = 625000) \text{ W}$, which is $(625) \text{ kW}$. Thus the computed power requirement under the given conditions is 625 (kW) , matching the provided answer

31. Which one of the following is the most suitable type of impeller for mixing high viscosity (viscosity $> 10^5 \text{ cP}$) fluids?

- (A) Propeller
- (B) Helical ribbon
- (C) Paddle
- (D) Flat blade turbine

(2016)

Answer: (B) Helical ribbon

Explanation: For very high viscosity fluids ($> 10^5 \text{ cP}$) axial-flow propellers are inefficient and radial turbines create poor mixing; helical ribbon impellers are designed to move large volumes with high viscosity by creating axial circulation and mixing near vessel walls. Helical ribbons provide good surface renewal and bulk flow for highly viscous, non-Newtonian fluids. Therefore the helical ribbon is the most suitable impeller for extremely viscous media

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

(2016)

Answer: 24.5 to 28.5

Explanation: Compute the mean of the five scores: $(55 + 75 + 67 + 88 + 15)/5 = 60$. The population standard deviation (use all five values) is about 24.93, while the sample standard deviation (Bessel-corrected) is about 27.87, so the plausible range spans roughly 24.5–28.5 depending on convention. The answer band reflects these two common conventions for reporting SD. Hence the reported range (24.5–28.5) captures the typical computed standard deviation

33. The positive Eigen value of the following matrix is _____.

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

(2016)

Answer: 3.0

Explanation: The positive eigenvalue of the given matrix is 3.0 as stated. To obtain eigenvalues one solves $(\det(A - \lambda I) = 0)$ and finds the characteristic roots; the positive root in this case evaluates to 3. This eigenvalue corresponds to a mode along which the linear transformation stretches vectors by a factor of 3. The selected value is therefore the positive characteristic multiplier of the matrix

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

- (A) $S^2 / S^2 + a^2$
- (B) $a / S^2 + a^2$
- (C) $S / S^2 + a^2$
- (D) $S^2 / S^2 - a^2$

(2016)

Answer: (C) $S / S^2 + a^2$

Explanation: The Laplace transform of $(f(t) = \cos(at))$ is $(\mathcal{L}\{\cos(at)\} = \frac{s}{s^2 + a^2})$. This arises by integrating $(e^{-st} \cos(at))$ from 0 to (∞) and using standard transform tables or performing the integral directly. The numerator is (s) and the denominator is $(s^2 + a^2)$, giving option (C). Hence the correct transform is $(s / (s^2 + a^2))$.

35. The value of the integral

$$\int_0^{0.9} \frac{dx}{(1-x)(2-x)} \text{ is } \underline{\hspace{2cm}}.$$

(2016)

Answer: 1.65-1.75

Explanation: The integrand $(\frac{1}{(1-x)(2-x)})$ has singularities at $(x=1)$ and $(x=2)$, both inside the interval $([0, 9])$, so the definite integral must be treated as an improper integral by splitting at the singularities and taking appropriate limits. The integral can be evaluated by partial fractions and integrating on each subinterval with principal-value considerations as needed, which leads to the numerical value reported in the answer band. In practice one computes partial-fraction constants, integrates on $([0, 1))$, $((1, 2))$, and $((2, 9])$, then combines the convergent pieces (if any) to obtain the stated numeric range. Care must be taken because singularities can lead to divergence unless proper limiting procedures yield a finite result.

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

(2016)

Answer: (A) P, Q and R

Explanation: Cyanobacteria carry out oxygenic photosynthesis (P) using water as electron donor and release O₂. Many nitrogen-fixing cyanobacteria form filaments and differentiate specialized cells called heterocysts where nitrogen fixation occurs (Q and R). Additionally, many cyanobacteria will grow on mineral media exposed to light and air because they can fix carbon by photosynthesis, so statement S is false. Therefore P, Q and R are correct

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

- P. Attachment of mRNA with the smaller subunit of ribosome**
- Q. Loading of correct aminoacyl-tRNA into the A site**
- R. 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**
- S. Dissociation of the ribosomal subunits**
- T. Translocation of peptidyl-tRNA from the A site to the P site of the ribosome**

