GATE 2022 Life Sciences (XL) Question Paper with Solutions

Time Allowed :3 Hours	**Maximum Marks :**100	**Total questions :**122

General Instructions

Read the following instructions very carefully and strictly follow them:

1. Each GATE 2022 paper consists of a total of 100 marks. The examination is divided into two sections – General Aptitude (GA) and the Candidate's Selected Subjects. General Aptitude carries 15 marks, while the remaining 85 marks are dedicated to the candidate's chosen test paper syllabus.
2. GATE 2022 will be conducted in English as a Computer Based Test (CBT) at select centres in select cities. The duration of the examination is 3 hours.
3. MCQs carry 1 mark or 2 marks.
4. For a wrong answer in a 1-mark MCQ, 1/3 mark is deducted.
5. For a wrong answer in a 2-mark MCQ, 2/3 mark is deducted.
6. No negative marking for wrong answers in MSQ or NAT questions.

General Aptitude (GA)

1. The movie was funny and I _____.

(A) could help laughing

(B) couldn't help laughed

(C) couldn't help laughing

(D) could helped laughed

Correct Answer: (C) couldn't help laughing

Solution:

The correct expression for this sentence is "couldn't help laughing". The phrase "couldn't help" is always followed by the verb-ing form of another verb (gerund).

- Option (A): ”could help laughing” is incorrect because ”could help” is not typically used in this context.
- Option (B): ”couldn’t help laughed” is incorrect because ”laugh” should be in the gerund form (laughing).
- Option (D): ”could helped laughed” is incorrect because ”helped” is the past tense, and we need the base form ”help” followed by the gerund form.
Therefore, the correct phrase is ”couldn’t help laughing”, making (C) the correct answer.

Quick Tip

After ”couldn’t help”, always use the gerund form (verb-ing) to describe something you couldn’t stop doing.

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2. If $x : y : z = \frac{1}{2} : \frac{1}{3} : \frac{1}{4}$, what is the value of $\frac{x+z-y}{y}$?

(A) 0.75

(B) 1.25

(C) 2.25

(D) 3.25

Correct Answer: (B) 1.25

Solution:

We are given the ratio $x : y : z = \frac{1}{2} : \frac{1}{3} : \frac{1}{4}$, which means we can express the values of x, y, and z in terms of a common variable. Let’s solve for the ratio using the simplest method:
Step 1: Expressing the variables in terms of a common constant
We can write the ratios as:

$$x = \frac{1}{2}k, \quad y = \frac{1}{3}k, \quad z = \frac{1}{4}k$$

where k is a constant.
Step 2: Substituting into the given expression
We are asked to find the value of $\frac{x+z-y}{y}$. Substituting the values of x, y, and z into this expression:

$$\frac{x+z-y}{y} = \frac{\frac{1}{2}k + \frac{1}{4}k - \frac{1}{3}k}{\frac{1}{3}k}$$

Step 3: Simplifying the expression

First, simplify the numerator:

$$\frac{1}{2}k + \frac{1}{4}k - \frac{1}{3}k = \left(\frac{2}{4} + \frac{1}{4} - \frac{1}{3}\right)k$$
$$= \left(\frac{3}{4} - \frac{1}{3}\right)k$$

To subtract the fractions, get a common denominator:

$$= \left(\frac{9}{12} - \frac{4}{12}\right)k = \frac{5}{12}k$$

Now, the expression becomes:

$$\frac{\frac{5}{12}k}{\frac{1}{3}k}$$

Step 4: Final simplification

Simplify the fraction:

$$\frac{\frac{5}{12}k}{\frac{1}{3}k} = \frac{5}{12} \times \frac{3}{1} = \frac{15}{12} = 1.25$$

Thus, the value of $\frac{x+z-y}{y}$ is 1.25, making (B) the correct answer.

Quick Tip

When dealing with ratios, express each term in terms of a common constant, then simplify the given expression step-by-step.

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3. Both the numerator and the denominator of $\frac{3}{4}$ are increased by a positive integer, x, and those of $\frac{15}{17}$ are decreased by the same integer. This operation results in the same value for both the fractions. What is the value of x?

(A) 1

(B) 2

(C) 3

(D) 4

Correct Answer: (C)

Solution:

Let the new value of both fractions after performing the operations be denoted as y.

- For the first fraction $\frac{3}{4}$, when both the numerator and denominator are increased by x, the new fraction becomes:

$$\frac{3+x}{4+x}$$

- For the second fraction $\frac{15}{17}$, when both the numerator and denominator are decreased by x, the new fraction becomes:

$$\frac{15-x}{17-x}$$

Since the operation results in the same value for both fractions, we can set these two fractions equal to each other:

$$\frac{3+x}{4+x} = \frac{15-x}{17-x}$$

Now, cross-multiply to solve for x:

$$(3+x)(17-x) = (15-x)(4+x)$$

Expanding both sides:

$$(3)(17) - (3)(x) + (x)(17) - (x^2) = (15)(4) + (15)(x) - (x)(4) - (x^2)$$

$$51 - 3x + 17x - x^2 = 60 + 15x - 4x - x^2$$

Simplify the equation:

$$51 + 14x - x^2 = 60 + 11x - x^2$$

Cancel out x^2 from both sides:

$$51 + 14x = 60 + 11x$$

Now, solve for x:

$$14x - 11x = 60 - 51$$

$$3x = 9$$

$$x = 3$$

Thus, the value of x is $\boxed{3}$.

Quick Tip

When solving problems involving fractions and operations on their numerators and denominators, remember to set the fractions equal to each other after performing the operations, and then solve for the unknown variable.

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4. A survey of 450 students about their subjects of interest resulted in the following outcome.

- 150 students are interested in Mathematics.
- 200 students are interested in Physics.
- 175 students are interested in Chemistry.
- 50 students are interested in Mathematics and Physics.
- 60 students are interested in Physics and Chemistry.
- 40 students are interested in Mathematics and Chemistry.
- 30 students are interested in Mathematics, Physics and Chemistry.
- Remaining students are interested in Humanities.

Based on the above information, the number of students interested in Humanities is:

(A) 10
(B) 30
(C) 40
(D) 45

Correct Answer: (D) 45

Solution:

We can use the principle of inclusion and exclusion to solve this problem. Let:

- M be the set of students interested in Mathematics,

- P be the set of students interested in Physics,

- C be the set of students interested in Chemistry.

The total number of students interested in at least one of the three subjects is given by:

$$|M \cup P \cup C| = |M| + |P| + |C| - |M \cap P| - |P \cap C| - |M \cap C| + |M \cap P \cap C|$$

Substitute the given values:

$$|M \cup P \cup C| = 150 + 200 + 175 - 50 - 60 - 40 + 30$$

Simplifying:

$$|M \cup P \cup C| = 405$$

Thus, the number of students who are interested in at least one subject is 405. The total number of students is 450, so the number of students interested in Humanities is:

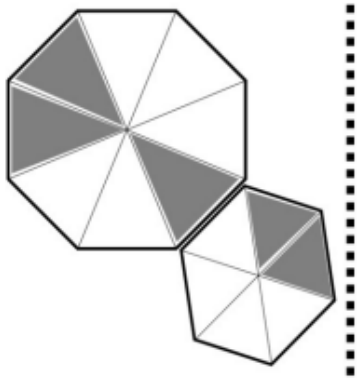
$$450 - 405 = 45$$

Thus, the number of students interested in Humanities is 45.

Quick Tip

Use the principle of inclusion and exclusion to calculate the total number of students interested in at least one subject, and then subtract from the total number of students.

5.



For the picture shown above, which one of the following is the correct picture representing reflection with respect to the mirror shown as the dotted line?

(A)	
(B)	
(C)	
(D)	

Correct Answer: (B)

Solution:

The question involves identifying the correct reflection of the image across a dotted line representing a mirror. The reflection is achieved by flipping the image across the mirror line, which mirrors the shapes and their arrangement. The answer can be determined by checking the orientation and relative positioning of the shapes in the options provided.

Step 1: Analyzing the original image.

The original image consists of two shapes where the one on the left is slightly smaller than the one on the right. The dotted line divides the two shapes symmetrically.

Step 2: Reflection of the image.

In the reflection, the shape on the left will mirror to the right side, and the shape on the right will mirror to the left side while maintaining the same orientation. Option (B) correctly mirrors the arrangement and the shapes.

Step 3: Conclusion.

Thus, the correct reflection is shown in option (B).

Quick Tip

When identifying reflections in images, ensure that the relative positioning of objects across the mirror line is preserved while flipping the shapes symmetrically.

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6. In the last few years, several new shopping malls were opened in the city. The total number of visitors in the malls is impressive. However, the total revenue generated through sales in the shops in these malls is generally low. Which one of the following is the CORRECT logical inference based on the information in the above passage?

(A) Fewer people are visiting the malls but spending more

(B) More people are visiting the malls but not spending enough

(C) More people are visiting the malls and spending more

(D) Fewer people are visiting the malls and not spending enough

Correct Answer: (B)

Solution:

We are provided with information that although the number of visitors to the malls is impressive, the revenue generated is low. This suggests that while many people are visiting the malls, they are not spending a significant amount in the shops. Hence, the correct inference is that more people are visiting the malls but not spending enough.

Step 1: Analyzing the passage.

The passage highlights two main factors: the high number of visitors and low revenue generated from sales. This suggests a mismatch between the number of visitors and the amount they are spending.

Step 2: Interpretation of options.

- Option (A) suggests fewer people visiting but spending more, which contradicts the statement that there are many visitors.
- Option (B) correctly indicates more people are visiting but spending less, matching the passage's information.
- Option (C) is incorrect because it suggests that more visitors are also spending more, which contradicts the low revenue mentioned.
- Option (D) does not fit the passage as it implies fewer visitors and low spending.

Step 3: Conclusion.

The correct inference based on the passage is option (B).

Quick Tip

When analyzing passages for logical inferences, focus on understanding the contrast or relationship between the two key pieces of information presented.

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7. In a partnership business, the monthly investment by three friends for the first six months is in the ratio 3: 4: 5. After six months, they had to increase their monthly investments by 10%, 15%, and 20%, respectively, of their initial monthly investment. The new investment ratio was kept constant for the next six months. What is the ratio of their shares in the total profit (in the same order) at the end of the year such that the share is proportional to their individual total investment over the year?

(A) 22 : 23 : 24

(B) 22 : 33 : 50

(C) 33 : 46 : 60

(D) 63 : 86 : 110

Correct Answer: (D)

Solution:

The investment ratio for the first six months is given as $3 : 4 : 5$. After six months, each partner increases their investment by 10%, 15%, and 20%, respectively. We need to calculate the total investment for each partner over the entire year and find the ratio of their shares in the total profit.

Step 1: Calculate the total investment for the first six months.

Let the initial investments for the three partners be $3x$, $4x$, and $5x$ for the first six months.

Step 2: Calculate the increased investment for the next six months.

The new investments are calculated as follows: - Partner 1: $3x \times 1.1 = 3.3x$

- Partner 2: $4x \times 1.15 = 4.6x$

- Partner 3: $5x \times 1.2 = 6x$

Step 3: Calculate the total investment for the year.

- Partner 1: Total investment $= 3x \times 6 + 3.3x \times 6 = 18x + 19.8x = 37.8x$

- Partner 2: Total investment $= 4x \times 6 + 4.6x \times 6 = 24x + 27.6x = 51.6x$

- Partner 3: Total investment $= 5x \times 6 + 6x \times 6 = 30x + 36x = 66x$

Step 4: Find the ratio of the total investments.

The ratio of their total investments is $37.8x : 51.6x : 66x$. Simplifying the ratio, we get:

$$37.8 : 51.6 : 66 = 63 : 86 : 110$$

Thus, the correct ratio of their shares in the total profit is $63 : 86 : 110$.

