

GATE 2024 Biotechnology(BT) Question Paper with Solution

Time Allowed :3 Hours	Maximum Marks :100	Total Questions :65
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Quick Tip

Read the following instructions very carefully and strictly follow them:

1. The GATE Exam will be structured with a total of 100 marks.
2. The exam mode is Online CBT (Computer Based Test)
3. The total duration of Exam is 3 Hours.
4. It will include 65 questions , divided in 3 sections.
5. Section 1 : General Aptitude.
6. Section 2 : Engineering Mathematics.
7. Section 3 : Subject Based Questions.
8. The marking scheme is as such : 1 and 2 marks Questions. Each correct answer will carry marks as specified in the question paper. Incorrect answers may carry negative marks, as indicated in the question paper.
9. Question Types: The exam will include a mix of Multiple Choice Questions (MCQs), Multiple Select Questions (MSQs), and Numerical Answer Type (NAT). questions.

GENERAL APTITUDE(GA)

Question 1-5 carry one mark each

1. If '→' denotes increasing order of intensity, then the meaning of the words [dry → arid → parched] is analogous to [diet → fast → ____]. Which one of the given options is appropriate to fill the blank?

- (A) starve
- (B) reject
- (C) feast
- (D) deny

Correct Answer: (A) starve

Solution: The relationship described in the first analogy is based on increasing intensity:

dry → arid → parched.

This progression moves from mild dryness (dry) to extreme dryness (parched). Similarly, in the second analogy:

diet → fast → _____.

Step 1: Analyze the terms.

"Diet" refers to controlled eating, "fast" indicates abstaining from food for a period, and the next step, representing extreme intensity, would be "starve," meaning complete deprivation of food.

Step 2: Eliminate incorrect options.

(1) "reject" and (4) "deny" do not align with the progression of increasing food deprivation.

(2) "feast" represents the opposite context of eating. Hence, (1) "starve" fits the progression.

Final Answer:

starve

Quick Tip

When solving analogy questions, focus on the nature and progression of relationships in terms of intensity, opposites, or categorization. Identify patterns in the first set to deduce the correct answer in the second set.

2. If two distinct non-zero real variables x and y are such that $(x + y)$ is proportional to $(x - y)$, then the value of $\frac{x}{y}$:

- (A) depends on xy
- (B) depends only on x and not on y
- (C) depends only on y and not on x
- (D) is a constant

Correct Answer: (D) is a constant

Solution: The given condition states that:

$$(x + y) \propto (x - y).$$

Let the proportionality constant be k , so:

$$x + y = k(x - y).$$

Step 1: Simplify the equation. Expanding and rearranging:

$$x + y = kx - ky.$$

$$x - kx = -ky - y.$$

$$x(1 - k) = -y(1 + k).$$

Step 2: Express $\frac{x}{y}$. Dividing both sides by $y(1 - k)$:

$$\frac{x}{y} = \frac{-(1 + k)}{1 - k}.$$

Step 3: Analyze the result. The value of $\frac{x}{y}$ is a function of the constant k and does not depend on the specific values of x and y . Hence, $\frac{x}{y}$ is a constant.

Final Answer:

is a constant

Quick Tip

When dealing with proportional relationships, always express the variables in terms of the proportionality constant. This often simplifies the problem and helps identify constants or dependencies.

3. Consider the following sample of numbers: 9, 18, 11, 14, 15, 17, 10, 69, 11, 13. The median of the sample is:

- (A) 13.5
- (B) 14
- (C) 11
- (D) 18.7

Correct Answer: (A) 13.5

Solution: The median is the middle value of a data set when arranged in ascending order. For an even number of observations, it is the average of the two middle values.

Step 1: Arrange the data in ascending order. The given numbers are:

9, 18, 11, 14, 15, 17, 10, 69, 11, 13.

Arranging in ascending order:

9, 10, 11, 11, 13, 14, 15, 17, 18, 69.

Step 2: Identify the middle values. Since there are 10 observations (even number), the two middle values are the 5th and 6th values:

13 and 14.

Step 3: Calculate the median. The median is the average of the two middle values:

$$\text{Median} = \frac{13 + 14}{2} = 13.5.$$

Final Answer:

13.5

Quick Tip

To find the median of a dataset:

- Arrange the numbers in ascending order.
- For an odd number of observations, choose the middle value.
- For an even number of observations, calculate the average of the two middle values.

4. The number of coins of 1, 5, and 10 denominations that a person has are in the ratio 5:3:13. Of the total amount, the percentage of money in 5 coins is:

- (A) 21%
(B) $14\frac{2}{7}\%$
(C) 10%
(D) 30%

Correct Answer: (C) 10%

Solution:

The total amount of money is calculated based on the given ratio of coins and their denominations.

Step 1: Represent the number of coins in terms of a variable. Let the number of coins of 1, 5, and 10 denominations be $5x$, $3x$, and $13x$, respectively.

Step 2: Calculate the total amount for each denomination.

$$\text{Amount in 1 coins} = 5x \cdot 1 = 5x.$$

$$\text{Amount in 5 coins} = 3x \cdot 5 = 15x.$$

$$\text{Amount in 10 coins} = 13x \cdot 10 = 130x.$$

Step 3: Calculate the total amount. The total amount is:

$$\text{Total Amount} = 5x + 15x + 130x = 150x.$$

Step 4: Calculate the percentage of money in 5 coins. The percentage of money in 5 coins is:

$$\text{Percentage} = \frac{\text{Amount in 5 coins}}{\text{Total Amount}} \cdot 100.$$

Substitute the values:

$$\text{Percentage} = \frac{15x}{150x} \cdot 100 = 10\%.$$

Final Answer:

10%

Quick Tip

When calculating percentages in ratio-based problems:

- Represent the quantities in terms of a variable.
- Compute the total and individual contributions to the total.
- Use the percentage formula: $\frac{\text{Part}}{\text{Total}} \cdot 100$.

5. For positive non-zero real variables p and q , if

$$\log(p^2 + q^2) = \log p + \log q + 2 \log 3,$$

then the value of $\frac{p^4 + q^4}{p^2 q^2}$ is:

- (A) 79
- (B) 81
- (C) 9
- (D) 83

Correct Answer: (A) 79

Solution:

Step 1: Expand the logarithmic equation. The given equation is:

$$\log(p^2 + q^2) = \log p + \log q + 2 \log 3.$$

Using the logarithmic properties:

$$\log(p^2 + q^2) = \log(pq) + \log 9.$$

This simplifies to:

$$\log(p^2 + q^2) = \log(9pq).$$

Step 2: Equating the arguments. Since the logarithmic functions are equal, their arguments must also be equal:

$$p^2 + q^2 = 9pq.$$

Step 3: Solve for $\frac{p^4+q^4}{p^2q^2}$. Using the given expression:

$$\frac{p^4 + q^4}{p^2q^2} = \frac{(p^2 + q^2)^2 - 2p^2q^2}{p^2q^2}.$$

Substitute $p^2 + q^2 = 9pq$:

$$\frac{p^4 + q^4}{p^2q^2} = \frac{(9pq)^2 - 2p^2q^2}{p^2q^2}.$$

Simplify:

$$\frac{p^4 + q^4}{p^2q^2} = \frac{81p^2q^2 - 2p^2q^2}{p^2q^2}.$$

$$\frac{p^4 + q^4}{p^2q^2} = \frac{79p^2q^2}{p^2q^2}.$$

$$\frac{p^4 + q^4}{p^2q^2} = 79.$$

Final Answer:

79

Quick Tip

When working with logarithmic equations:

- Use logarithmic properties to simplify terms.
- Equate the arguments of logarithms when their bases and values are equal.
- Substitute and simplify carefully for expressions involving powers and fractions.

Question 6-10 carry two marks each

6. In the given text, the blanks are numbered (i)–(iv). Select the best match for all the blanks.

Steve was advised to keep his head _____ (i) before heading _____ (ii) to bat; for, while he had a head _____ (iii) batting, he could only do so with a cool head _____ (iv) his shoulders.

- (A) (i) down (ii) down (iii) on (iv) for
(B) (i) on (ii) down (iii) for (iv) on
(C) (i) down (ii) out (iii) for (iv) on
(D) (i) on (ii) out (iii) on (iv) for

Correct Answer: (C) (i) down (ii) out (iii) for (iv) on

Solution:

The sentence requires appropriate prepositions and phrasal verbs that fit both the context and meaning:

Step 1: Analyze the blanks.

- Blank (i): "Steve was advised to keep his head _____." The phrase "keep his head down" is a common idiom meaning to remain calm or avoid attracting attention. Hence, (i) should be "down."
- Blank (ii): "before heading _____ to bat." The phrase "heading out to bat" is commonly used in cricket terminology. Hence, (ii) should be "out."
- Blank (iii): "for, while he had a head _____ batting." The phrase "had a head for batting" indicates an aptitude or skill. Hence, (iii) should be "for."
- Blank (iv): "he could only do so with a cool head _____ his shoulders." The correct phrase is "on his shoulders," which implies maintaining composure. Hence, (iv) should be "on."

Step 2: Verify the selected option. Option (C) matches all the blanks correctly:

(i) down, (ii) out, (iii) for, (iv) on.

Final Answer:

(C)

Quick Tip

When solving fill-in-the-blank questions:

- Pay attention to idioms, phrasal verbs, and collocations.
- Consider the context and overall meaning of the sentence to identify the correct options.