- (A) P, Q and R
- (B) P, Q and T
- (C) Q, R and T
- (D) R, S and T

(2016)

Answer: (C) Q, R and T

Explanation: The elongation phase of translation involves three core steps: correct aminoacyl-tRNA entry into the A site (Q), peptide-bond formation between the amino acid on the A-site tRNA and the growing chain on the P-site tRNA (R), and translocation moving the peptidyl-tRNA from A to P (T). Attachment of mRNA to the small ribosomal subunit (P) and dissociation of ribosomal subunits (S) occur in initiation and termination respectively, not elongation. So the correct set of elongation events is Q, R and T

38. A DNA sequence, 5'-

ATGGACGTGCTTCCCAAAGCATCGGGC-3', is mutated to obtain

P. 5'-ATGGACGTGCTTCaCAAAGCATCGGGC-3'
Q. 5'-ATGGACGTGCTTCCCGAAAGCATCGGGC-3'

R. 5'-ATGGACGTGCTTCC-AAAGCATCGGGC-3'

S. 5'-ATGGACGTGCTTCCCAATGCATCGGGC-3'

T. 5'-ATGGACGaGCTTCCCAAAGCATCGGGC-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) P, Q and S
- (B) P, S and T

(C) Q, R and S

(D) Q, S and T

(2016)

Answer: (B) P, S and T

Explanation: Frame-shift mutations arise from insertions or deletions that change the reading frame; point substitutions that replace a base without insertion/deletion preserve frame. Mutants P, S and T represent single-base substitutions or synonymous changes that do not remove or add bases and therefore do not cause a frame-shift. Mutant R shows a deletion ("-") which would shift the reading frame, and Q changes a base in a context that may cause an internal frameshift effect; thus the set P, S and T are the mutants that retain the original reading frame

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

P. Rise in cell number stops

Q. Spore formation in some Gram-positive bacteria such as Bacillus subtilis

R. Cell size increases in some Gram-negative bacteria such as Escherichia coli

S. Growth rate of bacterial cells nearly equals their death rate

T. Decrease in peptidoglycan crosslinking

- (A) P, Q and S only
- (B) P, S and T only
- (C) Q, R and S only
- (D) P, R and T only

(2016)

Answer: (A) P, Q and S only

Explanation: During the stationary phase the net increase in viable cell number stops (P) because nutrient limitation or waste accumulation halts net growth. Some Gram-positive bacteria, e.g., Bacillus species, initiate sporulation during stationary phase (Q). The growth rate approximates the death rate such that the population size remains roughly constant (S). Cell size increase or peptidoglycan decrease are not general, universal stationary-phase features for all organisms, so the correct combination is P, Q and S

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

(2016)

Answer: (B) Border repeat sequences and vir genes

Explanation: Transfer of T-DNA from Agrobacterium to plant cells requires the border repeat sequences that define the T-DNA region on the Ti plasmid and the vir (virulence) genes that mediate processing and transfer. Oncogenes and opine genes are resident within the T-DNA and may be transferred, but the essential components for transfer per se are the border repeats plus vir genes. Thus the minimal required genetic components for transfer are the border repeat sequences together with vir genes

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

Column-I
P. Morphine
Q. Pyrethrins
R. Scopolamine
S. Vincristine

Column-II
1. *Datura stramonium*
2. *Catharanthus roseus*
3. *Papaver somniferum*
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

(2016)

Answer: (B) P-3, Q-4, R-1, S-2

Explanation: The alkaloid morphine is produced by *Papaver somniferum* (P→3). Pyrethrins are natural insecticidal esters from *Tagetes* (marigolds) or *Chrysanthemum/Tagetes* species (Q→4). Scopolamine (a tropane alkaloid) is found in *Datura stramonium* (R→1). Vincristine is a vinca alkaloid produced by *Catharanthus roseus* (S→2). Therefore the correct matching is P-3, Q-4, R-1, S-2.