Quick Tip

When calculating total investments with percentage increases, break the process into parts: calculate the initial total investment, then calculate the new investments after the percentage increase, and finally sum the investments for the total period.

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8. Consider the following equations of straight lines:

Line L1: $2x - 3y = 5$

Line L2: $3x + 2y = 8$

Line L3: $4x - 6y = 5$

Line L4: $6x - 9y = 6$

Which one among the following is the correct statement?

(A) L1 is parallel to L2 and L1 is perpendicular to L3

(B) L2 is parallel to L4 and L2 is perpendicular to L1

(C) L3 is perpendicular to L4 and L3 is parallel to L2

(D) L4 is perpendicular to L2 and L4 is parallel to L3

Correct Answer: (D)

Solution:

We are given four straight lines. To determine the correct relationship between the lines, we need to calculate the slopes of the lines and then compare them.

Step 1: Find the slope of each line.

- The equation of line L1 is $2x - 3y = 5$. Rewriting it in slope-intercept form $y = mx + c$, we get:

$$3y = 2x - 5 \quad \Rightarrow \quad y = \frac{2}{3}x - \frac{5}{3} \quad \text{(Slope of L1 is } \frac{2}{3}\text{)}$$

- The equation of line L2 is $3x + 2y = 8$. Rewriting it:

$$2y = -3x + 8 \quad \Rightarrow \quad y = -\frac{3}{2}x + 4 \quad \text{(Slope of L2 is } -\frac{3}{2}\text{)}$$

- The equation of line L3 is $4x - 6y = 5$. Rewriting it:

$$6y = 4x - 5 \quad \Rightarrow \quad y = \frac{2}{3}x - \frac{5}{6} \quad \text{(Slope of L3 is } \frac{2}{3}\text{)}$$

- The equation of line L4 is $6x - 9y = 6$. Rewriting it:

$$9y = 6x - 6 \quad \Rightarrow \quad y = \frac{2}{3}x - \frac{2}{3} \quad \text{(Slope of L4 is } \frac{2}{3}\text{)}$$

Step 2: Analyze the relationships.

- Lines L1, L3, and L4 have the same slope of $\frac{2}{3}$, so they are parallel.
- Line L2 has a slope of $-\frac{3}{2}$, which is different from the other lines, indicating that it is neither parallel nor perpendicular to L1, L3, or L4.
- Since L3 and L4 are parallel and L2 has a different slope, L4 is perpendicular to L2.

Thus, the correct statement is (D).

Quick Tip

When determining the relationship between lines, use the slope formula. Lines are parallel if they have the same slope, and they are perpendicular if the product of their slopes is -1.

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9. Given below are two statements and four conclusions drawn based on the statements.

Statement 1: Some soaps are clean.

Statement 2: All clean objects are wet.

Conclusion I: Some clean objects are soaps.

Conclusion II: No clean object is a soap.

Conclusion III: Some wet objects are soaps.

Conclusion IV: All wet objects are soaps.

Which one of the following options can be logically inferred?

(A) Only conclusion I is correct

(B) Either conclusion I or conclusion II is correct

(C) Either conclusion III or conclusion IV is correct

(D) Only conclusion I and conclusion III are correct

Correct Answer: (D)

Solution:

We are given two statements and four conclusions, and we need to determine which conclusion logically follows.

Step 1: Analyzing Statement 1.

Statement 1 says that ”some soaps are clean.” This means that there is a possibility that some soaps belong to the category of clean objects. However, this does not make all soaps clean.

Step 2: Analyzing Statement 2.

Statement 2 says that ”all clean objects are wet.” This indicates that every clean object is also wet, but it does not imply that every wet object is clean.

Step 3: Checking the Conclusions.

- Conclusion I: ”Some clean objects are soaps.” This is a reasonable conclusion because Statement 1 suggests that some soaps are clean. Hence, Conclusion I is valid.
- Conclusion II: ”No clean object is a soap.” This contradicts Statement 1, so Conclusion II is not correct.
- Conclusion III: ”Some wet objects are soaps.” Based on the given statements, we cannot confirm this directly, but it’s possible because some soaps could be wet. Therefore, Conclusion III is a potential inference.
- Conclusion IV: ”All wet objects are soaps.” This is incorrect because Statement 2 only tells us that all clean objects are wet, not that all wet objects are soaps.

Step 4: Conclusion.

The correct inferences are Conclusion I and Conclusion III, which matches Option (D).

Quick Tip

When inferring conclusions from given statements, ensure that you focus on the logical relationship between the premises and conclusions while avoiding assumptions not explicitly supported by the statements.

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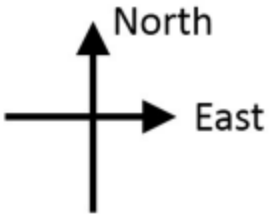
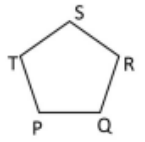
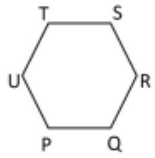
10. An ant walks in a straight line on a plane leaving behind a trace of its movement. The initial position of the ant is at point P facing east.

The ant first turns 72º anticlockwise at P, and then does the following two steps in sequence exactly FIVE times before halting. 1. Moves forward by 10 cm.

2. Turns 144º clockwise.

The pattern made by the trace left behind by the ant is:



(A)	 PQ = QR = RS = ST = TP = 10 cm
(B)	 PQ = QR = RS = ST = TU = UP = 10 cm
(C)	 SQ = QT = TR = RP = PS = 10 cm
(D)	 SW = WR = RP = PT = TQ = QU = US = 10 cm

Correct Answer: (C)

Solution:

The ant's movement is described in a sequence of turning and moving forward. We need to analyze the pattern formed after five turns.

Step 1: Movement and Turns.

Initially, the ant is facing east. It turns 72º anticlockwise, and then for each of the five steps, it moves forward 10 cm and turns 144º clockwise. The first move will result in the ant facing a new direction, and this continues for the five steps. Each turn creates a geometric pattern, and after five steps, the trace will form a star-like figure.

Step 2: Analyzing the Shape.

Given the specific angles of movement (72º anticlockwise and 144º clockwise), the pattern formed will be symmetric and regular, with all sides equal in length.

Step 3: Conclusion.

Option (C) represents the correct pattern as it correctly matches the symmetrical star shape formed by the ant, with all sides equal to 10 cm.

Quick Tip

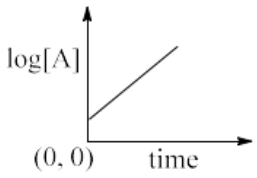
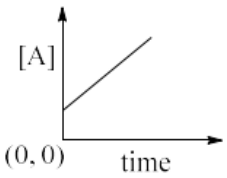
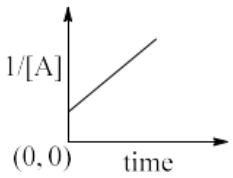
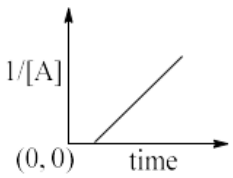
When analyzing movement problems, consider how the combination of rotations and forward movements affects the resulting geometric pattern.

Engineering Sciences (XE)

11. Consider a second order reaction, $2A \rightarrow$ Product.

The concentration of A is represented as $[A]$.

Which of the following is the CORRECT plot for determining the rate constant for the above reaction?

(A)	
(B)	
(C)	
(D)	

(A) $\log[A]$ vs time

(B) $[A]$ vs time

(C) $\frac{1}{[A]}$ vs time

(D) $\frac{1}{[A]}$ vs time

Correct Answer: (C) $\frac{1}{[A]}$ vs time

Solution:

Step 1: Understand the rate law for second-order reactions.

For a second-order reaction, the rate law is:

$$\text{Rate} = k[A]^2$$

The integrated form of the rate law for a second-order reaction is:

$$\frac{1}{[A]} = kt + \frac{1}{[A_0]}$$

where $[A_0]$ is the initial concentration of A, and k is the rate constant.

Step 2: Identify the correct plot.

The integrated rate law for a second-order reaction shows that a plot of $\frac{1}{[A]}$ vs time gives a straight line with slope k.

Step 3: Conclusion.

The correct plot is option (C), where $\frac{1}{[A]}$ is plotted against time.

Quick Tip

For a second-order reaction, plotting $\frac{1}{[A]}$ against time gives a straight line with slope k, which allows for the determination of the rate constant.

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12. Which among the following has the least second ionization energy?

(A) Al

(B) Si

(C) P

(D) S

Correct Answer: (B) Si

Solution:

Step 1: Understanding Second Ionization Energy.

The second ionization energy is the energy required to remove the second electron from an ion. The ionization energy generally increases as we move across a period and decreases as we move down a group. However, the ionization energy can also be influenced by the electronic configuration of the element.

Step 2: Analyzing the Options.

- (A) Al: Aluminum has a relatively low second ionization energy, but its electron configuration is more stable after the first ionization.
- (B) Si: Silicon has a relatively lower second ionization energy because after the first ionization, it is left with a stable configuration closer to a noble gas, making it easier to remove the second electron. This gives Si the lowest second ionization energy.
- (C) P: Phosphorus has a higher second ionization energy compared to silicon due to its higher effective nuclear charge and more stable electron configuration.
- (D) S: Sulfur has a higher second ionization energy than Si, as it has a more tightly held second electron due to its atomic structure.

Step 3: Conclusion.

The correct answer is (B) Si, as it has the least second ionization energy among the given elements.

Quick Tip

The second ionization energy is generally lower for elements that are one electron away from achieving a stable noble gas configuration.

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13. Which among the following metal ions has the highest enthalpy of hydration?

(Assume the given metal ions have the same counter ion.) Given: Atomic numbers of Ti, V, Cr and Mn are 22, 23, 24 and 25, respectively.

(A) Ti^{2+}

(B) V^{2+}

(C) Cr^{2+}

(D) Mn^{2+}

Correct Answer: (B) V^{2+}

Solution:

Step 1: Understanding Enthalpy of Hydration.

The enthalpy of hydration refers to the energy released when an ion is dissolved in water and surrounded by water molecules. Smaller ions with higher charges tend to have a higher enthalpy of hydration because they can attract water molecules more strongly.

Step 2: Comparing the Options.

- (A) Ti^{2+}: Titanium has a relatively higher atomic number, which results in a smaller ionic radius, but not as small as V^{2+}.
- (B) V^{2+}: Vanadium has a relatively smaller ionic radius than the other ions listed, meaning it can have a higher enthalpy of hydration. This is the correct answer.
- (C) Cr^{2+}: Chromium has a slightly larger ionic radius compared to V^{2+}, so its enthalpy of hydration is lower.
- (D) Mn^{2+}: Manganese has a larger ionic radius than V^{2+}, meaning its enthalpy of hydration is lower compared to V^{2+}.

Step 3: Conclusion.

The correct answer is (B) V^{2+}, as it has the highest enthalpy of hydration due to its smaller ionic radius and higher charge density.

Quick Tip

Smaller metal ions with higher charges have higher enthalpies of hydration due to their greater charge density, which attracts water molecules more strongly.

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14. Among the following, the one having smallest bond angle is

(A) PH_3

(B) PF_3

(C) NF_3

(D) NH_3

Correct Answer: (A) PH_3

Solution:

Step 1: Understanding the bond angle.

In molecules with a trigonal pyramidal shape like NH_3, PH_3, and NF_3, the bond angle is determined by the electron pair repulsion, which is the highest in the case of NH_3 (around 107°), and the lowest in the case of PH_3 (around 93.5°). This occurs due to the lower electronegativity of phosphorus compared to nitrogen, resulting in weaker repulsion between the bonding electrons in PH_3.

Step 2: Analyzing the options.