7. A rectangular paper sheet of dimensions $54 \text{ cm} \times 4 \text{ cm}$ is taken. The two longer edges of the sheet are joined together to create a cylindrical tube. A cube whose surface area is equal to the area of the sheet is also taken. Then, the ratio of the volume of the cylindrical tube to the volume of the cube is:

- (A) $\frac{1}{\pi}$
(B) $\frac{2}{\pi}$
(C) $\frac{3}{\pi}$
(D) $\frac{4}{\pi}$

Correct Answer: (A) $\frac{1}{\pi}$

Solution:

Step 1: Calculate the area of the paper sheet. The area of the rectangular sheet is:

$$\text{Area} = \text{Length} \times \text{Breadth} = 54 \text{ cm} \times 4 \text{ cm} = 216 \text{ cm}^2.$$

Step 2: Calculate the dimensions of the cylindrical tube. When the longer edges of the sheet are joined, the circumference of the base of the cylinder is 54 cm, and the height is 4 cm. The radius of the base is:

$$\text{Radius} = \frac{\text{Circumference}}{2\pi} = \frac{54}{2\pi} = \frac{27}{\pi} \text{ cm}.$$

The volume of the cylindrical tube is:

$$\text{Volume (Cylinder)} = \pi r^2 h = \pi \left(\frac{27}{\pi}\right)^2 \cdot 4 = \frac{216}{\pi} \text{ cm}^3.$$

Step 3: Calculate the volume of the cube. The surface area of the cube is equal to the area of the sheet, 216 cm^2 . The surface area of a cube is given by:

$$\text{Surface Area (Cube)} = 6a^2,$$

where a is the side length of the cube. Solving for a :

$$6a^2 = 216 \implies a^2 = 36 \implies a = 6 \text{ cm.}$$

The volume of the cube is:

$$\text{Volume (Cube)} = a^3 = 6^3 = 216 \text{ cm}^3.$$

Step 4: Calculate the ratio of the volumes. The ratio of the volume of the cylindrical tube to the volume of the cube is:

$$\text{Ratio} = \frac{\text{Volume (Cylinder)}}{\text{Volume (Cube)}} = \frac{\frac{216}{\pi}}{216} = \frac{216}{216\pi} = \frac{1}{\pi}.$$

Final Answer:

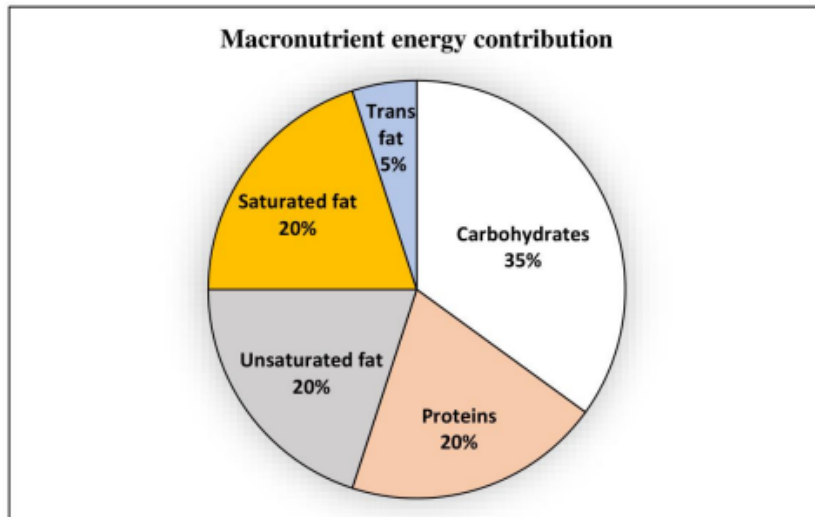
$$\boxed{\frac{1}{\pi}}$$

Quick Tip

When solving geometry problems involving shapes:

- Calculate areas and dimensions carefully when converting shapes.
- Use given surface area or volume relationships to determine unknown dimensions.
- For ratios, ensure units are consistent and simplify expressions as needed.

8. The pie chart presents the percentage contribution of different macronutrients to a typical 2,000 kcal diet of a person. The typical energy density (kcal/g) of these macronutrients is given in the table. The total fat (all three types), in grams, this person consumes is:



The typical energy density (kcal/g) of these macronutrients is given in the table.

Macronutrient	Energy density (kcal/g)
Carbohydrates	4
Proteins	4
Unsaturated fat	9
Saturated fat	9
Trans fat	9

The total fat (all three types), in grams, this person consumes is _____

- (A) 44.4
- (B) 77.8
- (C) 100
- (D) 3,600

Correct Answer: (C) 100

Solution:

The total daily caloric intake is 2,000 kcal. From the pie chart, the percentages of fats are:

- Unsaturated fat: 20%,
- Saturated fat: 20%,
- Trans fat: 5%.

The total fat percentage is:

$$\text{Total Fat} = 20\% + 20\% + 5\% = 45\%.$$

Step 1: Calculate the caloric contribution of fats. The total caloric contribution of fats is:

$$\text{Calories from Fat} = \frac{45}{100} \cdot 2,000 = 900 \text{ kcal}.$$

Step 2: Convert calories to grams. From the table, the energy density of fats (all types) is 9 kcal/g. The total fat in grams is:

$$\text{Total Fat (g)} = \frac{\text{Calories from Fat}}{\text{Energy Density}} = \frac{900}{9} = 100 \text{ g}.$$

Final Answer:

100

Quick Tip

To solve problems involving macronutrient contributions:

- Calculate the caloric contribution of each macronutrient based on its percentage.
- Use the energy density values to convert calories into grams.
- Ensure all percentages add up correctly for calculations involving multiple components.

9. A rectangular paper of $20 \text{ cm} \times 8 \text{ cm}$ is folded 3 times. Each fold is made along the line of symmetry, which is perpendicular to its long edge. The perimeter of the final folded sheet (in cm) is:

- (A) 18
- (B) 24

(C) 20

(D) 21

Correct Answer: (A) 18

Solution:

The dimensions of the rectangular paper are $20\text{ cm} \times 8\text{ cm}$. Each fold is along the line of symmetry, perpendicular to the long edge.

Step 1: Calculate the dimensions after each fold. After the first fold, the long edge is halved:

Dimensions after 1st fold: $10\text{ cm} \times 8\text{ cm}$.

After the second fold, the new long edge is halved again:

Dimensions after 2nd fold: $10\text{ cm} \times 4\text{ cm}$.

After the third fold, the new long edge is halved once more:

Dimensions after 3rd fold: $5\text{ cm} \times 4\text{ cm}$.

Step 2: Calculate the perimeter of the folded sheet. The perimeter of a rectangle is given by:

$$\text{Perimeter} = 2 \times (\text{Length} + \text{Breadth}).$$

Substitute the final dimensions:

$$\text{Perimeter} = 2 \times (5 + 4) = 2 \times 9 = 18\text{ cm}.$$

Final Answer:

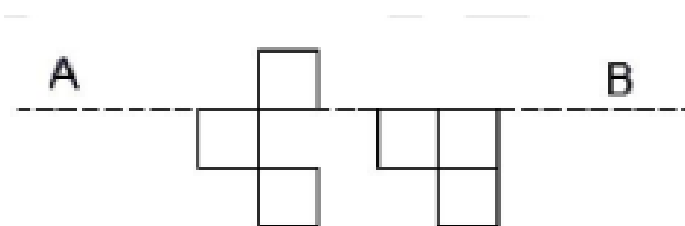
18

Quick Tip

When calculating the perimeter of folded shapes:

- Keep track of the changes in dimensions after each fold.
- Ensure that the folds are made along the specified axes or lines of symmetry.
- Use the formula for the perimeter of a rectangle: $2 \times (\text{Length} + \text{Breadth})$.

10. The least number of squares to be added in the figure to make AB a line of symmetry is:



- (A) 6
- (B) 4
- (C) 5
- (D) 7

Correct Answer: (A) 6

Solution:

To make AB a line of symmetry, the figure must be identical on both sides of the line AB . We need to analyze the asymmetry in the current arrangement and add the minimum number of squares required to balance the figure.

Step 1: Analyze the given figure. The figure currently has squares arranged asymmetrically across AB . To achieve symmetry:

- Identify the missing mirror-image squares for each part of the figure above and below AB .
- Count the number of additional squares required to complete the reflection.

Step 2: Count the squares to be added. Through visual analysis:

- The missing squares above AB and below AB collectively amount to 6 additional squares.
- These squares balance the figure and make AB a line of symmetry.

Final Answer:

6

Quick Tip

When solving symmetry-related problems:

- Identify the axis or line of symmetry and analyze the imbalance in the figure.
- Determine the minimum additions or modifications required to achieve symmetry.
- Visual inspection and systematic counting often help simplify the process.

Question 11-35 carry one mark each

11. In adsorption chromatography, the adsorption of uncharged solute molecules onto a silica-based stationary phase is by -----.

- (A) covalent bonds
- (B) electrostatic interactions
- (C) ionic bonds
- (D) van der Waals forces

Correct Answer: (D) van der Waals forces

Solution:

Adsorption chromatography involves the separation of molecules based on their interaction with the stationary phase. Silica, a common stationary phase, interacts with uncharged molecules through weak physical forces such as van der Waals forces.

Step 1: Identify the interaction mechanism. Silica-based stationary phases primarily rely on van der Waals forces for adsorption of uncharged molecules. These forces are weak intermolecular attractions that do not involve covalent or ionic bonding.

Step 2: Eliminate incorrect options.

- (A) Covalent bonds: These are strong chemical bonds, not involved in adsorption chromatography for uncharged molecules.
- (B) Electrostatic interactions: These are relevant for charged species, not uncharged molecules.
- (C) Ionic bonds: These are also related to charged species, not uncharged molecules.
- (D) van der Waals forces: Correct, as they govern the adsorption of uncharged molecules onto silica.

Final Answer:

van der Waals forces

Quick Tip

When solving adsorption chromatography questions:

- Determine the charge of the solute molecules to identify the interaction type.
- For uncharged molecules, van der Waals forces are the primary interaction.
- Electrostatic or ionic interactions typically occur with charged species.

12. The transfer function of a process is

$$G(s) = \frac{K_p}{\tau_p s + 1},$$

where K_p is the gain and τ_p is the time constant. This is a ----- process.

- (A) first order
- (B) multi-capacity
- (C) purely capacitive
- (D) second order

Correct Answer: (A) first order

Solution:

The given transfer function is:

$$G(s) = \frac{K_p}{\tau_p s + 1}.$$

Step 1: Identify the structure of the transfer function. The denominator of the transfer function is $\tau_p s + 1$, which is a first-order polynomial in s . A first-order process has a transfer function of the general form:

$$G(s) = \frac{K}{\tau s + 1},$$

where K is the gain, and τ is the time constant.

Step 2: Eliminate incorrect options.

- (A) First order: Correct, as the given transfer function matches the general form of a first-order system.

- (B) Multi-capacity: Incorrect, as multi-capacity processes involve higher-order transfer functions or multiple time constants.
- (C) Purely capacitive: Incorrect, as purely capacitive systems lack resistive components, which are present in this transfer function.
- (D) Second order: Incorrect, as a second-order process would have a quadratic term in the denominator.