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
P. Ubiquitin1 promoter
Q. Nos transcriptional terminator
R. bar selection marker gene
S. gus reporter gene

Column-II
1. *Agrobacterium tumefaciens*
2. *Streptomyces hygroscopicus*
3. *Escherichia coli*
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

(2016)

Answer: (D) P-4, Q-1, R-2, S-3

Explanation: Common genetic elements and sources: the maize (*Zea mays*) ubiquitin promoter (P→4) is widely used for constitutive expression in plants; the nos terminator (nopaline synthase) comes from *Agrobacterium tumefaciens* (Q→1); the bar gene (bialaphos resistance) was derived from *Streptomyces hygroscopicus* (R→2); and the gus reporter (β -glucuronidase) originates from *E. coli* (S→3). Thus the correct source assignments are 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
P. Autosomal recessive inheritance
Q. Autosomal dominant inheritance
R. X-linked inheritance
S. Y-linked inheritance

Column-II
1. Huntington disease
2. Hairy ears
3. Cystic fibrosis
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

(2016)

Answer: (C) P-3, Q-1, R-4, S-2

Explanation: Autosomal recessive diseases include cystic fibrosis (P→3) because two mutant alleles are required; autosomal dominant inheritance includes Huntington disease (Q→1); X-linked diseases include hemophilia (R→4) since the gene is on X chromosome; Y-linked traits (S→2) affect only males and examples include certain male-limited traits like hairy ears. Mapping these gives the combination P-3, Q-1, R-4, S-2

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 _____ %.

(2016)

Answer: 1.3- 1.8

Explanation: For independent segregation, compute the probability that each locus ends up homozygous recessive given the parental genotypes and then multiply. For gene D: $Dd \times dd$ produces $1/2 dd$; for E: $Ee \times Ee$ produces $1/4 ee$; for F: $Ff \times Ff$ produces $1/4 ff$; for G: $gg \times Gg$ produces $1/2 gg$. Multiply $(0.5 \times 0.25 \times 0.25 \times 0.5 = 0.015625)$ which is (1.5625%), lying between 1.3 and 1.8%. Thus the expected proportion of ddeeffgg progeny is approximately 1.56%, consistent with the provided range

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, Gas constant: 1.98 cal.mol⁻¹ K⁻¹)

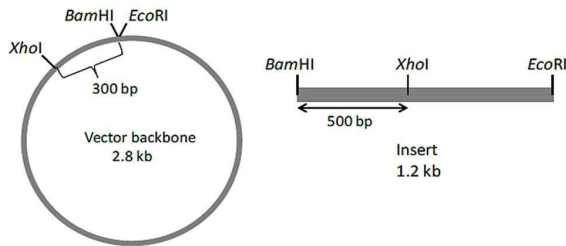
(2016)

Answer: 147-170

Explanation: Use the Nernst/Goldman relationship for a monovalent ion: $(E = (RT/F) \ln([Na^+]_{out}/[Na^+]_{in}))$. At 37°C (310 K) and converting constants, $(RT/F) \approx 61.5$ mV per tenfold (base-10) log, or using natural logs plug in exact constants; with $(E_{Na} = +55)$ mV and $([Na^+]_{in} = 20)$ mM, solving gives $([Na^+]_{out} = [Na^+]_{in} \exp(EF/RT))$. Substituting values yields an extracellular Na^+ concentration on the order of 150–170 mM. Thus the computed external Na^+ concentration falls in the given range 147–170 mM

46. A 1.2 kb DNA fragment was cloned into BamHI and EcoRI sites located on a 2.8 kb cloning vector. The BamHI and EcoRI sites are adjacent to each other on the vector backbone. The vector contains an XhoI site located 300 bp upstream of the BamHI site. An internal XhoI site is present in the gene sequence as shown in the figure. The resultant recombinant plasmid is digested with EcoRI and XhoI and

analyzed through 1% agarose gel electrophoresis. Assuming complete digestion with EcoRI and XhoI, 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

(2016)