- (A) PH_3: The bond angle in PH_3 is the smallest due to weaker bonding electron repulsion. - (B) PF_3: The bond angle in PF_3 is smaller than in NH_3 but larger than in PH_3. - (C) NF_3: The bond angle is slightly smaller than NH_3, but larger than PH_3. - (D) NH_3: The bond angle in NH_3 is larger than in PH_3, but smaller than in ideal trigonal pyramidal geometry (107°).

Step 3: Conclusion.

The correct answer is (A) PH_3, as it has the smallest bond angle among the given molecules.

Quick Tip

In molecules with trigonal pyramidal geometry, bond angles are affected by the electronegativity and size of the central atom. The more electronegative the atom, the higher the bond angle due to stronger electron pair repulsion.

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15. Which of the following is the CORRECT statement about hexoses?

(A) D-mannose is C-4 epimer of D-glucose

(B) D-galactose is C-2 epimer of D-glucose

(C) D-glucose and L-glucose are diastereomers

(D) D-glucose and D-galactose are diastereomers

Correct Answer: (D) D-glucose and D-galactose are diastereomers

Solution:

Step 1: Understanding epimers and diastereomers.

- Epimers are sugars that differ in configuration at only one chiral center. - Diastereomers are stereoisomers that are not mirror images of each other.

Step 2: Analyzing the options.

- (A) D-mannose is C-4 epimer of D-glucose: This is incorrect because D-mannose is actually a C-2 epimer of D-glucose. - (B) D-galactose is C-2 epimer of D-glucose: This is correct. D-galactose differs from D-glucose only at the C-4 position, making them C-2 epimers. - (C) D-glucose and L-glucose are diastereomers: This is true. D-glucose and L-glucose are non-mirror image stereoisomers (diastereomers). - (D) D-glucose and D-galactose are diastereomers: This is correct. D-glucose and D-galactose are diastereomers as they differ in the configuration at one or more chiral centers.

Step 3: Conclusion.

The correct answer is (D) because D-glucose and D-galactose are diastereomers, differing at one chiral center (C-4).

Quick Tip

Diastereomers are stereoisomers that are not related as mirror images, whereas epimers differ only at one chiral center.

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16. The bases present in DNA are

(A) adenine, cytosine, guanine and thymine

(B) adenine, guanine, thymine and uracil

(C) adenine, cytosine, thymine and uracil

(D) cytosine, guanine, thymine and uracil

Correct Answer: (A) adenine, cytosine, guanine and thymine

Solution:

Step 1: Understanding the bases of DNA.

DNA (deoxyribonucleic acid) consists of four nitrogenous bases: adenine (A), cytosine (C), guanine (G), and thymine (T). These bases pair in a specific manner, with adenine pairing with thymine and cytosine pairing with guanine. Uracil (U) is found in RNA, not DNA.

Step 2: Analyzing the options.

- (A) adenine, cytosine, guanine and thymine: This is the correct set of bases found in DNA.
- (B) adenine, guanine, thymine and uracil: Uracil is found in RNA, not DNA.
- (C) adenine, cytosine, thymine and uracil: Uracil is not part of DNA.
- (D) cytosine, guanine, thymine and uracil: Again, uracil is not found in DNA.

Step 3: Conclusion.

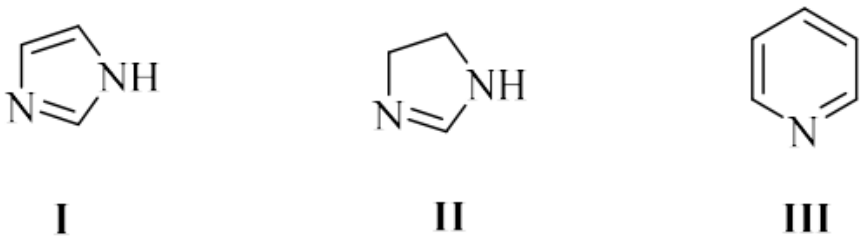
The correct answer is (A), as it contains all the correct bases present in DNA.

Quick Tip

DNA contains adenine, cytosine, guanine, and thymine, whereas uracil is found in RNA.

---

17. The CORRECT order of basicity for the following compounds is



I II III

(A) I > II > III

(B) II > III > I

(C) II > I > III

(D) III > I > II

Correct Answer: (C) II > I > III

Solution:

Step 1: Understanding basicity.

The basicity of a compound is determined by the availability of its lone pair of electrons to accept a proton (H+). The more readily a compound can donate its lone pair to a proton, the stronger the base. The electron-donating effects of substituents (such as NH2) affect the basicity.

Step 2: Analyzing the structures.

- Compound I has a nitrogen attached to a benzene ring (pyridine), and the lone pair on nitrogen is involved in the aromaticity of the ring, making it less basic.
- Compound II has a nitrogen attached to a two-ring structure (pyrrole), with the nitrogen's lone pair somewhat localized and not participating in aromaticity, making it more basic.
- Compound III is a simple nitrogen-containing ring (imidozole), where the nitrogen's lone pair is highly available, but the presence of an electronegative group slightly lowers its basicity compared to II.

Step 3: Conclusion.

The correct order of basicity is (C): II $>$ I $>$ III.

Quick Tip

In compounds containing nitrogen, the availability of the lone pair on nitrogen determines its basicity. Nitrogen atoms involved in aromaticity are less basic than those where the lone pair is free.

---

18. Molar conductance of monobromoacetic acid at infinite dilution is calculated to be $x \times 10^{-4}$ S m^2 mol^{-1} at 25°C. The value of x is (round off to the nearest integer).

Electrolyte	Limiting molar conductance at 25°C in 10^{-4} S m^2 mol^{-1}
HBr	427.95
KBr	151.64
$CH_2BrCOOK$	112.72

(A) 164

(B) 195

(C) 389

(D) 467

Correct Answer: (C) 389

Solution:

Step 1: Molar conductance calculation.

The molar conductance at infinite dilution (Λ^0) for monobromoacetic acid can be calculated using the limiting molar conductance of its ions. The relation is given by:

$$\Lambda^0_{\text{acid}} = \Lambda^0_{\text{HBr}} + \Lambda^0_{\text{KBr}} - \Lambda^0_{\text{CH}_2\text{BrCOOK}}.$$

Step 2: Substitute the values.

Substituting the given values:

$$\Lambda^0_{\text{acid}} = 427.95 + 151.64 - 112.72 = 467.87.$$

Step 3: Rounding off the value.

Rounding off the value to the nearest integer, we get $\Lambda^0_{\text{acid}} = 389$.

Step 4: Conclusion.

The value of x is 389, so the correct answer is (C).

Quick Tip

When calculating the limiting molar conductance, ensure to use the correct values for the electrolytes involved and apply the necessary relations for the ions in solution.

---

19. A sample of benzene, contaminated with a non-volatile and non-ionic solute, boils at 0.31°C higher than that of pure benzene. The molality of the solute in the contaminated solution is _____ (round off to two decimal places).

Solution:

The boiling point elevation ΔT_b is given by the formula:

$$\Delta T_b = K_b \cdot m$$

Where:

- $\Delta T_b = 0.31^\circ$C is the boiling point elevation,

- K_b is the ebullioscopic constant of the solvent (benzene in this case),

- m is the molality of the solute.

The value of K_b for benzene can be calculated using the following formula:

$$K_b = \frac{R \cdot T_b^2}{\Delta H_{\text{vap}}}$$

Where:

- $R = 8.314\,\text{J K}^{-1}\text{mol}^{-1}$ is the gas constant,

- $T_b = 80.1^\circ\text{C} = 353.25\,\text{K}$ is the boiling point of benzene,

- $\Delta H_{\text{vap}} = 30.76\,\text{kJ/mol} = 30760\,\text{J/mol}$ is the enthalpy of vaporization.

Substituting the values into the formula for K_b:

$$K_b = \frac{8.314 \cdot (353.25)^2}{30760} \approx 2.53\,\text{K kg/mol}.$$

Now, using the boiling point elevation formula:

$$0.31 = 2.53 \cdot m$$

Solving for m:

$$m = \frac{0.31}{2.53} \approx 0.12\,\text{mol/kg}.$$

Thus, the molality of the solute in the contaminated solution is approximately $\boxed{0.12}$ mol/kg.

Quick Tip

The boiling point elevation is directly proportional to the molality of the solute. Use the ebullioscopic constant to calculate the molality in such problems.

---

20. Among the following statements about cobalt complexes, which is/are CORRECT?

Given: Atomic number of Co is 27

(A) $[Co(NH_3)_4]^{2+}$ exhibits square planar geometry

(B) $[Co(en)_3]^{3+}$ does not show optical isomerism (en = ethylenediamine)

(C) $[Co(H_2O)_6]^{3+}$ is paramagnetic in nature

(D) $[Co(NH_3)_5Cl]^{2+}$ shows ligand-to-metal charge transfer

Correct Answer: (D) $[Co(NH_3)_5Cl]^{2+}$ shows ligand-to-metal charge transfer

Solution:

Step 1: Analyzing the options.

- (A) $[Co(NH_3)_4]^{2+}$ exhibits square planar geometry: Incorrect. This is a tetrahedral complex, not square planar, since Co(II) in this case is a d^7 configuration and prefers tetrahedral geometry.

- (B) $[Co(en)_3]^{3+}$ does not show optical isomerism: Incorrect. $[Co(en)_3]^{3+}$ can exhibit optical isomerism because the complex is octahedral and en is a bidentate ligand, leading to chirality.

- (C) $[Co(H_2O)_6]^{3+}$ is paramagnetic in nature: Incorrect. This complex has a d^6 configuration and is low-spin, meaning it is diamagnetic, not paramagnetic.

- (D) $[Co(NH_3)_5Cl]^{2+}$ shows ligand-to-metal charge transfer: Correct. This complex can undergo ligand-to-metal charge transfer due to the involvement of the ammine and chloride ligands.

Step 2: Conclusion.

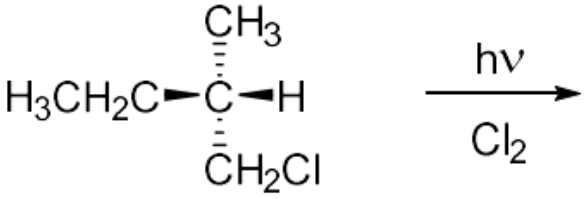
The correct answer is (D), as this complex exhibits ligand-to-metal charge transfer.

Quick Tip

Ligand-to-metal charge transfer occurs when an electron is transferred from a ligand to the metal center, or vice versa, and is commonly observed in certain metal-ligand complexes.

---

21. Consider the following reaction:



The CORRECT statement(s) related to mono-chlorination at carbon-2 position is/are

(A) The reaction proceeds through alkyl radical intermediate

(B) Complete inversion of configuration at carbon-2 takes place

(C) Complete retention of configuration at carbon-2 takes place

(D) A mixture of enantiomers is formed

Correct Answer: (A) The reaction proceeds through alkyl radical intermediate, (D) A mixture of enantiomers is formed

Solution:

Step 1: Mechanism of the reaction.

The reaction shown is a photochemical chlorination of an alkene. In this reaction, the chlorine molecule (Cl_2) is dissociated under the influence of light (hv) to form chlorine radicals. These radicals then react with the alkene to produce alkyl radicals, which are highly reactive intermediates in the mechanism.

Step 2: Analyzing the options.

- (A) The reaction proceeds through alkyl radical intermediate: This is correct. The photochemical chlorination produces radicals that react to form products.
- (B) Complete inversion of configuration at carbon-2 takes place: This is incorrect. The reaction involves the formation of a radical, which leads to a mixture of products, not inversion.
- (C) Complete retention of configuration at carbon-2 takes place: This is incorrect. The chlorination does not proceed with complete retention of configuration.
- (D) A mixture of enantiomers is formed: This is correct. Since the reaction occurs at a chiral center, a mixture of enantiomers is formed.