Final Answer:

first order

Quick Tip

When identifying the order of a process:

- Examine the highest power of s in the denominator of the transfer function.
- First-order systems have a single time constant and a denominator of the form $\tau s + 1$.
- Higher-order systems involve quadratic or higher-degree terms in s .

13. Which one of the following statements is correct in the context of thermodynamics?

- (A) In a closed system, neither mass nor energy is transferred across the system boundary
- (B) In a closed system, both mass and energy can be transferred across the system boundary
- (C) The total energy of the system is the sum of kinetic and potential energies
- (D) In a closed system, only energy can be transferred across the system boundary and not mass

Correct Answer: (D) In a closed system, only energy can be transferred across the system boundary and not mass

Solution:

In thermodynamics, systems are classified based on the transfer of mass and energy across their boundaries. A closed system is defined as a system where:

- Energy (in the form of heat or work) can be transferred across the boundary.
- Mass cannot be transferred across the boundary.

Step 1: Analyze the options.

- (A) Incorrect: In a closed system, energy can be transferred, so the statement that "neither mass nor energy is transferred" is wrong.
- (B) Incorrect: Mass cannot be transferred in a closed system, so the statement that "both mass and energy can be transferred" is wrong.
- (C) Incorrect: While the total energy of a system can include kinetic and potential energy, this statement does not describe the defining feature of a closed system.
- (D) Correct: This accurately describes a closed system where only energy can cross the boundary but not mass.

Final Answer:

In a closed system, only energy can be transferred across the system boundary and not mass.

Quick Tip

To classify thermodynamic systems:

- Closed System: Only energy can cross the boundary, not mass.
- Open System: Both mass and energy can cross the boundary.
- Isolated System: Neither mass nor energy can cross the boundary.

14. Which one of the following statements is correct about Reynolds Number (N_{Re}) in a stirred tank bioreactor?

- (A) N_{Re} is independent of the viscosity of the medium
- (B) In laminar flow, mixing time increases with an increase in N_{Re}
- (C) N_{Re} is inversely proportional to the impeller speed
- (D) In turbulent flow, mixing time is independent of N_{Re}

Correct Answer: (D) In turbulent flow, mixing time is independent of N_{Re}

Solution:

The Reynolds Number (N_{Re}) is a dimensionless quantity that characterizes the flow regime (laminar or turbulent) in a fluid system. It is defined as:

$$N_{Re} = \frac{\rho ND^2}{\mu},$$

where:

- ρ is the density of the fluid,
- N is the impeller speed,
- D is the impeller diameter,
- μ is the viscosity of the fluid.

Step 1: Analyze the options.

- (A) Incorrect: N_{Re} depends on the viscosity μ , as seen in the formula.
- (B) Incorrect: In laminar flow, mixing time increases with a decrease in N_{Re} , not an increase.
- (C) Incorrect: N_{Re} is directly proportional to the impeller speed N , not inversely.
- (D) Correct: In turbulent flow, mixing time becomes independent of N_{Re} , as turbulence ensures uniform mixing regardless of further increases in N_{Re} .

Final Answer:

In turbulent flow, mixing time is independent of N_{Re} .

Quick Tip

To understand Reynolds Number (N_{Re}):

- It characterizes flow regimes: laminar ($N_{Re} < 2000$) or turbulent ($N_{Re} > 4000$).
- Turbulent flow leads to uniform mixing, making mixing time independent of N_{Re} .
- The dependence of N_{Re} on fluid properties and system parameters should always be considered.

15. The relationship that involves the exchange of nutrients between two different species for their mutual growth is called

- (A) antagonism
- (B) commensalism
- (C) parasitism
- (D) syntrophism

Correct Answer: (D) syntrophism

Solution:

Syntrophism is a biological interaction where two or more species exchange nutrients or metabolic products to facilitate mutual growth and survival. It is a cooperative relationship essential in ecosystems and bioreactors.

Step 1: Analyze the definitions.

- (A) Antagonism: Refers to a harmful interaction where one organism inhibits the growth of another. Not applicable here.
- (B) Commensalism: A relationship where one organism benefits while the other is unaffected. This does not involve mutual nutrient exchange.
- (C) Parasitism: A relationship where one organism benefits at the expense of the other. This is not mutual.
- (D) Syntrophism: The correct answer, as it involves mutual nutrient exchange for the benefit of both species.

Final Answer:

syntrophism

Quick Tip

Key ecological interactions:

- Syntrophism: Mutual nutrient exchange for mutual benefit.
- Commensalism: One organism benefits, the other is unaffected.
- Parasitism: One organism benefits at the expense of the other.
- Antagonism: One organism inhibits or harms the other.

16. Mendel's 'law of segregation' applies to the segregation of _____ during gamete formation.

- (A) mitochondrial genes
- (B) alleles of a gene
- (C) linked genes on the same chromosome
- (D) unlinked genes on the same chromosome

Correct Answer: (B) alleles of a gene

Solution:

Mendel's law of segregation states that the two alleles for a gene segregate during gamete formation, and each gamete receives only one allele. This law applies specifically to alleles of the same gene.

Step 1: Analyze the options.

- (A) Mitochondrial genes: Incorrect, as they are inherited maternally and do not segregate during gamete formation.
- (B) Alleles of a gene: Correct, as the law of segregation describes the separation of alleles.
- (C) Linked genes on the same chromosome: Incorrect, as linked genes do not segregate independently due to their physical proximity.

- (D) Unlinked genes on the same chromosome: Incorrect, as unlinked genes are not part of the segregation described by this law.

Final Answer:

alleles of a gene

Quick Tip

Key points about Mendel's laws:

- Law of Segregation: Describes the separation of alleles during gamete formation.
- Law of Independent Assortment: Describes how genes on different chromosomes segregate independently.
- The laws apply specifically to alleles and not to linked or mitochondrial genes.

17. Co-translational translocation of proteins is observed in

- (A) endoplasmic reticulum
- (B) Golgi complex
- (C) mitochondria
- (D) peroxisomes

Correct Answer: (A) endoplasmic reticulum

Solution:

Co-translational translocation is a process where proteins are translocated into the endoplasmic reticulum (ER) while they are being synthesized on ribosomes. This process is facilitated by a signal recognition particle (SRP) that directs the ribosome-protein complex to the ER membrane.

Step 1: Analyze the options.

- (A) Endoplasmic reticulum: Correct, as co-translational translocation is a key mechanism for protein sorting in the ER.

- (B) Golgi complex: Incorrect, as protein modifications occur in the Golgi, but not co-translational translocation.
- (C) Mitochondria: Incorrect, as protein import into mitochondria occurs post-translationally.
- (D) Peroxisomes: Incorrect, as protein targeting to peroxisomes is also a post-translational process.

Final Answer:

endoplasmic reticulum

Quick Tip

Key points about protein translocation:

- Co-translational translocation occurs in the ER during protein synthesis.
- Post-translational translocation involves proteins synthesized in the cytoplasm and later transported to their target organelles (e.g., mitochondria, peroxisomes).

18. 2-mercaptoethanol breaks the _____ covalent bond between light and heavy chains of an immunoglobulin molecule.

- (A) C-N
- (B) N-O
- (C) S-C
- (D) S-S

Correct Answer: (D) S-S

Solution:

2-mercaptoethanol is a reducing agent that specifically breaks disulfide ($S - S$) bonds. These covalent bonds stabilize the structure of immunoglobulin molecules by linking their light and heavy chains.

Step 1: Analyze the types of covalent bonds.

- (A) C-N: These bonds are present in peptide backbones, not in disulfide linkages.

- (B) N-O: These are not found in immunoglobulin covalent structures.
- (C) S-C: These are not relevant to light and heavy chain linkage.
- (D) S-S: Correct, as these bonds link the light and heavy chains in immunoglobulins.

Final Answer:

S-S

Quick Tip

In immunology, disulfide bonds ($S - S$) are critical for stabilizing protein structures such as immunoglobulins. Reducing agents like 2-mercaptoethanol are used to break these bonds for analysis.

19. During normal embryonic development of the mice paw, elimination of cells from the inter-digital space is due to

- (A) apoptosis
- (B) meiosis
- (C) mutagenesis
- (D) necrosis

Correct Answer: (A) apoptosis

Solution:

Apoptosis, or programmed cell death, is a crucial process during embryonic development. It ensures the removal of unnecessary cells, such as those in the inter-digital regions of developing mice paws, to shape proper structures.

Step 1: Analyze the processes.

- (A) Apoptosis: Correct, as it involves controlled cell elimination during development.
- (B) Meiosis: Incorrect, as it is a process of cell division to produce gametes.
- (C) Mutagenesis: Incorrect, as it involves changes in the genetic material, not cell elimination.

- (D) Necrosis: Incorrect, as it is uncontrolled cell death often caused by injury, not a programmed developmental process.

Final Answer:

apoptosis

Quick Tip

Apoptosis is essential for shaping structures during development, such as fingers and toes in mammals. It is a controlled process that ensures proper organ and tissue formation.

20. A cultured skin fibroblast cell of a goat ‘P’ was fused with an enucleated ovum of a goat ‘Q’. The resultant activated early embryo was then transplanted into a pseudopregnant (surrogate) female goat ‘R’ of the same strain as ‘Q’. On completion of gestation, a female goat ‘S’ was born. With the exception of mitochondrial DNA, ‘S’ is a clone of -----.

- (A) Only P
- (B) Only Q
- (C) Only R
- (D) Both P and R

Correct Answer: (A) Only P

Solution:

In cloning, the genetic material of the offspring is identical to that of the donor from which the nucleus was obtained. In this case:

- The nucleus was taken from the skin fibroblast cell of goat ‘P’.
- The enucleated ovum from goat ‘Q’ provides the cytoplasm but does not contribute nuclear DNA.
- The surrogate goat ‘R’ does not contribute genetic material; it only supports gestation.

Therefore, goat 'S' is a clone of goat 'P', except for mitochondrial DNA, which comes from goat 'Q'.

Final Answer:

Only P

Quick Tip

Cloning involves transferring nuclear DNA from the donor to an enucleated egg. The genetic identity of the clone matches the nuclear DNA donor, with mitochondrial DNA coming from the egg donor.