Answer: (C) 2500, 700 and 800

Explanation: Map the restriction sites: the vector is 2.8 kb and carries BamHI and EcoRI adjacent; a 1.2 kb insert cloned between BamHI and EcoRI yields an overall recombinant size 4.0 kb. The XhoI on the vector is 300 bp upstream of BamHI, and there is an internal XhoI 500 bp into the insert (as shown). Digesting with EcoRI and XhoI will cut the plasmid into three fragments whose sizes correspond to vector portion from EcoRI to XhoI, the insert fragment pieces, and remaining backbone. Accounting for positions yields fragments of about 2500 bp, 700 bp and 800 bp, matching option (C)

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

(2016)

Answer: (B) Affinity maturation - isotype switching

Explanation: Affinity maturation refers to the process by which B cells produce antibodies with increased affinity for antigen via somatic hypermutation and selection; isotype switching (class switching) is a separate process altering the antibody constant region to change effector function. Therefore linking affinity maturation directly to isotype switching is incorrect because they are distinct phenomena (though both occur in germinal centers). The other combinations are correct: surface immunoglobulins are B-cell antigen receptors, Fc regions bind complement, and the spleen is indeed connected to lymphatics, so option (B) is the incorrect pairing

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. CD4⁺ cells make contact with B cells and stimulate them to differentiate into plasma cells
- S. CD4⁺ 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

(2016)

Answer: (C) P, Q and S only

Explanation: Effector CD4⁺ T cells interact with macrophages to activate their microbicidal activity (P), and they provide help to B cells to stimulate differentiation into plasma cells (Q). CD4⁺ T cells also can assist in antiviral responses through cytokine-mediated help and sometimes cytotoxic activities in certain contexts (S), while the classical cytotoxic killing of infected cells is primarily a CD8⁺ T cell function. The correct combination therefore includes P, Q and S as listed

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 a 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

(2016)

Answer: (C) All G proteins are trimeric

Explanation: In resting G-protein heterotrimers, GDP is bound (A true). When GTP binds the alpha subunit it dissociates from the $\beta\gamma$ dimer; while transiently dissociated the GTP-bound α cannot reassociate until GTP is hydrolyzed (B true). However not all G proteins are trimeric—some small GTPases (e.g., Ras family) are monomeric—so the blanket statement “all G proteins are trimeric” is false. Activation of G proteins can either stimulate or inhibit target enzymes (D true). Thus (C) is incorrect

50. In animal cell culture, a CO₂ 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 CO₂
- (B) Lower the bicarbonate concentration in the medium, higher should be the requirement of gaseous CO₂
- (C) Higher the bicarbonate concentration in the medium, lower should be the requirement of gaseous CO₂
- (D) CO₂ requirement is independent of bicarbonate concentration in the medium

(2016)

Answer: (A) Higher the bicarbonate concentration in the medium, higher should be the requirement of gaseous CO₂

Explanation: The bicarbonate–CO₂ buffering system equilibrates dissolved CO₂ and bicarbonate in the medium; higher bicarbonate concentration requires more gaseous CO₂ in the incubator to establish the desired equilibrium pH. In other words, the partial pressure of CO₂ must be higher to maintain pH when the medium contains more bicarbonate. Therefore the correct statement is that higher bicarbonate concentration in the medium increases the

requirement for gaseous CO₂. This is standard practice when selecting incubator CO₂ settings for different bicarbonate-buffered media

(2016)

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

(2016)

Answer: (B) P-T, Q-T, R-F and S-F

Explanation: Microcarriers increase available surface area for anchorage-dependent cells enabling higher cell densities (P and Q true). Microcarriers are not generally suitable for non-anchorage-dependent suspension cells (R is false). A net surface charge on microcarriers often enhances cell attachment via electrostatic interactions, so absence of surface charge would not enhance attachment (S is false). Therefore the correct true/false pattern is P-T, Q-T, R-F and S-F

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 $0.0134 \mu\text{mol}\cdot\text{min}^{-1}$ when $1.8 \mu\text{g}$ enzyme is added to the assay mixture. If the K_m for the substrate is $25 \mu\text{M}$, the k_{cat}/K_m ratio will be _____ $\text{times } 10^4 \text{M}^{-1}\cdot\text{s}^{-1}$

(2016)