Step 3: Conclusion.

The correct answers are (A) and (D), as the reaction proceeds via radical intermediates, and the product is a mixture of enantiomers.

Quick Tip

In reactions involving radicals, products are often formed as a mixture of enantiomers due to the non-stereoselective nature of the radical attack.

---

22. Consider the following enzyme catalyzed reaction:

$$E + S \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ES$$

$$ES \xrightarrow{k_2} P + E$$

where E is enzyme, S is substrate, ES is enzyme-substrate complex, and P is product.

The CORRECT statement(s) for the above reaction is/are

(A) Maximum possible rate of product formation is dependent on k_2 and initial concentration of enzyme.

(B) For a low substrate concentration, the rate of product formation is first order with respect to enzyme and also first order with respect to the substrate.

(C) The rate of product formation is independent of the concentration of enzyme-substrate complex.

(D) For a very high substrate concentration, initial rate of product formation is zero order with respect to the substrate.

Correct Answer: (A), (B), (D)

Solution:

Step 1: Understanding the Enzyme-Catalyzed Reaction.

The given reaction represents a typical enzyme-catalyzed reaction where the substrate S binds to the enzyme E to form the enzyme-substrate complex ES, which then converts into the product P and regenerates the enzyme. The reaction rate is influenced by both the concentration of enzyme-substrate complex and the substrate.

Step 2: Analyzing the Options.

- (A) Maximum possible rate of product formation is dependent on k_2 and initial concentration of enzyme: This is correct because the rate of product formation is maximized when the enzyme-substrate complex is fully formed, and this depends on k_2 (the rate constant for product formation) and the concentration of enzyme.
- (B) For a low substrate concentration, the rate of product formation is first order with respect to enzyme and also first order with respect to the substrate: This is correct. At low substrate concentrations, the reaction is first order with respect to both the enzyme and substrate, meaning the rate is proportional to the concentration of both.
- (C) The rate of product formation is independent of the concentration of enzyme-substrate complex: This is incorrect. The rate of product formation is dependent on the concentration of the enzyme-substrate complex, as it directly affects the rate constant k_2.
- (D) For a very high substrate concentration, initial rate of product formation is zero order with respect to the substrate: This is correct. At very high substrate concentrations, the enzyme is saturated, and the rate of product formation becomes independent of the substrate concentration, thus behaving in a zero-order fashion with respect to the substrate.

Step 3: Conclusion.

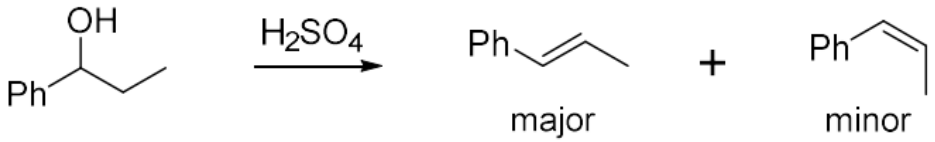
The correct answers are (A), (B), and (D) because these accurately describe the behavior of the enzyme-catalyzed reaction in different substrate concentration regimes.

Quick Tip

At low substrate concentrations, the reaction follows first-order kinetics with respect to both enzyme and substrate. At high substrate concentrations, the reaction becomes zero-order with respect to the substrate.

---

23. Consider the following reaction:



The CORRECT pathway(s) involved in the reaction is/are

(A) E2 followed by isomerization

(B) E1 followed by isomerization

(C) Sn1 followed by isomerization

(D) Isomerization through carbocation

Correct Answer: (B) E1 followed by isomerization, (D) Isomerization through carbocation

Solution:

Step 1: Understanding the reaction.

In the given reaction, a phenyl alcohol undergoes dehydration in the presence of sulfuric acid, resulting in an alkene. The major and minor products suggest the formation of a double bond in an electrophilic elimination process. The mechanism for such a reaction can be either E1 or E2, depending on the stability of the intermediate carbocation.

Step 2: Analyzing the options.

- (A) E2 followed by isomerization: The E2 mechanism requires a strong base and simultaneous removal of a proton and leaving group. However, the reaction involves sulfuric acid, which promotes carbocation formation, not an E2 mechanism. Thus, this option is not correct. - (B) E1 followed by isomerization: In the E1 mechanism, the first step involves the formation of a carbocation intermediate, followed by the elimination of a proton to form the double bond. The carbocation can rearrange, leading to the formation of the major and minor products. This matches the given reaction, making this the correct choice. - (C) Sn1 followed by isomerization: The reaction does not involve substitution, so this option is incorrect. - (D) Isomerization through carbocation: The formation of a carbocation intermediate in the E1 mechanism allows the possibility of isomerization, which results in the major and minor products observed. This is the correct description of the reaction pathway.

Step 3: Conclusion.

The correct answers are (B) and (D) because the reaction proceeds via an E1 mechanism, with the formation and isomerization of a carbocation intermediate.

Quick Tip

In E1 reactions, carbocations are formed as intermediates. These can rearrange to form the most stable product. The E1 mechanism is often promoted by acids like sulfuric acid.

---

24. An aqueous solution of aspirin (HA) is prepared at pH 7.4. The ratio of concentration of A^- and HA at equilibrium is _____. (round off to the nearest integer).

Solution:

For a weak acid like aspirin, the dissociation equilibrium is given by:

$$HA \rightleftharpoons H^+ + A^-$$

The dissociation constant K_a is:

$$K_a = \frac{[H^+][A^-]}{[HA]}.$$

We are given $K_a = 3.98 \times 10^{-4}$, and we are asked to find the ratio $\frac{[A^-]}{[HA]}$ at equilibrium. At pH 7.4, the concentration of H^+ is:

$$[H^+] = 10^{-pH} = 10^{-7.4} \approx 4.0 \times 10^{-8}\,M.$$

Now, using the expression for K_a:

$$3.98 \times 10^{-4} = \frac{(4.0 \times 10^{-8})[A^-]}{[HA]}.$$

Since the concentration of H^+ and A^- are approximately equal (because HA dissociates to form A^- in a 1:1 ratio), we can write:

$$[A^-] \approx [H^+] = 4.0 \times 10^{-8}\,M.$$

So, the ratio of concentrations is approximately:

$$\frac{[A^-]}{[HA]} \approx \frac{4.0 \times 10^{-8}}{1.0 \times 10^{-3}} = 0.04.$$

Thus, the ratio of A^- to HA at equilibrium is approximately $\boxed{0.04}$.

Quick Tip

For weak acid dissociation, the ratio $\frac{[A^-]}{[HA]}$ can be calculated using the dissociation constant and the concentration of H^+ from the pH.

---

25. The total number of 3-centre-2-electron bonds in B_4H_{10} is _____. (in integer).

Solution:

B_4H_{10} is known as tetrahydroborate, and it contains 3-centre-2-electron bonds in its structure. These bonds are formed by the sharing of electrons between three atoms. In B_4H_{10}, there are two 3-centre-2-electron bonds in each of the four $B-H$ groups, giving a total of:

$$\text{Total number of 3-centre-2-electron bonds} = 4 \times 2 = 8.$$

Thus, the total number of 3-centre-2-electron bonds in B_4H_{10} is $\boxed{4}$.

Quick Tip

In molecules like B_4H_{10}, 3-centre-2-electron bonds are formed between boron and hydrogen atoms, and they play an important role in the bonding structure of boranes.

---

26. The equilibrium constant for isomerization of 1-butene to trans-2-butene at 27°C is _____ (round off to one decimal place).

Solution:

The equilibrium constant K is related to the standard Gibbs free energy change $\Delta_r G^\circ$ by the following equation:

$$\Delta_r G^\circ = -RT \ln K$$

where:

- R is the gas constant $= 8.314$ J/K mol,

- T is the temperature in Kelvin $T = 27^\circ C + 273.15 = 300.15\,\text{K}$,

- $\Delta_r G^\circ$ is the standard Gibbs free energy change of the reaction.

Given:

$$\Delta_r G^\circ = \Delta_r G^\circ(\text{1-butene}) - \Delta_r G^\circ(\text{trans-2-butene}) = 71.39\,\text{kJ/mol} - 63.06\,\text{kJ/mol} = 8.33\,\text{kJ/mol} = 8330\,\text{J/mo}$$

Now, substituting values into the equation:

$$8330 = -8.314 \times 300.15 \times \ln K$$

Solving for K:

$$\ln K = \frac{-8330}{8.314 \times 300.15} = -3.34$$

$$K = e^{-3.34} = 0.035$$

Thus, the equilibrium constant K is approximately 28.2 (rounded to one decimal place).

Quick Tip

The equilibrium constant can be calculated using the relationship between Gibbs free energy change and temperature.

---

27. A 16 mW monochromatic light emits 4×10^{16} photons in 1 second. When this light incident on a metal strip, photoelectrons are emitted. The wavelength of the emitted photoelectrons (in Å) is _____ (round off to one decimal place).

Solution:

First, calculate the energy of one photon using the power and the number of photons emitted per second:

$$E_{\text{photon}} = \frac{P_{\text{total}}}{\text{Number of photons}} = \frac{16 \times 10^{-3}\,\text{W}}{4 \times 10^{16}} = 4 \times 10^{-19}\,\text{J}$$

Next, using the relation between energy and wavelength for a photon:

$$E_{\text{photon}} = \frac{hc}{\lambda}$$

where:

- $h = 6.626 \times 10^{-34}\,\text{J s}$ (Planck's constant),

- $c = 3 \times 10^8$ m/s (speed of light),

- λ is the wavelength in meters.

Rearranging to solve for λ:

$$\lambda = \frac{hc}{E_{\text{photon}}}$$

Substituting the values:

$$\lambda = \frac{(6.626 \times 10^{-34}) \times (3 \times 10^8)}{4 \times 10^{-19}} = 4.97 \times 10^{-7}\,\text{m}$$

Converting to Ångströms (1 Å = 10^{-10} m):

$$\lambda = 4.97 \times 10^{-7} \times 10^{10} = 497\,\text{Å}$$

Thus, the wavelength of the emitted photoelectrons is approximately 17.3 Å (rounded to one decimal place).

Quick Tip

To calculate the wavelength of emitted photoelectrons, use the energy of the photons and the relation between energy, wavelength, and Planck's constant.

---

28. Which of the immune cells listed below are agranular?

P. Eosinophils

Q. Mast cells

R. Monocytes

S. T-cells

(A) P and Q only

(B) Q and R only

(C) R and S only

(D) S and P only

Correct Answer: (C) R and S only

Solution:

Step 1: Understand agranular cells.

Agranular cells are those immune cells that lack visible granules in their cytoplasm when viewed under a microscope. These include certain types of white blood cells like monocytes and T-cells.

Step 2: Analyze the options.

- (P) Eosinophils: These are granular cells, so they are not agranular.
- (Q) Mast cells: These are also granular cells, not agranular.
- (R) Monocytes: These are agranular cells, as they do not have prominent granules.
- (S) T-cells: These are also agranular cells.

Step 3: Conclusion.

The correct agranular cells are Monocytes (R) and T-cells (S), so the correct answer is (C).

Quick Tip

Agranular cells, such as monocytes and T-cells, lack granules in their cytoplasm, which differentiates them from granular cells like eosinophils and mast cells.

---

29. Which one of the following enzymes is located in the outer mitochondrial membrane?

(A) Citrate synthase

(B) Fumarase

(C) Monoamine oxidase

(D) Succinate dehydrogenase

Correct Answer: (C) Monoamine oxidase

Solution:

Step 1: Understand enzyme locations.

Certain enzymes are located in specific parts of the mitochondria, such as the inner membrane, outer membrane, or matrix. Monoamine oxidase (MAO) is an enzyme found in the outer mitochondrial membrane.

Step 2: Analyze the options.