21. Which one of the following bacteriophages has a genome composed of single-stranded circular DNA?

- (A) $\phi X174$
- (B) λ
- (C) T5
- (D) P1

Correct Answer: (A) $\phi X174$

Solution:

Bacteriophage $\phi X174$ has a genome composed of single-stranded circular DNA. This unique property differentiates it from other bacteriophages:

- $\phi X174$: Single-stranded circular DNA (Correct).
- λ : Double-stranded linear DNA.
- T5: Double-stranded linear DNA.
- P1: Double-stranded linear DNA.

Final Answer:

$\phi X174$

Quick Tip

Bacteriophage $\phi X174$ is widely studied for its unique single-stranded circular DNA genome, making it an important model organism in molecular biology.

22. Which one of the following is an insect cell line?

- (A) HEK 293
- (B) Sf9
- (C) DH5 α
- (D) CHO

Correct Answer: (B) Sf9

Solution:

Sf9 is a widely used insect cell line derived from the ovarian tissue of the fall armyworm, *Spodoptera frugiperda*. It is commonly utilized in the baculovirus expression system for protein production.

Step 1: Analyze the options.

- (A) HEK 293: Incorrect, as it is a human embryonic kidney cell line.
- (B) Sf9: Correct, as it is an insect cell line.
- (C) DH5 α : Incorrect, as it is an *E. coli* bacterial strain used for cloning.
- (D) CHO: Incorrect, as it is a Chinese hamster ovary cell line, not an insect cell line.

Final Answer:

Sf9

Quick Tip

When identifying cell lines:

- Insect cell lines like Sf9 are commonly used in protein expression systems.
- HEK 293 and CHO are mammalian cell lines used for different purposes.
- DH5 α is a bacterial strain, not a cell line.

23. Which one of the following is the basic principle of Sanger's DNA sequencing method?

- (A) Chain termination by incorporation of dideoxynucleotides
- (B) Chain elongation by incorporation of dideoxynucleotides
- (C) Release of inorganic pyrophosphate
- (D) Chain cleavage by modification of dideoxynucleotides

Correct Answer: (A) Chain termination by incorporation of dideoxynucleotides

Solution:

Sanger's DNA sequencing method relies on the incorporation of dideoxynucleotides (ddNTPs) into the growing DNA strand. These ddNTPs lack a 3'-OH group, causing chain termination when incorporated.

Step 1: Analyze the process.

- Dideoxynucleotides (ddNTPs) act as chain terminators.
- When a ddNTP is incorporated, no further elongation occurs, creating DNA fragments of varying lengths.
- These fragments are analyzed to determine the DNA sequence.

Final Answer:

Chain termination by incorporation of dideoxynucleotides

Quick Tip

Key points about Sanger sequencing:

- ddNTPs are chain terminators that halt DNA synthesis.
- The method produces DNA fragments of varying lengths for sequence analysis.
- Modern sequencing technologies are based on principles derived from Sanger sequencing.

24. An element that is present in a nucleotide but not in a nucleoside is _____.

- (A) carbon
- (B) nitrogen
- (C) oxygen
- (D) phosphorus

Correct Answer: (D) phosphorus

Solution:

Nucleotides consist of three components: a nitrogenous base, a sugar, and a phosphate group. In contrast, nucleosides lack the phosphate group, and therefore, they do not contain phosphorus.

Step 1: Analyze the components.

- (A) Carbon: Present in both nucleosides and nucleotides as part of the sugar and base.
- (B) Nitrogen: Present in both as part of the nitrogenous base.
- (C) Oxygen: Present in both as part of the sugar and phosphate group.
- (D) Phosphorus: Correct, as it is part of the phosphate group found only in nucleotides.

Final Answer:

phosphorus

Quick Tip

Differences between nucleosides and nucleotides:

- Nucleosides contain a sugar and a nitrogenous base.
- Nucleotides contain an additional phosphate group, which includes phosphorus.
- Phosphorus is essential for nucleotide functions, including DNA and RNA synthesis.

25. Krebs (TCA) cycle is _____ pathway.

- (A) only an anabolic
- (B) only a catabolic
- (C) an amphibolic
- (D) a pyogenic

Correct Answer: (C) an amphibolic

Solution:

The Krebs cycle is termed an amphibolic pathway because it plays a dual role:

- Catabolic: It oxidizes acetyl-CoA to produce energy in the form of ATP, NADH, and FADH₂.
- Anabolic: It provides intermediates for biosynthetic pathways, such as amino acid and nucleotide synthesis.

Final Answer:

an amphibolic

Quick Tip

Key features of the Krebs cycle:

- It is central to energy production and biosynthetic processes.
- Amphibolic pathways have both catabolic and anabolic roles.
- Intermediates are precursors for macromolecule synthesis.

26. If a denatured protein of human origin is injected into a rabbit, antibodies generated will recognize the _____ structure of the protein.

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

Correct Answer: (A) primary

Solution:

Denatured proteins lose their secondary, tertiary, and quaternary structures but retain their primary structure (amino acid sequence). Antibodies generated against the denatured protein recognize epitopes based on the primary structure.

Step 1: Analyze the structural levels.

- (A) Primary: Correct, as the amino acid sequence remains intact after denaturation.
- (B) Secondary: Incorrect, as secondary structures like alpha-helices and beta-sheets are lost.
- (C) Tertiary: Incorrect, as the three-dimensional folding is disrupted.
- (D) Quaternary: Incorrect, as the interaction between subunits is also lost.

Final Answer:

primary

Quick Tip

Protein structures:

- Primary structure refers to the sequence of amino acids.
- Secondary, tertiary, and quaternary structures are disrupted during denaturation.
- Antibodies often recognize linear epitopes based on the primary structure.

27. All pseudogenes DO NOT code for a _____.

- (A) protein with original function
- (B) protein with altered function
- (C) RNA with coding sequence
- (D) RNA with regulatory function

Correct Answer: (A) protein with original function

Solution:

Pseudogenes are non-functional sequences of DNA that resemble functional genes but have lost the ability to code for a protein with its original function. They may have mutations, deletions, or insertions that disrupt their coding potential.

Step 1: Analyze the options.

- (A) Protein with original function: Correct, as pseudogenes cannot produce functional proteins.
- (B) Protein with altered function: Incorrect, as pseudogenes typically do not produce proteins.
- (C) RNA with coding sequence: Incorrect, as pseudogenes may not be transcribed into RNA with coding potential.
- (D) RNA with regulatory function: Incorrect, as some pseudogenes may have regulatory roles, such as acting as RNA decoys.

Final Answer:

protein with original function

Quick Tip

Key facts about pseudogenes:

- Pseudogenes are non-functional remnants of genes.
- They may have regulatory roles but cannot code for functional proteins.
- Mutations and deletions often render them inactive.

28. A value of k for which the linear equations $(k - 1)x + 3y = 0$ and $2x + ky = 0$ have a non-zero solution is

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

Correct Answer: (C) 3

Solution:

The given equations are:

$$(k - 1)x + 3y = 0 \quad (1)$$

$$2x + ky = 0 \quad (2).$$

For the system of linear equations to have a non-zero solution, the determinant of the coefficient matrix must be zero:

$$\text{Determinant} = \begin{vmatrix} k - 1 & 3 \\ 2 & k \end{vmatrix} = 0.$$

Compute the determinant:

$$(k - 1)(k) - (2)(3) = 0.$$

$$k^2 - k - 6 = 0.$$

Solve the quadratic equation:

$$k^2 - k - 6 = (k - 3)(k + 2) = 0.$$

Therefore, $k = 3$ or $k = -2$. Since the problem asks for a positive value of k , the correct answer is:

$$k = 3.$$

Final Answer:

3

Quick Tip

For a system of linear equations to have a non-zero solution, ensure the determinant of the coefficient matrix is zero. Solve the resulting equation to find the possible values of the parameter.

29. The value of the series $1 + \sin x + \cos^2 x + \sin^3 x + \dots$ at $x = \frac{\pi}{4}$ is

- (A) $\frac{1}{\sqrt{2}+1}$
- (B) $\frac{\sqrt{2}}{\sqrt{2}+1}$
- (C) $\frac{1}{\sqrt{2}-1}$
- (D) $\frac{\sqrt{2}}{\sqrt{2}-1}$

Correct Answer: (D) $\frac{\sqrt{2}}{\sqrt{2}-1}$

Solution:

The given series is:

$$S = 1 + \sin x + \cos^2 x + \sin^3 x + \dots$$

At $x = \frac{\pi}{4}$:

$$\sin \frac{\pi}{4} = \cos \frac{\pi}{4} = \frac{1}{\sqrt{2}}.$$

Substitute $\sin x = \cos x = \frac{1}{\sqrt{2}}$ into the series:

$$S = 1 + \frac{1}{\sqrt{2}} + \left(\frac{1}{\sqrt{2}}\right)^2 + \left(\frac{1}{\sqrt{2}}\right)^3 + \dots$$

This is an infinite geometric series with the first term $a = 1$ and common ratio $r = \frac{1}{\sqrt{2}}$:

$$S = \frac{a}{1 - r}.$$

Substituting the values:

$$S = \frac{1}{1 - \frac{1}{\sqrt{2}}} = \frac{1}{\frac{\sqrt{2}-1}{\sqrt{2}}} = \frac{\sqrt{2}}{\sqrt{2}-1}.$$

Final Answer:

$$\boxed{\frac{\sqrt{2}}{\sqrt{2}-1}}$$

Quick Tip

For infinite geometric series:

$$S = \frac{a}{1 - r},$$

where a is the first term and r is the common ratio. Ensure $|r| < 1$ for the series to converge.

30. The solution of the differential equation $\frac{dy}{dx} = y + e^{-x}$ that satisfies $y(0) = -\frac{1}{2}$ is _____.