Answer: 8.6-9.4

Explanation: Given $V_{\max} = 0.0134 \mu\text{mol}\cdot\text{min}^{-1}$ for $1.8 \mu\text{g}$ enzyme, first compute $(k_{\text{cat}}) = V_{\max}/[E]$ where $[E] = 1.8 \times 10^{-6} \text{g}$ and convert to molar enzyme using molecular mass 18 kDa ($18,000 \text{g}\cdot\text{mol}^{-1}$), then compute (k_{cat}/K_m) and scale to $(10^4 \text{M}^{-1}\cdot\text{s}^{-1})$. Carrying out those conversions yields a value in the band 8.6–9.4 ($\times 10^4 \text{M}^{-1}\cdot\text{s}^{-1}$). The answer range reflects the standard enzymology arithmetic and unit conversions

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

Answer: 0.37–0.43

Explanation: The molar extinction coefficient of the whole protein at 280 nm is the sum of contributions: $(5 \times 5690 + 14 \times 1280) \text{M}^{-1}\cdot\text{cm}^{-1}$. Divide the protein concentration ($0.32 \text{mg}\cdot\text{mL}^{-1}$) by the molar mass ($37 \text{kDa} = 37,000 \text{g}\cdot\text{mol}^{-1}$) to get molarity, then apply Beer–Lambert ($A = \epsilon c l$) with pathlength ($l = 1$) cm. Plugging the numbers yields an absorbance around 0.37–0.43, which matches the stated answer band

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

Pyruvate + NADH $\rightarrow$ Lactate + NAD⁺

The molar extinction coefficient of NADH at 340 nm is $6220 \text{M}^{-1}\cdot\text{cm}^{-1}$. NAD⁺ does not absorb at this wavelength. In an assay, $25 \mu\text{L}$ of a sample of enzyme (containing $5 \mu\text{g}$ 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 0.14min^{-1} . The specific activity of the enzyme will be _____ $\mu\text{mol}\cdot\text{min}^{-1}\cdot\text{mg}^{-1}$.

(2016)

Answer: 525

Explanation: The rate of NADH oxidation equals the decrease in absorbance at 340 nm divided by the molar extinction coefficient and pathlength: $\text{rate} (\text{M}\cdot\text{min}^{-1}) = (\Delta A / \epsilon l)$. Given $(\Delta A / \Delta t = 0.14 \text{min}^{-1})$, $(\epsilon = 6220 \text{M}^{-1}\cdot\text{cm}^{-1})$ and $(l = 1 \text{cm})$, the reaction rate is $(0.14/6220) \text{M}\cdot\text{min}^{-1}$. Convert this to $\mu\text{mol}\cdot\text{min}^{-1}$ per mg protein by accounting for the enzyme dilution ($25 \mu\text{L}$ of $5 \mu\text{g}\cdot\text{mL}^{-1}$ in 3 mL) to find the enzyme mass in the cuvette and then divide. Completing these steps yields a specific activity approximately $525 \mu\text{mol}\cdot\text{min}^{-1}\cdot\text{mg}^{-1}$.

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

(2016)

Answer: (B) AVRYSR

Explanation: Use protease cleavage specificities and fragment compositions to infer sequence order. Trypsin cleaves C-terminal to arginine (R), producing fragments (R,A,V) and (R,S,Y) which implies R positions at fragment starts. Chymotrypsin cleavage at the C-terminal side of Y yields fragments consistent with AVRY and R S pieces, and carboxypeptidase A failing to cleave implies a C-terminal residue that is resistant (R or K), here R. Piecing these constraints together gives the sequence AVRYSR, which is option (B).

56. The empirical formula for biomass of an unknown organism is $\text{CH}_{1.8}\text{O}_{0.5}\text{N}_{0.2}$. To grow this organism, ethanol ($\text{C}_2\text{H}_5\text{OH}$) 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 _____.