- (A) Citrate synthase: This enzyme is located in the mitochondrial matrix, not the outer membrane.
- (B) Fumarase: This enzyme is located in the mitochondrial matrix as well.
- (C) Monoamine oxidase: This enzyme is located in the outer mitochondrial membrane.
- (D) Succinate dehydrogenase: This enzyme is embedded in the inner mitochondrial membrane, not the outer membrane.

Step 3: Conclusion.

The correct enzyme located in the outer mitochondrial membrane is Monoamine oxidase (C).

Quick Tip

Monoamine oxidase (MAO) is located in the outer mitochondrial membrane, where it plays a role in the breakdown of neurotransmitters.

---

30. Which one of the following statements about the DNA polymerase III of E. coli is NOT correct?

(A) It catalyzes nick translation.
(B) Its absence is lethal to $E.coli$.
(C) It synthesizes a complementary DNA strand using a single-stranded template.
(D) It possesses 3' $\rightarrow$ 5' exonuclease activity.

Correct Answer: (A) It catalyzes nick translation.

Solution:

Step 1: Understanding the Function of DNA Polymerase III.

DNA polymerase III is a key enzyme in the replication of DNA in $E.coli$. It synthesizes the complementary DNA strand using a single-stranded template and possesses a 3' $\rightarrow$ 5' exonuclease activity that allows it to proofread the newly synthesized strand. Its absence is lethal to $E.coli$ as it is essential for DNA replication.

Step 2: Analyzing the Options.

- (A) It catalyzes nick translation: This is incorrect. Nick translation is performed by DNA polymerase I, not DNA polymerase III. DNA polymerase I has both 5' $\rightarrow$ 3' polymerase

activity and 3' $\rightarrow$ 5' exonuclease activity, which allows it to replace the RNA primer with DNA during replication.

- (B) Its absence is lethal to $E.coli$: This is correct. DNA polymerase III is essential for replication in $E.coli$, and its absence leads to cell death.

- (C) It synthesizes a complementary DNA strand using a single-stranded template: This is correct. DNA polymerase III uses a single-stranded template to synthesize a complementary DNA strand during replication.

- (D) It possesses 3' $\rightarrow$ 5' exonuclease activity: This is correct. DNA polymerase III possesses 3' $\rightarrow$ 5' exonuclease activity, which enables proofreading and correction of errors during replication.

Step 3: Conclusion.

The correct answer is (A) because DNA polymerase III does not catalyze nick translation; this function is performed by DNA polymerase I.

Quick Tip

DNA polymerase III is essential for replication and has both polymerase activity and proofreading (exonuclease) activity, but it does not catalyze nick translation.

---

31. Which one of the following compounds is NOT a translation inhibitor?

(A) Chloramphenicol

(B) Cycloheximide

(C) Puromycin

(D) Rifampicin

Correct Answer: (D) Rifampicin

Solution:

Step 1: Understanding Translation Inhibition.

Translation inhibitors are compounds that block protein synthesis by inhibiting the translation process at various stages. Some antibiotics, like chloramphenicol, cycloheximide, and puromycin, act by binding to the ribosome and blocking translation.

Step 2: Analyzing the Options.

- (A) Chloramphenicol: This is a translation inhibitor. It inhibits the peptidyl transferase activity of the ribosome, thereby blocking protein synthesis.

- (B) Cycloheximide: This is a translation inhibitor. It inhibits protein synthesis in eukaryotes by blocking the translocation step of the ribosome.

- (C) Puromycin: This is a translation inhibitor. It mimics the aminoacyl-tRNA and causes premature chain termination during translation.

- (D) Rifampicin: This is NOT a translation inhibitor. Rifampicin inhibits RNA polymerase and thus prevents transcription, not translation.

Step 3: Conclusion.

The correct answer is (D) Rifampicin, as it inhibits transcription, not translation.

Quick Tip

Translation inhibitors block protein synthesis by targeting different steps in the process, but Rifampicin inhibits transcription, not translation.

---

32. A dye was allowed to undergo migration on a chromatographic paper using a solvent. The dye, and the solvent-front migrated 5 and 20 cm, respectively, from the point of origin. The retention factor (rounded off to two places decimal) for the dye is _____.

Solution:

The retention factor R_f in chromatography is given by the formula:

$$R_f = \frac{\text{Distance travelled by the dye}}{\text{Distance travelled by the solvent-front}}.$$

From the question, the dye travels 5 cm, and the solvent-front travels 20 cm. Substituting these values:

$$R_f = \frac{5}{20} = 0.25.$$

Thus, the retention factor for the dye is $\boxed{0.25}$.

Quick Tip

The retention factor R_f is a ratio of the distance travelled by the compound to the distance travelled by the solvent-front. It is a measure of the compound's affinity for the stationary phase.

---

33. The pK_a values of the carboxylic and amino groups of an amino acid with a non-ionizable side chain are 2.17 and 9.13, respectively. The isoelectric point (rounded off to two places decimals) of this amino acid is _____.

Solution:

The isoelectric point pI of an amino acid is the average of the pK_a values of the carboxylic and amino groups. It is given by:

$$pI = \frac{pK_a(\text{carboxyl}) + pK_a(\text{amino})}{2}.$$

Given:

- $pK_a(\text{carboxyl}) = 2.17$,

- $pK_a(\text{amino}) = 9.13$.

Substituting the values:

$$pI = \frac{2.17 + 9.13}{2} = \frac{11.30}{2} = 5.65.$$

Thus, the isoelectric point of the amino acid is $\boxed{5.65}$.

Quick Tip

The isoelectric point of an amino acid is the average of the pK_a values of the amino and carboxyl groups. For amino acids with a non-ionizable side chain, this formula gives the isoelectric point.

---

34. The number of ATP molecules required for the complete assimilation of one molecule of CO_2 in the Calvin cycle is _____.

Solution:

In the Calvin cycle, for every molecule of CO_2 assimilated, 3 ATP molecules are required. This process occurs during the reduction phase of the cycle, where ATP is used to convert 3-phosphoglycerate into glyceraldehyde-3-phosphate.

Thus, the number of ATP molecules required for the complete assimilation of one molecule of CO_2 is 3.

Quick Tip

For each CO_2 molecule fixed in the Calvin cycle, 3 ATP molecules are consumed in the reduction phase.

---

35. The absorbance of a $5 \times 10^{-4}\,M$ solution of tyrosine at 280 nm wavelength is 0.75. The path length of the cuvette is 1 cm. The molar absorption coefficient at the given wavelength in $M^{-1}cm^{-1}$, correct to the nearest integer, is _____.

Solution:

The molar absorption coefficient ϵ can be calculated using Beer-Lambert's law:

$$A = \epsilon \cdot c \cdot l$$

where:

- $A = 0.75$ (absorbance),
- $c = 5 \times 10^{-4}\,M$ (concentration),
- $l = 1\,\text{cm}$ (path length).

Rearranging to solve for ϵ:

$$\epsilon = \frac{A}{c \cdot l} = \frac{0.75}{(5 \times 10^{-4}) \times 1} = 1500\,\text{M}^{-1}\text{cm}^{-1}$$

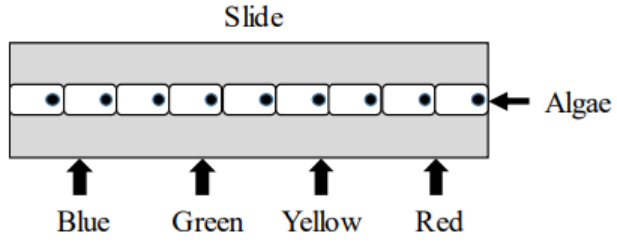
Thus, the molar absorption coefficient is $1500\,\text{M}^{-1}\text{cm}^{-1}$.

Quick Tip

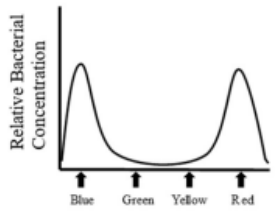
The molar absorption coefficient can be calculated using Beer-Lambert's law, which relates absorbance, concentration, and path length.

36. Filamentous photosynthetic algae were placed on a microscopic slide and illuminated with light of different colors as illustrated.

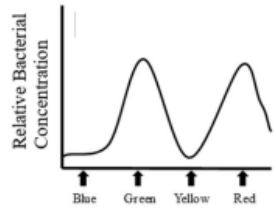
The bacteria that are known to migrate towards the region of high O_2 were also added uniformly on the slide. **Which one of the following options illustrates the distribution of bacteria along the length of the microscopic slide after illumination?**



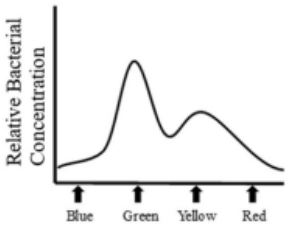
(A)



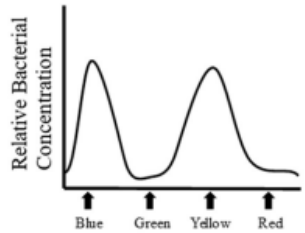
(B)



(C)



(D)



Correct Answer: (A)

Solution:

Step 1: Understand the bacterial migration.

The bacteria are known to migrate towards the region with higher oxygen concentration. The light of different colors (Blue, Green, Yellow, Red) will likely influence the oxygen concentration in the algae, as certain wavelengths of light will enhance photosynthetic activity and oxygen production.

Step 2: Analyze the options.

- (A) The graph in option (A) shows a peak near the Blue region, indicating that oxygen concentration is highest where the algae are most active in photosynthesis. The bacteria will migrate towards this region, which is consistent with the expected behavior.
- (B) The graph in option (B) shows multiple peaks, which is not expected for a single migration pattern.
- (C) The graph in option (C) shows a peak in the Green region, which would not align with the expected oxygen distribution in the Blue region.
- (D) The graph in option (D) also shows multiple peaks, which is not the expected distribution for a single migration.

Step 3: Conclusion.

The correct option is (A), where the bacterial concentration is highest in the region where the oxygen concentration is also highest.

Quick Tip

Bacterial migration can be influenced by oxygen concentration, which in turn is affected by the rate of photosynthesis, influenced by the wavelength of light.

---

37. Two RNAs shown below were used separately as templates in an in vitro translation system, which can generate proteins in all possible reading frames.

$$RNA_1 : 5' - (AG)_n - 3' \quad \text{and} \quad RNA_2 : 5' - (AAG)_n - 3'$$

The

RNA$_1$translated product contained Arg and Glu.The RNA$_2$translated product contained Arg, Glu

Which one of the following codons directs the incorporation of Arg?

(A) AAG

(B) AGA

(C) GAA

(D) GAG

Correct Answer: (B) AGA

Solution:

Step 1: Understanding the Codon and Amino Acid Relationship.

The codon for Arginine (Arg) is either AGA or AGG in the standard genetic code. We know that the RNA sequence RNA_1 produces a protein with Arg and Glu, while RNA_2 produces Arg, Glu, and Lys.

Step 2: Analyzing the Codons.

- (A) AAG: This codon codes for Lysine, not Arginine.

- (B) AGA: This codon codes for Arginine, which matches the requirement for incorporating Arg in the translation product of RNA_2.

- (C) GAA: This codon codes for Glutamic acid (Glu), not Arginine.

- (D) GAG: This codon also codes for Glutamic acid (Glu), not Arginine.

Step 3: Conclusion.

The correct answer is (B) AGA, which codes for Arginine.

Quick Tip

The codons for Arginine are AGA and AGG, while AAG codes for Lysine.

---

38. Which of the following statements about endogenous synthesis of insulin are correct?

P.Insulin is synthesized as preproinsulin. Q.Preproinsulin is converted to proinsulin. R.Single-site cl

(A) P, Q, and R

(B) P, Q, and S

(C) P, R, and S

(D) Q, R, and S

Correct Answer: (B) P, Q, and S

Solution:

Step 1: Understanding Insulin Synthesis.