- (A) $-\frac{1}{2}e^{-\frac{x}{2}}$
- (B) $-\frac{1}{2}e^x$
- (C) $-\frac{1}{2}e^{-x}$
- (D) $-\frac{1}{2}e^{\frac{x}{2}}$

Correct Answer: (C) $-\frac{1}{2}e^{-x}$

Solution:

The given differential equation is:

$$\frac{dy}{dx} = y + e^{-x}.$$

This is a first-order linear differential equation. Rewrite it as:

$$\frac{dy}{dx} - y = e^{-x}.$$

The integrating factor (IF) is:

$$e^{\int -1 dx} = e^{-x}.$$

Multiply through by the integrating factor:

$$e^{-x} \frac{dy}{dx} - e^{-x} y = e^{-2x}.$$

Simplify:

$$\frac{d}{dx} (ye^{-x}) = e^{-2x}.$$

Integrate both sides:

$$ye^{-x} = \int e^{-2x} dx = -\frac{1}{2}e^{-x} + C,$$

where C is the constant of integration. Solve for y :

$$y = -\frac{1}{2}e^{-x} + Ce^x.$$

Use the initial condition $y(0) = -\frac{1}{2}$ to find C :

$$-\frac{1}{2} = -\frac{1}{2} + C \cdot 1 \implies C = 0.$$

Thus, the solution is:

$$y = -\frac{1}{2}e^{-x}.$$

Final Answer:

$$\boxed{-\frac{1}{2}e^{-x}}$$

Quick Tip

For first-order linear differential equations:

$$\frac{dy}{dx} + Py = Q,$$

the solution is given by:

$$y \cdot (\text{Integrating Factor}) = \int Q \cdot (\text{Integrating Factor}) dx + C.$$

Always apply initial conditions to determine the constant of integration.

31. The six faces of a cube (die) are numbered as 1, 2, 3, 4, 5, and 6, and it is rolled once. An outcome is the observed number on the top face. If the probability of getting an odd number as an outcome is twice that of an even number, then the probability of getting a number less than 3 is ____.

- (A) $\frac{1}{9}$
- (B) $\frac{2}{9}$
- (C) $\frac{1}{3}$
- (D) $\frac{4}{9}$

Correct Answer: (C) $\frac{1}{3}$

Solution:

The die has 3 odd numbers (1, 3, 5) and 3 even numbers (2, 4, 6). Let the probability of an even number be p . Then, the probability of an odd number is $2p$. Since the total probability must equal 1:

$$p + 2p = 1 \implies 3p = 1 \implies p = \frac{1}{3}.$$

Thus:

$$\text{Probability of an even number} = \frac{1}{3},$$

$$\text{Probability of an odd number} = \frac{2}{3}.$$

The numbers less than 3 are 1 and 2:

- Probability of rolling a 1 (odd): $\frac{2}{3} \times \frac{1}{3} = \frac{2}{9}$.
- Probability of rolling a 2 (even): $\frac{1}{3} \times \frac{1}{3} = \frac{1}{9}$.

Add these probabilities:

$$\text{Probability of getting a number less than 3} = \frac{2}{9} + \frac{1}{9} = \frac{3}{9} = \frac{1}{3}.$$

Final Answer:

$$\boxed{\frac{1}{3}}$$

Quick Tip

When solving probability questions:

- Use the total probability rule: $P(\text{total}) = 1$.
- Identify outcomes and assign probabilities based on given conditions.
- Sum probabilities for combined events.

32. Let \vec{OR} be the vector that is perpendicular to the vectors $\vec{OP} = 2\mathbf{i} - 3\mathbf{j} + \mathbf{k}$ and $\vec{OQ} = -2\mathbf{i} + \mathbf{j} + \mathbf{k}$. If the length of the vector \vec{OR} is $\alpha\sqrt{3}$, then α is

- (A) 3
- (B) 4
- (C) 5
- (D) 6

Correct Answer: (B) 4

Solution:

To find a vector perpendicular to both \vec{OP} and \vec{OQ} , take their cross product:

$$\vec{OP} \times \vec{OQ} = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 2 & -3 & 1 \\ -2 & 1 & 1 \end{vmatrix}.$$

Expanding the determinant:

$$\begin{aligned} \vec{OP} \times \vec{OQ} &= \mathbf{i}((-3)(1) - (1)(1)) - \mathbf{j}((2)(1) - (-2)(1)) + \mathbf{k}((2)(1) - (-3)(-2)), \\ \vec{OP} \times \vec{OQ} &= -4\mathbf{i} - 4\mathbf{j} - 4\mathbf{k}. \end{aligned}$$

The magnitude of this vector is:

$$\|\vec{OP} \times \vec{OQ}\| = \sqrt{(-4)^2 + (-4)^2 + (-4)^2} = 4\sqrt{3}.$$

Since the length of \vec{OR} is $\alpha\sqrt{3}$, equating:

$$\alpha\sqrt{3} = 4\sqrt{3} \implies \alpha = 4.$$

Final Answer:

4

Quick Tip

To find a vector perpendicular to two given vectors, use the cross product. The magnitude of the resultant vector can then be used to determine required parameters.

33. The degree of reduction (reductance) for oxalic acid ($C_2H_2O_4$) is

Correct Answer: 1

Solution:

The degree of reduction (reductance) is calculated based on the oxidation state of carbon in the molecule. For oxalic acid ($C_2H_2O_4$):

- Carbon has an oxidation state of +3.
- The reductance is determined as the ratio of hydrogen to carbon or calculated based on the reduction potential.

Final Answer:

1

Quick Tip

For reductance calculations:

- Determine the oxidation states of the elements.
- Use the ratio of hydrogen to carbon for organic compounds.

34. If the rate at which *E.coli* divides is 0.5 h^{-1} , then its doubling time is

Correct Answer: 2 h

Solution:

Step 1: The doubling time (t_d) is calculated using the formula:

$$t_d = \frac{1}{\text{Rate of Division}}$$

Step 2: Substitute the given rate of division (0.5 h^{-1}) into the formula:

$$t_d = \frac{1}{0.5}$$

Step 3: Solve the expression:

$$t_d = 2 \text{ h}$$

Final Answer:

2 h

Quick Tip

To find the doubling time, use the formula $\text{Doubling Time} = \frac{1}{\text{Rate}}$. This formula is simple and effective for calculating growth-related time intervals.

35. The decimal reduction time of a microbe during sterilization at 120°C with a first-order thermal death rate constant of 1 min^{-1} will be ____ min (rounded off to 1 decimal place).

Correct Answer: 2.3

Solution:

Decimal reduction time (D) is related to the rate constant (k) by:

$$D = \frac{\log_e 10}{k}$$

Substitute $k = 1 \text{ min}^{-1}$:

$$D = \frac{\log_e 10}{1} = 2.302 \text{ min.}$$

Rounded to one decimal place, the decimal reduction time is 2.3 min.

Final Answer:

2.3

Quick Tip

For decimal reduction time:

- Use $D = \frac{\log_e 10}{k}$ for first-order reactions.
- Ensure proper unit consistency when substituting rate constants.

Question 36-65 carry two mark each

36. Match the disease (Column I) with its biological vector (Column II).

Column I	Column II
P. Chagas disease	1. Tsetse flies
Q. Trypanosomiasis	2. Mosquitoes
R. Leishmaniasis	3. Sandflies
S. Yellow Fever	4. Reduviid bugs

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

Correct Answer: (A) P-4; Q-1; R-3; S-2

Solution:

Match the diseases with their respective biological vectors:

- **Chagas disease (P):** Transmitted by Reduviid bugs (4).
- **Trypanosomiasis (Q):** Transmitted by Tsetse flies (1).
- **Leishmaniasis (R):** Transmitted by Sandflies (3).
- **Yellow Fever (S):** Transmitted by Mosquitoes (2).

The correct matching is:

$$P - 4; Q - 1; R - 3; S - 2.$$

Final Answer:

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

Quick Tip

When solving matching questions, ensure to understand the biological vectors specific to each disease. Familiarize yourself with common pairings like:

- Reduviid bugs: Chagas disease.
- Tsetse flies: Trypanosomiasis.
- Sandflies: Leishmaniasis.
- Mosquitoes: Yellow Fever.

37. Match the industrial enzyme (Column I) with its application (Column II).

Column I	Column II
P. Lipase	1. Maltose syrup production
Q. Ficin	2. Oil degradation
R. Amylase	3. Oligosaccharide/monosaccharide production
S. Glucosidase	4. Meat tenderization

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

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

Solution:

Match the industrial enzymes with their applications:

- **Lipase (P):** Used in oil degradation (2).
- **Ficin (Q):** Used in meat tenderization (4).
- **Amylase (R):** Used in maltose syrup production (1).
- **Glucosidase (S):** Used in oligosaccharide/monosaccharide production (3).

The correct matching is:

$P - 2; Q - 4; R - 1; S - 3.$

Final Answer:

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

Quick Tip

When solving matching questions involving enzymes, remember:

- **Lipase:** Degrades fats and oils.
- **Ficin:** Proteolytic enzyme used in meat tenderization.
- **Amylase:** Breaks down starch into maltose.
- **Glucosidase:** Converts polysaccharides into simpler sugars.

38. Match the enzyme (Column I) with its corresponding function (Column II).

Column I	Column II
P. Primase	1. RNA dependent RNA synthesis
Q. Reverse transcriptase	2. DNA dependent DNA synthesis
R. RNA Replicase	3. RNA dependent DNA synthesis
S. DNA Polymerase III	4. DNA dependent RNA synthesis

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

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

Solution:

Match the enzymes with their corresponding functions:

- **Primase (P):** Performs DNA dependent RNA synthesis (4).
- **Reverse Transcriptase (Q):** Performs RNA dependent DNA synthesis (3).

- **RNA Replicase (R):** Performs RNA dependent RNA synthesis (1).
- **DNA Polymerase III (S):** Performs DNA dependent DNA synthesis (2).

The correct matching is:

$$P - 4; Q - 3; R - 1; S - 2.$$

Final Answer:

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

Quick Tip

For matching enzymes with functions, remember:

- **Primase:** Synthesizes RNA primers for DNA replication.
- **Reverse Transcriptase:** Converts RNA into complementary DNA.
- **RNA Replicase:** Synthesizes RNA from an RNA template.
- **DNA Polymerase III:** Extends the DNA strand during replication.

39. Match the item (Column I) with its corresponding use (Column II).

Column I	Column II
P. Glutamine	1. Detachment of adherent cells
Q. Trypsin	2. Selection of transfected mammalian cell lines
R. Hypoxanthine	3. Source of carbon and nitrogen in animal cell culture media
S. Neomycin	4. A component of medium for selection of hybridoma in monoclonal antibody production

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

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

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

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

Correct Answer: (A) P-3; Q-1; R-4; S-2

Solution:

Match the items with their corresponding uses:

- **Glutamine (P):** A source of carbon and nitrogen in animal cell culture media (3).
- **Trypsin (Q):** Facilitates the detachment of adherent cells (1).
- **Hypoxanthine (R):** A component of the medium for the selection of hybridoma in monoclonal antibody production (4).
- **Neomycin (S):** Used for the selection of transfected mammalian cell lines (2).