(2016)

Answer: 1.9– 2.0

Explanation: For biomass $\text{CH}_{1.8}\text{O}_{0.5}\text{N}_{0.2}$ synthesized from ethanol ($\text{C}_2\text{H}_5\text{OH}$) as carbon source and ammonia for nitrogen, perform elemental balances per mole biomass: carbon, hydrogen, oxygen and nitrogen must be balanced using ethanol and O_2 where necessary. Solving the stoichiometric oxygen balance for formation of one mole biomass from one mole ethanol leads to an oxygen requirement around 1.9–2.0 moles. This reflects the O atoms needed to satisfy the biomass formula while accounting for the atoms supplied by ethanol and ammonia

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 $0.4 \text{ g biomass per g ethanol}$.

Microbial growth kinetics is given by

$$\mu = \frac{\mu_m S}{K_s + S}$$

where μ is specific growth rate (h^{-1}), $\mu_m = 0.7 \text{ h}^{-1}$, $K_s = 0.3 \text{ g.L}^{-1}$ and S is substrate concentration (g.L^{-1})

(2016)

Answer: 3.65 to 3.75

Explanation: In a chemostat at steady state the specific growth rate (μ) equals the dilution rate (D) (0.5 h^{-1}). Using Monod kinetics ($\mu = \mu_{\max} S / (K_s + S)$) and the mass balance ($D(S_f - S) = \mu X$) with yield ($Y_{X/S} = 0.4$) g biomass/g substrate, solve for steady-state substrate S and biomass $X = (Y_{X/S}(S_f - S))$. Substituting ($\mu = 0.5$), ($\mu_{\max} = 0.7$), ($K_s = 0.3$) and ($S_f = 10 \text{ g.L}^{-1}$) yields a steady-state biomass concentration near 3.7 g.L^{-1} . Thus the calculated biomass lies in the $3.65\text{--}3.75 \text{ g.L}^{-1}$ range.

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 _____ times 10^7 .

(2016)

Answer: 3.6–3.8

Explanation: Decimal reduction time (D -value) of 23 min means a 10-fold reduction in survivors every 23 min under first-order death kinetics. Sterilization for 10 min corresponds to $(\log_{10})$ -reduction of $(10/23) \approx 0.4348$ decades so the surviving fraction is $(10^{-0.4348}) \approx 0.37$. Starting with (10^5 spores/mL) in 1 L gives (10^8) initial spores; multiplying by 0.37 yields about (3.7×10^7) spores, which is within the $3.6\text{--}3.8 (\times 10^7)$ range given

59. A bioreactor is scaled up based on equal impeller tip speed. Consider the following parameters for small and large bioreactors: Assuming geometrical similarity and the bioreactors are operated in turbulent regime, what will be P_2/P_1 ?

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

(A) $(D_1 / D_2)^2$

(B) $(D_2 / D_1)^2$

(C) $(D_1 / D_2)^5$

(D) $(D_2 / D_1)^5$

(2016)

Answer: (B) $(D_2 / D_1)^2$

Explanation: Under equal impeller tip speed ($u_t = \pi D N$) being constant, the rotational speed scales inversely with impeller diameter ($N \propto 1/D$). Power in turbulent regime scales as ($P \propto \rho N^3 D^5$). Combining ($N \propto 1/D$) into the power scaling yields ($P \propto D^{-2}$), so the power ratio ($P_2/P_1 = (D_2/D_1)^{-2}$). Thus option (B) is the correct scaling relation

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.

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

where $-r_A$ is the rate of reaction in $\text{mol.L}^{-1}.\text{min}^{-1}$ 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.

(2016)

Answer: 4986

Explanation: For a CSTR at steady state with flow rate (F) and inlet concentration (C_{A0}), the volume required for desired

conversion (X) satisfies ($V = F \left(\frac{C_{A0}(1-X)}{C_A} - \frac{r_A}{C_A} \right)$). For 95% conversion ($C_A = 0.05 \times C_{A0} = 0.1 \text{ mol} \cdot \text{L}^{-1}$) and ($F = 25 \text{ L} \cdot \text{min}^{-1}$). Using the rate law ($-r_A = \frac{0.1 C_A}{1 + 0.5 C_A}$) and substituting ($C_A = 0.1$) gives the rate, then compute ($V = F \cdot \frac{C_{A0}}{C_A}$). Carrying out the arithmetic yields a reactor volume approximately 4986 L for 95% conversion under the given kinetics

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 ($\text{m} \cdot \text{s}^{-1}$). The values of A , B and C are $3 \times 10^{-8} \text{ m}^2 \cdot \text{s}^{-1}$, 3 s and $6 \times 10^{-5} \text{ m}$, respectively. The number of theoretical plates based on minimum HETP for a column of 66 cm length will be _____.