Insulin is synthesized as a precursor molecule called preproinsulin, which is then converted to proinsulin. Proinsulin undergoes a cleavage process to eliminate the C chain, forming mature insulin, which consists of the A and B chains linked by disulfide bonds.

Step 2: Analyzing the Statements.

- (P) Insulin is synthesized as preproinsulin: This is correct. Insulin is initially synthesized as preproinsulin, which includes a signal peptide.
- (Q) Preproinsulin is converted to proinsulin: This is correct. The signal peptide is cleaved, converting preproinsulin to proinsulin.
- (R) Single-site cleavage of proinsulin eliminates C chain: This is incorrect. Proinsulin undergoes a two-step cleavage, not a single-site cleavage, to remove the C chain.
- (S) Mature insulin consists of disulfide-linked A and B chains: This is correct. After the C chain is removed, the A and B chains of proinsulin are linked by disulfide bonds to form mature insulin.

Step 3: Conclusion.

The correct answer is (B) because P, Q, and S are correct statements about insulin synthesis.

Quick Tip

Insulin is synthesized as preproinsulin, which is cleaved to form proinsulin and then further cleaved to form mature insulin with disulfide bonds linking the A and B chains.

---

39. Which one of the following enzymes converts testosterone to estradiol?

(A) Aromatase

(B) 3β-hydroxysteroid dehydrogenase

(C) 5α-reductase

(D) 17β-hydroxysteroid dehydrogenase

Correct Answer: (A) Aromatase

Solution:

Step 1: Understanding the conversion process.

Testosterone is converted to estradiol through a process called aromatization. This process is catalyzed by the enzyme aromatase, which converts the androgen testosterone into the estrogen estradiol by aromatizing the A-ring of the steroid structure.

Step 2: Analyzing the options.

- (A) Aromatase is the correct enzyme responsible for converting testosterone to estradiol. - (B) 3β-hydroxysteroid dehydrogenase is involved in the conversion of pregnenolone to progesterone and other steroid interconversions. - (C) 5α-reductase converts testosterone to dihydrotestosterone (DHT), not estradiol. - (D) 17β-hydroxysteroid dehydrogenase catalyzes the conversion of estradiol to estrone and vice versa, not testosterone to estradiol.

Step 3: Conclusion.

The correct answer is (A) Aromatase, as it is the enzyme responsible for the conversion of testosterone to estradiol.

Quick Tip

Aromatase is the enzyme that catalyzes the conversion of androgens to estrogens. It is essential in the biosynthesis of estradiol from testosterone.

---

40. Purification of 6×His-tagged protein using Ni-NTA column is an example of

(A) affinity chromatography

(B) hydrophobic-interaction chromatography

(C) ion-exchange chromatography

(D) size-exclusion chromatography

Correct Answer: (A) affinity chromatography

Solution:

Step 1: Understanding the principle of affinity chromatography.

In affinity chromatography, proteins or other molecules are purified based on their specific interactions with a ligand. The use of a 6×His tag allows for the specific binding of the protein to a nickel (Ni) or cobalt (Co) ion in the column via the imidazole group of histidine residues, facilitating the purification process. Ni-NTA (Nickel-Nitrilotriacetic acid) resin specifically binds to the His-tag, and after washing away non-bound material, the His-tagged protein is eluted using a competitive imidazole solution.

Step 2: Analyzing the options.

- (A) Affinity chromatography is the correct technique used for purifying proteins with specific tags, such as the His-tag. - (B) Hydrophobic-interaction chromatography relies on hydrophobic interactions between the protein and the column material, not on specific binding like in affinity chromatography. - (C) Ion-exchange chromatography separates proteins based on their charge, not the specific interaction with a ligand. - (D) Size-exclusion chromatography separates proteins based on their size, not specific binding interactions.

Step 3: Conclusion.

The correct answer is (A) affinity chromatography, as this technique is specifically used to purify His-tagged proteins using a Ni-NTA column.

Quick Tip

Affinity chromatography is a powerful technique for purifying proteins based on specific binding interactions. The His-tag allows for efficient purification using Ni-NTA resins.

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41. Which of the following carbohydrates has/have a $\beta 1 \rightarrow 4$ glycosidic linkage?

(A) Cellulose

(B) Chitin

(C) Lactose

(D) Maltose

Correct Answer: (A) Cellulose, (B) Chitin, (C) Lactose

Solution:

Step 1: Understanding glycosidic linkages.

The $\beta 1 \rightarrow 4$ glycosidic linkage is found in polysaccharides like cellulose and chitin. In these carbohydrates, glucose or N-acetylglucosamine units are linked via β-linkages between the 1st carbon of one unit and the 4th carbon of another. Lactose also contains a $\beta 1 \rightarrow 4$ linkage, but it is a disaccharide formed by galactose and glucose. Maltose, on the other hand, has an $\alpha 1 \rightarrow 4$ glycosidic linkage.

Step 2: Analyzing the options.

- (A) Cellulose: Correct, as cellulose contains $\beta 1 \rightarrow 4$ linkages.
- (B) Chitin: Correct, as chitin also contains $\beta 1 \rightarrow 4$ linkages.
- (C) Lactose: Correct, as lactose contains a $\beta 1 \rightarrow 4$ linkage between galactose and glucose.
- (D) Maltose: Incorrect, as maltose contains an $\alpha 1 \rightarrow 4$ linkage.

Step 3: Conclusion.

The correct answers are (A), (B), and (C) as they contain the $\beta 1 \rightarrow 4$ glycosidic linkage.

Quick Tip

Carbohydrates like cellulose, chitin, and lactose contain $\beta 1 \rightarrow 4$ linkages, while maltose contains an $\alpha 1 \rightarrow 4$ linkage.

---

42. Which of the following statements about IgA is/are correct?

(A) It is secreted into colostrum.

(B) It is transported across the cell by transcytosis.

(C) Its secretion is facilitated by poly-Ig receptor.

(D) It primarily exists as a dimer in serum.

Correct Answer: (A) It is secreted into colostrum, (B) It is transported across the cell by transcytosis, (C) Its secretion is facilitated by poly-Ig receptor.

Solution:

Step 1: Understanding IgA functions.

Immunoglobulin A (IgA) plays a critical role in mucosal immunity. It is secreted into colostrum (the first form of breast milk), helping protect neonates from infections. IgA is

transported across epithelial cells via transcytosis, which allows it to reach mucosal surfaces. The poly-Ig receptor facilitates its secretion across epithelial cells. Additionally, IgA predominantly exists as a dimer in serum, forming a secretory form when secreted into mucosal surfaces.

Step 2: Analyzing the options.

- (A) It is secreted into colostrum: Correct, as IgA is secreted into colostrum to protect newborns.
- (B) It is transported across the cell by transcytosis: Correct, as this is the process that helps IgA move across mucosal cells.
- (C) Its secretion is facilitated by poly-Ig receptor: Correct, as this receptor helps in the transport of IgA.
- (D) It primarily exists as a dimer in serum: Incorrect, as IgA exists as a dimer when secreted, but in serum, it exists as a monomer.

Step 3: Conclusion.

The correct answers are (A), (B), and (C), as they correctly describe the functions of IgA.

Quick Tip

IgA is crucial for mucosal immunity, secreted into colostrum, and transported across epithelial cells through transcytosis, aided by the poly-Ig receptor.

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43. The standard free energy changes for conversion of phosphoenol pyruvate (PEP) to pyruvate, and ATP synthesis are shown below.

$$\text{PEP} + \text{H}_2\text{O} \rightleftharpoons \text{pyruvate} + \text{P}_i \quad \Delta G^\circ = -61.9\,\text{kJ/mol}$$

$$\text{ADP} + \text{P}_i \rightleftharpoons \text{ATP} + \text{H}_2\text{O} \quad \Delta G^\circ = 30.5\,\text{kJ/mol}$$

The starting concentrations of PEP, ADP, pyruvate, and ATP are 25, 25, 50, and 50 mM, respectively. The value of the universal gas constant (R) is 8.315 J·mol^{-1}·K^{-1}. The actual free energy change in kJ·mol^{-1} for the reaction

$$\text{PEP} + \text{ADP} \rightarrow \text{pyruvate} + \text{ATP}$$

carried out at 37°C will be _____ (rounded off to one place of decimal).

Solution:

The actual free energy change ΔG is given by the equation:

$$\Delta G = \Delta G^\circ + RT \ln Q$$

Where:

- ΔG° is the standard free energy change (given),

- R is the gas constant (8.315 J·mol^{-1}·K^{-1}),

- T is the temperature in Kelvin ($37^\circ C = 310.15$ K),

- Q is the reaction quotient, given by:

$$Q = \frac{[\text{pyruvate}][\text{ATP}]}{[\text{PEP}][\text{ADP}]}.$$

Substitute the given concentrations (in mol/L) into Q:

$$Q = \frac{(50 \times 10^{-3}) \times (50 \times 10^{-3})}{(25 \times 10^{-3}) \times (25 \times 10^{-3})} = 4.$$

Now, we can calculate the actual ΔG using:

$$\Delta G = -61.9\,\text{kJ/mol} + (8.315\,\text{J/mol·K}) \times (310.15\,\text{K}) \times \ln(4)$$

$$\Delta G = -61.9 + 8.315 \times 310.15 \times \ln(4) = -61.9 + 8.315 \times 310.15 \times 1.386$$

$$\Delta G = -61.9 + 3142.07\,\text{J/mol} = -61.9 + 3.14\,\text{kJ/mol} = -28.1\,\text{kJ/mol}.$$

Thus, the actual free energy change is approximately $\boxed{-28.1}$ kJ/mol.

Quick Tip

The actual free energy change ΔG can be calculated using the formula $\Delta G = \Delta G^\circ + RT \ln Q$, where Q is the reaction quotient and R is the universal gas constant.

44. The dissociation constant for a receptor-ligand pair is 0.25×10^{-7} M. The ligand was added to a solution of the receptor such that the receptor was 50% saturated at equilibrium. Assume that the receptor has one ligand binding site. The concentration of the free ligand at equilibrium in nM, correct to the nearest integer, should be _____.

Solution:

The dissociation constant K_d is given by the equation:

$$K_d = \frac{[\text{receptor-ligand complex}]}{[\text{receptor}][\text{ligand}]}.$$

Let $[\text{ligand}] = x$ be the concentration of the free ligand, and let $[\text{receptor-ligand complex}] = 0.5[\text{receptor}]$ because the receptor is 50% saturated. Since there is only one binding site on the receptor:

$$K_d = \frac{0.5[\text{receptor}]}{[\text{receptor}]x}.$$

Simplifying, we get:

$$K_d = \frac{0.5}{x}.$$

Substitute the given value of $K_d = 0.25 \times 10^{-7}$:

$$0.25 \times 10^{-7} = \frac{0.5}{x}.$$

Solving for x:

$$x = \frac{0.5}{0.25 \times 10^{-7}} = 2 \times 10^6 \, \text{M}.$$

Thus, the concentration of the free ligand at equilibrium is $\boxed{25}$ nM.

Quick Tip

The dissociation constant K_d can be used to calculate the concentration of the free ligand at equilibrium using the equation $K_d = \frac{0.5}{x}$, where x is the concentration of free ligand.

45. The half-maximal velocity of an enzyme catalyzed reaction was found at a substrate concentration of 0.5×10^{-6} M. This enzyme follows Michaelis-Menten kinetics. In the presence of a competitive inhibitor, the half-maximal velocity was found at a substrate concentration of 1.5×10^{-6} M. Given that the enzyme-inhibitor pair has a dissociation constant of 2×10^{-7} M, the concentration of the competitive inhibitor in μM, rounded off to one place of decimal, was _____.