The correct matching is:

$P - 3; Q - 1; R - 4; S - 2.$

Final Answer:

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

Quick Tip

For matching biological items with their uses, remember:

- **Glutamine:** A key nutrient in cell culture media.
- **Trypsin:** Enzyme used to detach adherent cells during cell passaging.
- **Hypoxanthine:** Important in hybridoma selection in monoclonal antibody production.
- **Neomycin:** Antibiotic used in the selection of transfected mammalian cells.

40. Match the chemical (Column I) with its use (Column II).

Column I	Column II
P. Diethylpyrocarbonate	1. Chelation of magnesium ion during DNA purification
Q. Cesium chloride	2. Prevention of RNA degradation in aqueous environment
R. Ethidium bromide	3. Separation of DNA by density gradient centrifugation
S. Ethylenediaminetetraacetic acid	4. Staining of RNA in agarose gel

Options:

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

Correct Answer: (D)

Solution:

Step 1: Match each chemical with its specific use based on their properties:

- **Diethylpyrocarbonate (P):** Prevents RNA degradation in aqueous environments (2).
- **Cesium chloride (Q):** Used for separation of DNA by density gradient centrifugation (3).
- **Ethidium bromide (R):** Stains RNA in agarose gel (4).
- **Ethylenediaminetetraacetic acid (S):** Chelates magnesium ions during DNA purification (1).

Step 2: Assign the correct matches:

P-2, Q-3, R-4, S-1

Final Answer:

(D)

Quick Tip

Use the properties and functions of chemicals to match them to their correct applications. For example, chelation removes metal ions, while ethidium bromide is a common dye.

41. Match the item in Column I with the corresponding technique in Column II.

Column I	Column II
P. Blue laser	1. Electron microscopy
Q. Tungsten filament	2. Fluorescence activated cell sorting
R. ^{15}N labelled protein	3. Electrophoresis
S. Polyacrylamide	4. Nuclear magnetic resonance spectroscopy

Options:

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

Correct Answer: (B)

Solution:

Step 1: Match each item in Column I with its corresponding technique in Column II:

- **Blue laser (P):** Used in fluorescence activated cell sorting (2).
- **Tungsten filament (Q):** Used in electron microscopy (1).
- **^{15}N labelled protein (R):** Used in nuclear magnetic resonance spectroscopy (4).
- **Polyacrylamide (S):** Used in electrophoresis (3).

Step 2: Assign the correct matches:

P-2, Q-1, R-4, S-3

Final Answer:

(B)

Quick Tip

Each technique corresponds to a specific tool or material. For example, polyacrylamide is commonly used in gel electrophoresis, and tungsten filament is a key component in electron microscopy.

Q41. Match the item in Column I with the corresponding technique in Column II.

Column I	Column II
P. Blue laser	1. Electron microscopy
Q. Tungsten filament	2. Fluorescence activated cell sorting
R. ^{15}N labelled protein	3. Electrophoresis
S. Polyacrylamide	4. Nuclear magnetic resonance spectroscopy

Options:

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

Correct Answer: (B)

Solution:

Step 1: Match each item in Column I with its corresponding technique in Column II:

- **Blue laser (P):** Used in fluorescence activated cell sorting (2).
- **Tungsten filament (Q):** Used in electron microscopy (1).
- **^{15}N labelled protein (R):** Used in nuclear magnetic resonance spectroscopy (4).
- **Polyacrylamide (S):** Used in electrophoresis (3).

Step 2: Assign the correct matches:

P-2, Q-1, R-4, S-3

Final Answer:

(B)

Quick Tip

Each technique corresponds to a specific tool or material. For example, polyacrylamide is commonly used in gel electrophoresis, and tungsten filament is a key component in electron microscopy.

Q42. Match the genetic disorder (Column I) with its molecular basis (Column II).

Column I	Column II
P. Sickle-cell anemia	1. Mutation in nucleotide excision repair
Q. Xeroderma pigmentosum	2. Trisomy of chromosome 21
R. Tay-Sachs disease	3. Mutation in β -globin gene
S. Down Syndrome	4. Mutation in hexosaminidase A gene

Options:

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

Correct Answer: (C)

Solution:

Step 1: Match each genetic disorder with its molecular basis:

- **Sickle-cell anemia (P):** Caused by a mutation in the β -globin gene (3).
- **Xeroderma pigmentosum (Q):** Caused by a mutation in nucleotide excision repair (1).
- **Tay-Sachs disease (R):** Caused by a mutation in hexosaminidase A gene (4).

- **Down Syndrome (S):** Caused by trisomy of chromosome 21 (2).

Step 2: Assign the correct matches:

P-3, Q-1, R-4, S-2

Final Answer:

(C)

Quick Tip

Understand the molecular basis of genetic disorders. For example, nucleotide excision repair is defective in Xeroderma pigmentosum, and trisomy of chromosome 21 results in Down Syndrome.

43. The evolution of wings in bats and insects is an example of evolution.

- (A) convergent
- (B) divergent
- (C) neutral
- (D) parallel

Correct Answer: (A) convergent

Solution:

The evolution of wings in bats and insects is classified as convergent evolution because:

- Both evolved wings independently for flight.
- Their wings are analogous structures (different origin, similar function).

Final Answer:

(A) convergent

Quick Tip

Convergent evolution: Independent evolution of similar traits in species of different lineages due to similar selective pressures.

44. Which of the following statements is/are correct about an uncompetitive inhibitor of an enzyme?

- (A) It binds to the substrate binding site of the enzyme only
- (B) It binds to the enzyme-substrate complex only
- (C) It reduces the V_{\max} of the enzyme
- (D) It binds to both free enzyme and enzyme-substrate complex

Correct Answer: (B) It binds to the enzyme-substrate complex only, (C) It reduces the V_{\max} of the enzyme

Solution:

Uncompetitive inhibitors:

- Bind only to the enzyme-substrate complex, not to the free enzyme.
- Reduce the V_{\max} , the maximum rate of the reaction, by stabilizing the enzyme-substrate complex.
- Do not interfere with substrate binding directly, as they do not bind to the active site.

Final Answer:

(B, C)

Quick Tip

Uncompetitive inhibitors only bind to the enzyme-substrate complex and primarily impact V_{\max} , making the enzyme less efficient.

Question 45-65 carry Two mark each

45. Which of the following plant-based secondary metabolites belong(s) to the class of alkaloids?

- (A) Ajmalicine ($C_{21}H_{24}N_2O_3$)
- (B) Azadirachtin ($C_{35}H_{44}O_{16}$)

(C) Camptothecin ($C_{20}H_{16}N_2O_4$)

(D) Vinblastine ($C_{46}H_{58}N_4O_9$)

Correct Answer: (A) Ajmalicine, (C) Camptothecin, (D) Vinblastine

Solution:

Alkaloids are secondary metabolites that contain nitrogen and exhibit biological activity.

From the given options:

- **Ajmalicine (A):** An indole alkaloid used as an antihypertensive.
- **Camptothecin (C):** A quinoline alkaloid with anticancer properties.
- **Vinblastine (D):** A vinca alkaloid used in chemotherapy.
- **Azadirachtin (B):** Though biologically active, it is classified as a limonoid, not an alkaloid.

Final Answer:

(A, C, D)

Quick Tip

Alkaloids are nitrogen-containing secondary metabolites. Focus on identifying the nitrogen and the biological relevance for classification.

46. Which of the following features help(s) in distinguishing alleles using restriction fragment length polymorphism (RFLP)?

- (A) Differences in the number of recognition sites for a given restriction enzyme
- (B) Differences in the ability of alleles to undergo recombination
- (C) Differences in the ability of alleles to undergo segregation
- (D) Differences in the number of tandem repeats

Correct Answer: (A) Differences in the number of recognition sites for a given restriction enzyme, (D) Differences in the number of tandem repeats

Solution:

RFLP helps in distinguishing alleles based on:

- **Number of recognition sites (A):** Different alleles may have variations in restriction sites, producing fragments of varying lengths.
- **Tandem repeats (D):** Differences in the number of repeats alter the size of the restriction fragments.
- Recombination (B) and segregation (C) do not directly influence RFLP as they are unrelated to restriction fragment patterns.

Final Answer:

(A, D)

Quick Tip

RFLP is based on variations in DNA sequences, such as restriction site differences or tandem repeats, leading to fragment length differences.

47. Which of the following is/are considered as biotic elicitor(s) in plant cell culture?

- (A) Cellulase
- (B) Chitin
- (C) Chitosan
- (D) Mercuric chloride

Correct Answer: (A) Cellulase, (B) Chitin, (C) Chitosan

Solution:

Biotic elicitors in plant cell culture are compounds derived from biological sources that induce a response in plant cells:

- **Cellulase (A):** An enzyme that breaks down cellulose and acts as a biotic elicitor.
- **Chitin (B):** A polymer of N-acetylglucosamine derived from fungal cell walls, inducing plant defense responses.

- **Chitosan (C):** A derivative of chitin with similar elicitor activity.
- **Mercuric chloride (D):** A chemical compound, not a biotic elicitor, as it is abiotic and toxic to cells.

Final Answer:

(A, B, C)

Quick Tip

Biotic elicitors originate from biological sources (e.g., enzymes, fungal components) and trigger plant defense mechanisms, while abiotic elicitors are non-biological.

48. Under which of the following conditions, a mammalian somatic cell fails to undergo mitosis during cell cycle?

- (A) Initiation of cell plate formation
- (B) Incomplete DNA replication
- (C) Chiasmata formation
- (D) Irreparable DNA damage

Correct Answer: (B) Incomplete DNA replication, (D) Irreparable DNA damage

Solution:

Mammalian somatic cells fail to undergo mitosis under the following conditions:

- **Incomplete DNA replication (B):** The cell cannot proceed past the G2 checkpoint.
- **Irreparable DNA damage (D):** Activates cell cycle arrest or apoptosis.
- **Initiation of cell plate formation (A):** Specific to plant cells and not relevant here.
- **Chiasmata formation (C):** Occurs during meiosis, not mitosis.

Final Answer:

(B, D)

Quick Tip

Key checkpoints like G1, G2, and spindle assembly ensure proper cell cycle progression. Errors in replication or severe DNA damage halt mitosis.