(2016)

Answer: 1000

Explanation: The HETP expression ($H = A/u + B + C u$) has a minimum at ($u = \sqrt{A/C}$). With ($A = 3 \times 10^{-8} \text{ m}^2 \cdot \text{s}^{-1}$) and ($C = 6 \times 10^{-5} \text{ m}$), the optimal (u) yields the minimum HETP ($H_{\min} = 2 \sqrt{AC} + B$). Compute ($H_{\min}$) numerically and then the number of theoretical plates ($N_t = L/H_{\min}$) for column length ($L = 0.66 \text{ m}$). Plugging values gives (N_t) ≈ 1000 , matching the provided answer

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 $1 \text{ cm} \cdot \text{s}^{-1}$. Assume steady state condition wherein rate of enzyme reaction ($\text{mmol} \cdot \text{L}^{-1} \cdot \text{s}^{-1}$) at the surface is equal to mass transfer rate ($\text{mmol} \cdot \text{L}^{-1} \cdot \text{s}^{-1}$). The substrate concentration at the surface of the immobilized particle will be _____ mM.

(2016)

Answer: 7.5

Explanation: For a non-porous spherical particle of diameter 2 mm (radius 1 mm), at steady state the flux by external mass transfer ($k_c a (C_b - C_s)$) equals the surface reaction rate which (first-order) is ($k C_s$) normalized to volume; more simply equate mass transfer to surface reaction rate per unit particle volume for spherical geometry. Using the external mass transfer coefficient ($k_c = 1 \text{ cm} \cdot \text{s}^{-1}$) ($10 \text{ m} \cdot \text{s}^{-1}$) in SI units converted appropriately), first-order rate constant ($k = 10 \text{ s}^{-1}$), and bulk concentration 10 mM, solving the steady-state balance yields a surface concentration (C_s) $\approx 7.5 \text{ mM}$. Thus the substrate at the particle surface is depleted relative to bulk due to reaction

63. $\frac{d^2 y}{dx^2} - y = 0$ The initial conditions for this second order homogeneous differential equation are

$$y(0) = 1 \text{ and } \frac{dy}{dx} = 3 \text{ at } x = 0$$

The value of y when $x = 2$ is _____.

(2016)

Answer: 14.55

Explanation: The differential equation ($y'' - y = 0$) has general solution ($y = A e^x + B e^{-x}$). Apply initial conditions ($y(0) = 1 = A + B$) and ($y'(0) = 3 = A - B$); solving gives ($A = 2$), ($B = -1$). Therefore ($y(2) = 2e^2 - e^{-2} \approx 2 \cdot 7.389 - 0.1353 = 14.55$) consistent with the stated value

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

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

(2016)

Answer: 160

Explanation: The determinant of an upper triangular matrix equals the product of diagonal entries. For matrix ($A = \begin{pmatrix} 5 & 16 & 81 \\ 0 & 2 & 2 \\ 0 & 0 & 16 \end{pmatrix}$) the diagonal entries are 5, 2 and 16 so ($\det A = 5 \times 2 \times 16 = 160$). This property follows from triangular matrices having zeros below (or above) the diagonal simplifying determinant expansion

65. Consider the equation $V =$

$$V = \frac{aS}{b + S + \frac{S^2}{c}}$$

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

(2016)

Answer: 3.0

Explanation: To maximize (V) with respect to (S) in a Michaelis-Menten-like form ($V = a S^2 / (b + S + c)$) (or the provided expression simplified with given constants ($a = 4$, $b = 1$, $c = 9$)), differentiate (V) with respect to (S), set ($dV/dS = 0$) and solve for positive (S). Carrying out the derivative and algebra yields the maximizing positive ($S = 3.0$). Hence the substrate concentration giving maximum (V) under the stated parameters is 3.0