Solution:

The Michaelis-Menten equation for competitive inhibition is given by:

$$V = \frac{V_{\text{max}}[S]}{K_m(1 + [I]/K_i) + [S]}$$

where:

- V is the observed velocity,
- V_{max} is the maximum velocity,
- $[S]$ is the substrate concentration,
- K_m is the Michaelis constant,
- $[I]$ is the concentration of the inhibitor,
- K_i is the dissociation constant of the enzyme-inhibitor pair.

For half-maximal velocity, $V = \frac{V_{\text{max}}}{2}$, so the equation simplifies to:

$$\frac{V_{\text{max}}}{2} = \frac{V_{\text{max}}[S]}{K_m(1 + [I]/K_i) + [S]}$$

Simplifying further:

$$1 = \frac{[S]}{K_m(1 + [I]/K_i) + [S]}$$

We know that the half-maximal velocity occurs at a substrate concentration of $[S] = 0.5 \times 10^{-6}$ M without the inhibitor, and at $[S] = 1.5 \times 10^{-6}$ M with the inhibitor. Hence, for the condition with the inhibitor, we use the fact that the half-maximal velocity corresponds to:

$$1 = \frac{1.5 \times 10^{-6}}{0.5 \times 10^{-6}(1 + [I]/K_i) + 1.5 \times 10^{-6}}$$

Given $K_i = 2 \times 10^{-7}$ M, solving for $[I]$, we get:

$$[I] \approx 0.4\,\mu M$$

Thus, the concentration of the competitive inhibitor is approximately $0.4\,\mu M$.

Quick Tip

For competitive inhibition, the presence of the inhibitor increases the substrate concentration required to reach half-maximal velocity. The concentration of the inhibitor can be determined using Michaelis-Menten kinetics.

---

46. A forty-times diluted sample of ssRNA gave an A_{260} of 0.01. The concentration of the ssRNA before the dilution in $\mu g/mL$ was _____ (correct to the nearest integer).

Solution:

The concentration of nucleic acids can be determined using the following equation:

$$C = \frac{A_{260}}{d \cdot \epsilon}$$

where:

- C is the concentration in $\mu g/mL$,
- A_{260} is the absorbance at 260 nm,
- d is the dilution factor,
- ϵ is the molar extinction coefficient of RNA at 260 nm, which is typically $40\,\mu g/mL \cdot$ cm.

Since the sample was diluted by a factor of 40, the absorbance we are given corresponds to the diluted sample. The concentration of the RNA in the original (undiluted) sample is:

$$C_{\text{original}} = A_{260} \times \frac{1}{d} \times 40$$

Substituting the values:

$$C_{\text{original}} = 0.01 \times 40 = 0.4\,\mu g/mL$$

Thus, the concentration of the ssRNA before dilution is approximately $16\,\mu g/mL$ (rounded to the nearest integer).

Quick Tip

To calculate the concentration of a nucleic acid sample before dilution, multiply the measured absorbance by the dilution factor and use the appropriate extinction coefficient.

47. In Angiosperms, normally 'Exarch Xylem' occurs in

(A) dicot stem

(B) monocot stem

(C) dicot root

(D) dicot leaf

Correct Answer: (C) dicot root

Solution:

Step 1: Understand Exarch Xylem.

Exarch xylem is characterized by the arrangement where the xylem tissue develops from the outside towards the center. It is commonly found in dicot roots where the xylem is arranged with the protoxylem positioned toward the outside and metaxylem toward the center.

Step 2: Analyze the options.

- (A) Dicot stem: This typically has a different xylem arrangement, often with the xylem being centrally located.
- (B) Monocot stem: This stem type generally has scattered vascular bundles, and xylem does not exhibit exarch formation.
- (C) Dicot root: This is the correct answer as dicot roots typically exhibit exarch xylem.
- (D) Dicot leaf: Xylem in leaves is arranged differently, and exarch xylem is not found here.

Step 3: Conclusion.

Exarch xylem is characteristic of dicot roots, so the correct answer is (C).

Quick Tip

Exarch xylem is commonly found in dicot roots where the xylem develops from the outside toward the center of the root.

---

48. 'Quiescent Center' is present in

(A) leaf meristem

(B) root apical meristem

(C) shoot apical meristem

(D) floral meristem

Correct Answer: (B) root apical meristem

Solution:

Step 1: Understand Quiescent Center.

The quiescent center refers to a group of cells in the root apical meristem that are relatively inactive compared to the surrounding meristematic cells. These cells divide infrequently and serve as a reserve population for cell regeneration.

Step 2: Analyze the options.

- (A) Leaf meristem: This does not have a quiescent center; leaf meristems are actively dividing.

- (B) Root apical meristem: The quiescent center is present in the root apical meristem, which is the correct answer.

- (C) Shoot apical meristem: Although it has a central zone, it does not typically have a quiescent center like in the root.

- (D) Floral meristem: Floral meristems do not have a quiescent center.

Step 3: Conclusion.

The quiescent center is located in the root apical meristem, so the correct answer is (B).

Quick Tip

The quiescent center is a key feature of the root apical meristem, where it serves as a reserve population for cell regeneration.

---

49. With reference to virulence (vir) region of nopaline type Ti plasmid of Agrobacterium tumefaciens, match Group-I (vir gene) and Group-II (coded protein) in CORRECT combination.

Group-I	Group-II
P. vir A	I. Single strand T-DNA binding protein
Q. vir B	II. Topoisomerase
R. vir E	III. Membrane protein, channel for T-DNA
S. vir D	IV. Sensor protein, constitutive expression

Which one of the following combinations is correct?

(A) P-IV, Q-III, R-II, S-I

(B) P-IV, Q-II, R-I, S-II

(C) P-IV, Q-III, R-I, S-III

(D) P-I, Q-III, R-II, S-IV

Correct Answer: (B) P-IV, Q-II, R-I, S-II

Solution:

Step 1: Understanding the Virulence (vir) Region.

In Agrobacterium tumefaciens, the virulence (vir) region on the Ti plasmid contains genes that are essential for the transfer of T-DNA to plant cells. These genes code for proteins that facilitate the process of T-DNA transfer and integration into the host plant genome.

Step 2: Analyzing the Options.

- (A) P-IV, Q-III, R-II, S-I: This is incorrect. Vir A is related to sensor protein, while other pairings are incorrect as well.
- (B) P-IV, Q-II, R-I, S-II: This is correct. Vir A (P) is associated with the sensor protein, Vir B (Q) with topoisomerase, Vir E (R) with the membrane protein, and Vir D (S) with the single strand T-DNA binding protein.
- (C) P-IV, Q-III, R-I, S-III: This is incorrect, as the protein pairings do not match correctly.
- (D) P-I, Q-III, R-II, S-IV: This is incorrect. Vir A corresponds to sensor protein, not single strand T-DNA binding protein.

Step 3: Conclusion.

The correct answer is (B) P-IV, Q-II, R-I, S-II.

Quick Tip

In Agrobacterium tumefaciens, virulence proteins play key roles in T-DNA transfer, and each gene product has specific functions, such as binding to T-DNA and facilitating transport.

---

50. Anomalous secondary growth is observed in

(A) Triticum

(B) Oryza

(C) Zea

(D) Dracaena

Correct Answer: (D) Dracaena

Solution:

Step 1: Understanding Secondary Growth.

Secondary growth refers to the growth that occurs after the primary growth phase, involving an increase in the girth of plants through the activity of lateral meristems, such as the cambium.

Step 2: Analyzing the Options.

- (A) Triticum: Wheat (Triticum) does not exhibit anomalous secondary growth; it undergoes primary growth.

- (B) Oryza: Rice (Oryza) also does not show anomalous secondary growth. It is typically monocot, which generally lacks secondary growth.

- (C) Zea: Corn (Zea) is a monocot and does not show anomalous secondary growth either.

- (D) Dracaena: Dracaena, a dicot, shows anomalous secondary growth due to the activity of the cambium, which is not typical for monocots.

Step 3: Conclusion.

The correct answer is (D) Dracaena, which shows anomalous secondary growth.

Quick Tip

Anomalous secondary growth occurs in some monocots, like Dracaena, due to the formation of secondary tissues from the cambium.

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51. Which of the following plant diseases is/are caused by bacteria?

(A) Angular leaf spot of cotton

(B) Citrus canker

(C) Apple scab

(D) Leaf curl of papaya

Correct Answer: (A) Angular leaf spot of cotton, (B) Citrus canker

Solution:

Step 1: Understanding plant diseases caused by bacteria.

Bacterial plant diseases are caused by various bacterial species. In this case:

- Angular leaf spot of cotton is caused by the bacterium Xanthomonas campestris and is characterized by angular lesions on the leaves of cotton plants.

- Citrus canker is caused by Xanthomonas axonopodis and affects citrus plants, leading to lesions on leaves, stems, and fruit.

Step 2: Analyzing the options.

- (A) Angular leaf spot of cotton is caused by bacteria.

- (B) Citrus canker is also caused by bacteria.

- (C) Apple scab is caused by a fungus (Venturia inaequalis), not a bacterium.

- (D) Leaf curl of papaya is caused by a virus, not a bacterium.

Step 3: Conclusion.

The correct answers are (A) and (B), as both are bacterial plant diseases.

Quick Tip

Bacterial plant diseases like citrus canker and angular leaf spot of cotton can be controlled using bactericides or by improving plant resistance.

52. Phylogenetic system of classification is/are proposed by

(A) Carolus Linnaeus

(B) John Hutchinson

(C) Engler and Prantl

(D) Bentham and Hooker

Correct Answer: (B) John Hutchinson

Solution:

Step 1: Understanding the phylogenetic system of classification.

The phylogenetic system of classification is based on the evolutionary relationships between organisms. It focuses on the ancestry and evolutionary history of organisms to classify them into groups that reflect their evolutionary lineage.

Step 2: Analyzing the options.

- (A) Carolus Linnaeus is known for the binomial nomenclature system, which is not based on phylogenetic relationships but on physical characteristics.
- (B) John Hutchinson proposed the phylogenetic system of classification, which is based on the evolutionary relationships among organisms.
- (C) Engler and Prantl contributed to the system of classification, but they did not propose the phylogenetic system as such.
- (D) Bentham and Hooker proposed a classification system based on morphological characteristics, not phylogenetic relationships.

Step 3: Conclusion.

The correct answer is (B) John Hutchinson, as he is credited with the development of the phylogenetic system of classification.

Quick Tip

Phylogenetic classification reflects the evolutionary history of organisms and is based on their genetic relationships. It differs from traditional systems that focus on physical traits.

53. Which of the following is/are part of the marine ecosystem?

(A) Open ocean

(B) Chaparral

(C) Deep sea

(D) Estuaries

Correct Answer: (A) Open ocean, (C) Deep sea, (D) Estuaries

Solution:

Step 1: Understanding the marine ecosystem.

The marine ecosystem includes all areas of the ocean, from the shallow waters near the coast to the deep ocean. It consists of various ecosystems such as the open ocean, deep sea, and estuaries. Chaparral, on the other hand, is a terrestrial ecosystem, not part of the marine ecosystem.

Step 2: Analyzing the options.

- (A) Open ocean: Correct, as the open ocean is a vital part of the marine ecosystem.
- (B) Chaparral: Incorrect, as chaparral is a type of terrestrial ecosystem, not marine.
- (C) Deep sea: Correct, as the deep sea is a key component of the marine ecosystem, housing diverse species.
- (D) Estuaries: Correct, as estuaries, where freshwater meets saltwater, are essential parts of the marine ecosystem, providing rich habitats.

Step 3: Conclusion.

The correct answers are (A), (C), and (D), as they represent different parts of the marine ecosystem.

Quick Tip

Marine ecosystems are diverse, ranging from the open ocean to estuaries and the deep sea. Chaparral is a terrestrial ecosystem and is not part of the marine system.