49. Which of the following is/are synthetic auxin(s) that does/do NOT occur naturally?

- (A) 2,4-Dichlorophenoxyacetic acid
- (B) Indole-3-acetic acid
- (C) Indole-3-butyric acid
- (D) 1-Naphthaleneacetic acid

Correct Answer: (A) 2,4-Dichlorophenoxyacetic acid, (D) 1-Naphthaleneacetic acid

Solution:

Synthetic auxins mimic the action of natural auxins but do not occur naturally:

- **2,4-Dichlorophenoxyacetic acid (A):** A synthetic auxin used as a herbicide.
- **1-Naphthaleneacetic acid (D):** A synthetic auxin used for rooting.
- **Indole-3-acetic acid (B):** A naturally occurring auxin.
- **Indole-3-butyric acid (C):** Though naturally derived, it has synthetic applications but does occur in plants.

Final Answer:

(A, D)

Quick Tip

Synthetic auxins like 2,4-D and NAA are extensively used in agriculture for growth regulation, whereas natural auxins (e.g., IAA) are endogenous to plants.

50. Which of the following statements regarding the below mentioned mRNA sequence is/are TRUE?

5' – UGAUGAGCCCUUAACCGGGAACGAAUUUAAAG – 3'

- (A) It contains nine codons in the reading frame
- (B) It contains ten codons in the reading frame
- (C) It codes for eight amino acids
- (D) It codes for nine amino acids

Correct Answer: (A) It contains nine codons in the reading frame, (C) It codes for eight amino acids

Solution:

To determine the codons and amino acids:

- The reading frame starts from the first AUG (start codon).
- From the sequence, the codons are: AUG, AGC, CCU, UAA (stop codon), CCG, GGA, ACG, AAU, UUA.
- This makes a total of nine codons in the reading frame (A is correct).
- UAA is a stop codon, so it does not code for an amino acid. Hence, there are eight amino acids coded by this sequence (C is correct).

Final Answer:

(A, C)

Quick Tip

To determine the number of codons and amino acids:

- Count all codons from the start codon (AUG) to the stop codon.
- Exclude the stop codon when counting amino acids.

51. Which of the following conditions induce(s) the expression of β -galactosidase gene in the lac operon?

- (A) Absence of glucose
- (B) Absence of lactose
- (C) Presence of glucose
- (D) Presence of lactose

Correct Answer: (A) Absence of glucose, (D) Presence of lactose

Solution:

For the lac operon to express β -galactosidase:

- **Absence of glucose (A):** Enables activation of the cAMP-CAP complex, promoting transcription of the lac operon.
- **Presence of lactose (D):** Lactose acts as an inducer by binding to the repressor, preventing it from inhibiting the operon.
- The absence of lactose (B) or presence of glucose (C) represses the lac operon and inhibits expression.

Final Answer:

(A, D)

Quick Tip

The lac operon is active only when:

- Glucose is absent (ensuring high cAMP levels for activation).
- Lactose is present (inducing the operon by inactivating the repressor).

52. Which of the following factors can affect the growth of a microbial culture in a batch cultivation process?

- (A) pH of the medium
- (B) Osmolarity of the medium
- (C) Substrate concentration in the medium
- (D) Substrate feed rate

Correct Answer: (A) pH of the medium, (B) Osmolarity of the medium, (C) Substrate concentration in the medium

Solution:

The growth of microbial cultures in batch cultivation is influenced by several environmental and nutrient-related factors:

- **pH of the medium (A):** Affects enzyme activity and cellular processes.
- **Osmolarity of the medium (B):** Impacts water movement and cell integrity.
- **Substrate concentration in the medium (C):** Provides nutrients and energy sources essential for growth.
- **Substrate feed rate (D):** Irrelevant in batch processes as feed is constant and not added continuously.

Final Answer:

(A, B, C)

Quick Tip

In batch cultivation, environmental factors like pH and osmolarity and substrate availability play crucial roles, while feed rate is relevant in fed-batch or continuous processes.

53. Under complete cell washout condition in a chemostat with sterile feed, which of the following statements is/are correct?

- (A) Biomass concentration in the reactor is maximum
- (B) Substrate concentration in the exit stream is less than that in the inlet stream
- (C) Substrate concentration in the exit stream is equal to that in the inlet stream
- (D) Substrate concentration in the exit stream is zero

Correct Answer: (C) Substrate concentration in the exit stream is equal to that in the inlet stream

Solution:

In a chemostat under complete cell washout:

- **Biomass concentration (A):** It is negligible as no cells remain in the reactor.
- **Substrate concentration in the exit stream (C):** It equals the inlet stream concentration because no biomass is present to consume the substrate.
- **Substrate concentration being zero (D):** Is incorrect under these conditions.

Final Answer:

(C)

Quick Tip

In a chemostat with sterile feed and complete cell washout, substrate utilization does not occur, leading to identical substrate concentrations in the inlet and outlet streams.

54. Fermentation medium is cooled from 121 °C to 30 °C in a double pipe heat exchanger. If cold water is flowing in the counter-current direction and is heated from 10 °C to 70 °C, then the Log-Mean Temperature Difference (LMTD) is °C (rounded off to the nearest integer).

Correct Answer: The LMTD is in the range of 33 to 35° C.

Solution:

The LMTD is calculated using the formula:

$$\text{LMTD} = \frac{(T_1 - t_2) - (T_2 - t_1)}{\ln \left(\frac{T_1 - t_2}{T_2 - t_1} \right)},$$

where:

- $T_1 = 121$, C, $T_2 = 30$ C (hot fluid temperatures).
- $t_1 = 10$ C, $t_2 = 70$ C (cold fluid temperatures).

Substituting the values:

$$\text{LMTD} = \frac{(121 - 70) - (30 - 10)}{\ln \left(\frac{121 - 70}{30 - 10} \right)}.$$

Simplifying:

$$\text{LMTD} = \frac{51 - 20}{\ln\left(\frac{51}{20}\right)} \approx \frac{31}{0.916} \approx 33.8 \text{ C.}$$

Rounded off to the nearest integer, the LMTD is 34 C.

Final Answer:

33 to 35 C

Quick Tip

For counter-current heat exchangers, always use the LMTD formula with the temperature differences at each end to find the average driving force.

55. Aspergillus niger is grown in a 10,000 L stirred batch bioreactor under aerated conditions to produce citric acid. At steady state oxygen transfer conditions, the specific oxygen uptake rate of the organism and the volumetric mass transfer coefficient are 1×10^{-4} g oxygen consumed g biomass⁻¹ s⁻¹ and 60 min⁻¹, respectively. If the oxygen solubility is 8×10^{-3} kg m⁻³, based only on oxygen dynamics, the maximum possible cell concentration is kg m⁻³ (Answer in integer).

Correct Answer: 80

Solution:

Using the relationship:

$$C_x = \frac{k_L a \cdot C^*}{q_o},$$

where:

- $k_L a = 60 \text{ min}^{-1} = 1 \text{ s}^{-1}$,
- $C^* = 8 \times 10^{-3} \text{ kg m}^{-3}$,
- $q_o = 1 \times 10^{-4} \text{ g oxygen consumed g biomass}^{-1} \text{ s}^{-1} = 1 \times 10^{-4} \text{ kg oxygen kg biomass}^{-1} \text{ s}^{-1}$.

Substituting the values:

$$C_x = \frac{8 \times 10^{-3}}{1 \times 10^{-4}} = 80 \text{ kg m}^{-3}.$$

Final Answer:

80 kg m⁻³

Quick Tip

For oxygen-limited growth, the maximum biomass concentration depends on the mass transfer coefficient, oxygen solubility, and specific oxygen uptake rate.

Q56. Ethanol is produced in a 10,000 L stirred bioreactor using an impeller of diameter 1 m. The density and viscosity of fermentation broth are 1000 kg m^{-3} and 1 cp, respectively. The data relating the Power number and Impeller Reynolds number is given below:

Reynolds number	Power number
1–5	70
5–500	10
$> 10^5$	5

Using the above data, the power required for the stirrer to operate at 300 rpm is _____ kW (Answer in integer).

Correct Answer: 625 kW

Solution:

Step 1: Calculate the Reynolds number using the formula:

$$\text{Re} = \frac{\rho \cdot N \cdot D^2}{\mu}$$

where:

- $\rho = 1000 \text{ kg/m}^3$ (density),
- $N = 300 \text{ rpm} = \frac{300}{60} \text{ rps} = 5 \text{ rps}$ (rotation speed),
- $D = 1 \text{ m}$ (impeller diameter),
- $\mu = 1 \text{ cp} = 0.001 \text{ Pa.s}$ (viscosity).

Substitute the values:

$$\text{Re} = \frac{1000 \cdot 5 \cdot (1)^2}{0.001} = 5 \times 10^6$$

Step 2: From the table, for $\text{Re} > 10^5$, the Power number (P_0) is 5.

Step 3: Use the formula for power calculation:

$$P = P_0 \cdot \rho \cdot N^3 \cdot D^5$$

Substitute the known values:

$$P = 5 \cdot 1000 \cdot (5)^3 \cdot (1)^5$$

$$P = 5 \cdot 1000 \cdot 125 = 625,000 \text{ W}$$

Step 4: Convert power to kilowatts:

$$P = \frac{625,000}{1000} = 625 \text{ kW}$$

Final Answer:

$$\boxed{625 \text{ kW}}$$

Quick Tip

Use the Power number and Reynolds number relationship to simplify calculations. Always ensure units are consistent when applying formulas.

57. The free energy change of ATP hydrolysis at 25°C is $-32.2 \text{ kJ mol}^{-1}$. The free energy change for hydrolysis of α -glycerophosphate to glycerol is -8.2 kJ mol^{-1} . Using the above information, the free energy change for the formation of α -glycerophosphate from glycerol and ATP is kJ mol^{-1} (Answer in integer).

Correct Answer: The free energy change is in the range of -24 to -24 kJ mol^{-1} .

Solution:

Using the relationship:

$$\Delta G = \Delta G_{\text{ATP hydrolysis}} - \Delta G_{\text{glycerophosphate hydrolysis}}$$

Substituting the values:

$$\Delta G = -32.2 - (-8.2) = -24.0 \text{ kJ mol}^{-1}$$

Final Answer:

$$\boxed{-24 \text{ kJ mol}^{-1}}$$

Quick Tip

To calculate free energy changes for coupled reactions, sum the free energy changes of the individual reactions.

58. *E.coli* is inoculated in a shake flask containing nutrient-rich medium. The initial number of viable cells in the medium is 10^2 . After four hours, the number of viable cells is 10^6 . Assuming cell division by binary fission, the number of generations that have taken place is (rounded off to the nearest integer).

Correct Answer: 13.32

Solution:

The number of generations n is calculated using:

$$n = \frac{\log_2(N_f/N_i)}{1}$$

where:

- $N_f = 10^6$ (final number of cells),
- $N_i = 10^2$ (initial number of cells).

Substituting the values:

$$n = \log_2(10^6/10^2) = \log_2(10^4) = 13.32 \text{ generations.}$$

Final Answer:

13.32 generations

Quick Tip

Binary fission results in exponential cell growth. The number of generations can be estimated using the formula $n = \log_2(N_f/N_i)$.

59. A fermentor is filled with medium at a rate of 1 L min^{-1} . A leak develops at the bottom of the fermentor when the medium in the fermentor reaches 200 L. The rate of medium leakage is $2t \text{ L min}^{-1}$, where t is the time at which the leak begins. The volume of medium in the fermentor after 10 min of leakage is L (Answer in integer).

Correct Answer: 110

Solution:

The rate of inflow of the medium is:

$$Q_{\text{in}} = 1 \text{ L min}^{-1}.$$

The rate of leakage (outflow) is:

$$Q_{\text{out}} = 2t \text{ L min}^{-1}.$$

The differential volume of the fermentor at any time t is:

$$\frac{dV}{dt} = Q_{\text{in}} - Q_{\text{out}} = 1 - 2t.$$

Integrating from $t = 0$ to 10:

$$V(t) = \int_0^{10} (1 - 2t) dt.$$

Evaluating:

$$V(t) = [t - t^2]_0^{10} = (10 - 100) - (0 - 0) = -90.$$

Since the fermentor starts with 200 L:

$$V_{\text{final}} = 200 - 90 = 110 \text{ L}.$$

Quick Tip

To calculate fluid volumes with variable rates, integrate the net inflow and outflow rates over the given time period.

60. A fed batch process is running at quasi-steady state with respect to substrate and biomass concentration. At 2 h, the culture volume is 500 L with a constant sterile inlet feed at 50 L h⁻¹ of glucose. The culture kinetic parameters μ_m and K_S are 0.2 h⁻¹ and 0.1 g L⁻¹, respectively.

The substrate concentration in the reactor will be _____ g L⁻¹ (rounded off to one decimal place).

Correct Answer: 0.1 g L⁻¹

Solution:

Step 1: For a quasi-steady state in a fed-batch reactor, the substrate concentration is determined by the Monod equation:

$$\mu = \mu_m \cdot \frac{S}{K_S + S}$$

where:

- $\mu_m = 0.2 \text{ h}^{-1}$ (maximum specific growth rate),
- $K_S = 0.1 \text{ g L}^{-1}$ (substrate concentration at half-maximum growth rate),
- $\mu = D = \frac{F}{V}$, the dilution rate.

Step 2: Calculate the dilution rate (D):

$$D = \frac{F}{V} = \frac{50}{500} = 0.1 \text{ h}^{-1}$$

Step 3: Substitute D and other values into the Monod equation:

$$0.1 = 0.2 \cdot \frac{S}{0.1 + S}$$

Step 4: Solve for S (substrate concentration):

$$0.1 \cdot (0.1 + S) = 0.2 \cdot S$$

$$0.01 + 0.1S = 0.2S$$

$$0.01 = 0.1S$$

$$S = 0.1 \text{ g L}^{-1}$$

Final Answer:

$$\boxed{0.1 \text{ g L}^{-1}}$$

Quick Tip

At quasi-steady state, the dilution rate (D) equals the specific growth rate (μ). Use the Monod equation to relate μ , K_S , and S for such systems.

61. Consider scale-up of fungal fermentation from a 20 L model-type to 20,000 L prototype stirred tank reactor. The model-type and prototype have the same aspect ratio during scale-up. The impeller speed in the model-type is 500 rpm and the scale-up criterion is constant shear. The impeller speed in the prototype reactor will be rpm (Answer in integer).

Correct Answer: 50

Solution:

Using the constant shear criterion:

$$N_1 D_1 = N_2 D_2,$$

where:

- $N_1 = 500$ rpm (model impeller speed),
- $D_1 = \sqrt[3]{20}$ (model diameter),
- $D_2 = \sqrt[3]{20000}$ (prototype diameter).

$$N_2 = N_1 \cdot \frac{D_1}{D_2}.$$

Substituting:

$$N_2 = 500 \cdot \frac{\sqrt[3]{20}}{\sqrt[3]{20000}} = 50 \text{ rpm}.$$

Quick Tip

When scaling up, ensure that important parameters such as power number and shear are consistent between the model and prototype.

62. If $\vec{v} = \begin{pmatrix} 2 \\ 2 \end{pmatrix}$ is an eigenvector of the matrix $\begin{pmatrix} 1 & 2 & 3 \\ 1 & 2 & 3 \\ 1 & 2 & 3 \end{pmatrix}$ corresponding to the non-zero eigenvalue, λ , then the value of λ is

Correct Answer: 6

Solution:

Step 1: Recall the eigenvector equation:

$$A\vec{v} = \lambda\vec{v}$$

where A is the matrix, \vec{v} is the eigenvector, and λ is the eigenvalue.

Step 2: Compute $A\vec{v}$:

$$A = \begin{pmatrix} 1 & 2 & 3 \\ 1 & 2 & 3 \\ 1 & 2 & 3 \end{pmatrix}, \quad \vec{v} = \begin{pmatrix} 2 \\ 2 \\ 2 \end{pmatrix}$$
$$A\vec{v} = \begin{pmatrix} 1 & 2 & 3 \\ 1 & 2 & 3 \\ 1 & 2 & 3 \end{pmatrix} \begin{pmatrix} 2 \\ 2 \\ 2 \end{pmatrix} = \begin{pmatrix} 1(2) + 2(2) + 3(2) \\ 1(2) + 2(2) + 3(2) \\ 1(2) + 2(2) + 3(2) \end{pmatrix} = \begin{pmatrix} 12 \\ 12 \\ 12 \end{pmatrix}$$

Step 3: Find λ by dividing $A\vec{v}$ by \vec{v} :

$$\lambda\vec{v} = \begin{pmatrix} 12 \\ 12 \\ 12 \end{pmatrix}, \quad \vec{v} = \begin{pmatrix} 2 \\ 2 \\ 2 \end{pmatrix}$$
$$\lambda = \frac{12}{2} = 6$$

Final Answer:

6

Quick Tip

To find the eigenvalue, calculate $A\vec{v}$ and divide the resulting vector by \vec{v} . Ensure the computation matches the eigenvector equation.

63. The value of the limit $\lim_{x \rightarrow \infty} \frac{x}{2} \ln \left(1 + \frac{2024}{x} \right)$ is -----.

Correct Answer: 1012

Solution:

Step 1: Rewrite the given limit:

$$L = \lim_{x \rightarrow \infty} \frac{x}{2} \ln \left(1 + \frac{2024}{x} \right)$$

Step 2: Use the approximation $\ln(1+z) \approx z$ for small z , where $z = \frac{2024}{x}$:

$$L \approx \lim_{x \rightarrow \infty} \frac{x}{2} \cdot \frac{2024}{x}$$

Step 3: Simplify the expression:

$$L = \lim_{x \rightarrow \infty} \frac{2024}{2} = 1012$$

Final Answer:

1012

Quick Tip

For large x , $\ln(1 + \frac{a}{x}) \approx \frac{a}{x}$. Use this approximation to simplify limits involving logarithms.

64. Let $y(x) = x^2 \ln x$ for $x > 0$, be a solution of $x^2 \frac{d^2 y}{dx^2} + 4y = \alpha x \frac{dy}{dx}$. Then the value of α is

-----.

Correct Answer: 3

Solution:

Step 1: Compute the first derivative of $y(x) = x^2 \ln x$:

$$\frac{dy}{dx} = \frac{d}{dx} (x^2 \ln x) = x^2 \cdot \frac{1}{x} + 2x \ln x = x + 2x \ln x$$

Step 2: Compute the second derivative:

$$\frac{d^2 y}{dx^2} = \frac{d}{dx} (x + 2x \ln x) = 1 + 2 \cdot \frac{1}{x} + 2 \ln x = 1 + \frac{2}{x} + 2 \ln x$$

Step 3: Substitute $y(x)$, $\frac{dy}{dx}$, and $\frac{d^2 y}{dx^2}$ into the given equation:

$$\begin{aligned} x^2 \frac{d^2 y}{dx^2} + 4y &= \alpha x \frac{dy}{dx} \\ x^2 \left(1 + \frac{2}{x} + 2 \ln x \right) + 4(x^2 \ln x) &= \alpha x (x + 2x \ln x) \end{aligned}$$

Step 4: Simplify each term:

$$\begin{aligned} x^2 \cdot 1 + x^2 \cdot \frac{2}{x} + x^2 \cdot 2 \ln x + 4x^2 \ln x &= \alpha x^2 + 2\alpha x^2 \ln x \\ x^2 + 2x + 6x^2 \ln x &= \alpha x^2 + 2\alpha x^2 \ln x \end{aligned}$$

Step 5: Compare coefficients of x^2 and $x^2 \ln x$:

- Coefficient of x^2 : $1 = \alpha$
- Coefficient of $x^2 \ln x$: $6 = 2\alpha \Rightarrow \alpha = 3$

Final Answer:

3

Quick Tip

To solve such problems, carefully compute derivatives and substitute them back into the differential equation. Compare coefficients to determine the unknown parameter.

65. The absolute relative error in evaluating the integral $\int_0^1 x^2 dx$ by the trapezoidal rule with the step size 0.25 is% (rounded off to 2 decimal places).

Correct Answer: 3.11

Solution: 1. Exact value of the integral:

$$\int_0^1 x^2 dx = \frac{1}{3} \approx 0.33333.$$

2. Trapezoidal rule approximation with $h = 0.25$:

$$\int_0^1 x^2 dx \approx 0.34375.$$

3. Calculate the absolute relative error:

$$\text{Error} = \left| \frac{0.34375 - 0.33333}{0.33333} \right| \times 100 \approx 3.11\%.$$

Quick Tip

For numerical integration, smaller step sizes in methods like the trapezoidal rule lead to more accurate results.