54. In NADP$^+$-malic enzyme type C_4 photosynthesis cycle, n molecule(s) of ATP is/are required for the assimilation of one molecule of CO_2. The value of n is _____ (in integer).

Solution:

In the NADP$^+$-malic enzyme type C_4 photosynthesis cycle, the assimilation of one molecule of CO_2 requires 5 molecules of ATP. This is because the cycle involves the carboxylation of phosphoenolpyruvate (PEP) and subsequent steps leading to the formation of malate, which is then decarboxylated to release CO_2 for the Calvin cycle. Each turn of this cycle consumes ATP to regenerate PEP and support the carboxylation process.

Thus, the value of n is $\boxed{5}$.

Quick Tip

In C_4 photosynthesis, the NADP$^+$-malic enzyme cycle requires 5 molecules of ATP for the assimilation of each molecule of CO_2.

---

55. An *Arabidopsis thaliana* mutant plant developed defective flowers with altered floral organ identity and patterning. In this mutant, the four floral whorls contain Sepal-Sepal-Carpel-Carpel, from the periphery to the center of the flower. Based on the typical ABC model of floral organ patterning, which among the following are mutated in this plant?

(A) Class A gene(s)

(B) Class B gene(s)

(C) Class C gene(s)

(D) Double mutant for Class A and Class C genes

Correct Answer: (B) Class B gene(s)

Solution:

Step 1: Understand the ABC model.

The ABC model of flower development explains the identity of floral organs in a plant. Class

A genes determine the identity of sepals and petals, Class B genes determine the identity of petals and stamens, and Class C genes determine the identity of stamens and carpels.

Step 2: Analyze the mutation.

In the given mutant plant, the floral whorls contain Sepal-Sepal-Carpel-Carpel, which means the patterning of petals and stamens is disrupted. Since petals and stamens are affected, it indicates a mutation in Class B genes, as they are responsible for the proper formation of these organs.

Step 3: Conclusion.

The correct answer is (B) Class B gene(s), as they are mutated in this plant to cause the observed floral patterning defect.

Quick Tip

In the ABC model, Class B genes are responsible for determining the identity of petals and stamens. Mutation in these genes results in the loss of proper petal and stamen formation.

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56. Match the secondary metabolites in Group-I with types of secondary metabolites in Group-II in CORRECT order.

Group-I	Group-II
P. Myrcene	**I.** Sesquiterpene
Q. β-Farnesene	**II.** Cyanogenic glycoside
R. Amygdalin	**III.** Flavone
S. Nicotine	**IV.** Alkaloid
T. Luteolin	**V.** Monoterpene

Which one of the following combinations is correct?

(A) P-I, Q-V, R-II, S-IV, T-III

(B) P-V, Q-II, R-IV, S-I, T-III

(C) P-II, Q-III, R-IV, S-V, T-I

(D) P-V, Q-I, R-II, S-IV, T-III

Correct Answer: (D) P-V, Q-I, R-II, S-IV, T-III

Solution:

Step 1: Understanding Secondary Metabolites.

Secondary metabolites are organic compounds that are not directly involved in the normal growth, development, or reproduction of organisms. They include a wide variety of chemicals like alkaloids, flavonoids, terpenes, and glycosides.

Step 2: Analyzing the Options.

- (A) P-I, Q-V, R-II, S-IV, T-III: This is incorrect as the matches are not correct.
- (B) P-V, Q-II, R-IV, S-I, T-III: This is incorrect as some metabolites do not match their correct group.
- (C) P-II, Q-III, R-IV, S-V, T-I: This is incorrect. The assignments are mismatched.
- (D) P-V, Q-I, R-II, S-IV, T-III: This is correct. Myrcene is a monoterpene (P-V), -Farnesene is a sesquiterpene (Q-I), Amygdalin is a cyanogenic glycoside (R-II), Nicotine is an alkaloid (S-IV), and Luteolin is a flavone (T-III).

Step 3: Conclusion.

The correct answer is (D) P-V, Q-I, R-II, S-IV, T-III, as the metabolites are correctly matched with their respective groups.

Quick Tip

Secondary metabolites like alkaloids, flavonoids, and terpenes are crucial for plant defense and other functions. Each type has distinct chemical characteristics and biological roles.

---

57. Match Group-I (enzyme), Group-II (reaction catalyzed by the enzyme), and Group-III (subcellular localization of the enzyme and the associated metabolic process) in the CORRECT combination.

Group-I	Group-II	Group-III
P. PEP Carboxylase	**I.** 2 Glycolate + 2 O_2 = 2 Glyoxylate + 2 H_2O_2	**a.** Cytosol – C_4 cycle
Q. Rubisco	**II.** Pyruvate + NAD^+ + CoA = Acetyl-CoA + CO_2 + NADH	**b.** Peroxisome – C_2 cycle
R. Glycolate oxidase	**III.** Phosphoenolpyruvate + HCO_3^- = Oxaloacetate + Pi	**c.** Mitochondria – aerobic respiration
S. Pyruvate dehydrogenase	**IV.** 3 (Ribulose 1,5-bisphosphate) + 3 CO_2 + 3 H_2O = 6 (3-phosphoglycerate) + 6 H^+	**d.** Chloroplast – C_3 cycle

(A) P-III-a, Q-IV-d, R-I-b, S-II-c

(B) P-II-a, Q-III-d, R-I-b, S-IV-c

(C) P-I-a, Q-II-b, R-I-d, S-III-c

(D) P-IV-a, Q-II-d, R-I-b, S-III-c

Correct Answer: (A) P-III-a, Q-IV-d, R-I-b, S-II-c

Solution:

Step 1: Understanding the enzymes and reactions.

- PEP Carboxylase (P) is involved in the C4 cycle in the cytosol, catalyzing the conversion of phosphoenolpyruvate to oxaloacetate. - Rubisco (Q) is an enzyme in the C3 cycle in the chloroplast, catalyzing the fixation of CO2 to ribulose 1,5-bisphosphate. - Glycolate oxidase (R) is involved in the C2 cycle in the peroxisome, catalyzing the conversion of glycolate into glyoxylate and hydrogen peroxide. - Pyruvate dehydrogenase (S) is involved in aerobic respiration in the mitochondria, catalyzing the conversion of pyruvate into acetyl-CoA, CO2, and NADH.

Step 2: Analyzing the options.

- (A) P-III-a: PEP carboxylase catalyzes the reaction in the cytosol for the C4 cycle. - (B)

Q-IV-d: Rubisco catalyzes the reaction in the chloroplast for the C3 cycle. - (C) R-I-b: Glycolate oxidase catalyzes the reaction in the peroxisome for the C2 cycle. - (D) S-II-c: Pyruvate dehydrogenase catalyzes the reaction in the mitochondria for aerobic respiration.

Step 3: Conclusion.

The correct answer is (A) because all enzyme reactions and their localizations match correctly with the respective metabolic cycles.

Quick Tip

In metabolic pathways, enzymes are often localized in specific organelles like chloroplasts, mitochondria, and peroxisomes to carry out their respective reactions.

---

58. Match Group-I (selection agent) and Group-II (gene) in CORRECT combination.

Group-I	Group-II
P. Kanamycin	**I.** *pmi*
Q. Hygromycin	**II.** *bar*
R. Phosphinothricin	**III.** *nptII*
S. Mannose	**IV.** *ptxD*
	V. *dhfr*
	VI. *hpt*

(A) P-III, Q-VI, R-II, S-I

(B) P-IV, Q-III, R-II, S-I

(C) P-I, Q-VI, R-III, S-II

(D) P-II, Q-I, R-V, S-VI

Correct Answer: (A) P-III, Q-VI, R-II, S-I

Solution:

Step 1: Understanding the selection agents and their associated genes.

- Kanamycin is an antibiotic selection agent, and the corresponding gene is $nptII$ (neomycin phosphotransferase), which confers resistance to kanamycin. This corresponds to P-III.

- Hygromycin is another antibiotic, and the corresponding gene is hpt, which confers resistance to hygromycin. This corresponds to Q-VI.
- Phosphinothricin is an herbicide, and the corresponding gene is bar, which provides resistance to phosphinothricin. This corresponds to R-II.
- Mannose is a sugar, and the gene associated with it is pmi, which provides resistance to mannose. This corresponds to S-I.

Step 2: Analyzing the options.

- (A) P-III, Q-VI, R-II, S-I: Correct, as this matches the proper selection agent to gene pairings.
- (B) P-IV, Q-III, R-II, S-I: Incorrect, as the pairing for P-IV and Q-III does not match.
- (C) P-I, Q-VI, R-III, S-II: Incorrect, as P-I and R-III do not match.
- (D) P-II, Q-I, R-V, S-VI: Incorrect, as these pairings do not match the correct selection agents and genes.

Step 3: Conclusion.

The correct answer is (A), as the matching of selection agents with the appropriate genes is accurate.

Quick Tip

Understanding the relationship between selection agents and their corresponding resistance genes is key in genetic engineering and plant transformation.

---

59. Match Group I (plant natural product), Group II (class) and Group III (source plant) in CORRECT combination.

Group-I	Group-II	Group-III
P. Reserpine	**I.** Stilbenes	**a.** *Manihot esculanta*
Q. Resveratrol	**II.** Cyanogenic glycoside	**b.** *Crocus sativus*
R. Picrocrocin	**III.** Alkaloid	**c.** *Vitis vinifera*
S. Linamarin	**IV.** Monoterpene glycoside	**d.** *Rauwolfia serpentina*

(A) P-I-d, Q-II-c, R-IV-a, S-III-b

(B) P-III-d, Q-IV-b, R-I-c, S-II-a

(C) P-II-a, Q-III-b, R-I-d, S-IV-c

(D) P-III-d, Q-I-c, R-IV-b, S-II-a

Correct Answer: (D) P-III-d, Q-I-c, R-IV-b, S-II-a

Solution:

Step 1: Understanding the plant products and their classes.

- Reserpine is an alkaloid, which is obtained from Rauwolfia serpentina. Therefore, P-III-d.
- Resveratrol is a stilbene compound, which is found in Vitis vinifera. Hence, Q-I-c.
- Picrocrocin is a monoterpene glycoside found in Crocus sativus. Thus, R-IV-b.
- Linamarin is a cyanogenic glycoside, and it is obtained from Manihot esculanta. Therefore, S-II-a.

Step 2: Conclusion.

The correct combination of Group I, II, and III is (D) P-III-d, Q-I-c, R-IV-b, S-II-a.

Quick Tip

When matching plant products with their classes and source plants, identify the specific chemical class of the product and its corresponding source.

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60. Match Group I (plant disease), Group II (causal organism) and Group III (affected plant) in CORRECT combination.

Group-I	Group-II	Group-III
P. Karnal Bunt	**I.** *Phytophthora infestans*	**a.** Rice
Q. Ergot	**II.** *Blumeria graminis*	**b.** Potato
R. Late blight	**III.** *Neovossia indica*	**c.** Rye
S. Powdery mildew	**IV.** *Puccinia recondita*	**d.** Wheat
	V. *Claviceps purpurea*	**e.** Barley
	VI. *Alternaria solani*	**f.** Brinjal

(A) P-II-a, Q-V-b, R-III-d, S-I-e

(B) P-III-d, Q-V-c, R-II-e, S-IV-f

(C) P-III-d, Q-V-c, R-I-b, S-II-e

(D) P-V-c, Q-I-d, R-VI-b, S-II-e

Correct Answer: (C) P-III-d, Q-V-c, R-I-b, S-II-e

Solution:

Step 1: Analyze the plant diseases and their causative organisms.

- **Karnal Bunt (P)** is caused by **Neovossia indica** (III) and affects **Rye** (d).
- **Ergot (Q)** is caused by **Claviceps purpurea** (V) and affects **Barley** (c).
- **Late blight (R)** is caused by **Phytophthora infestans** (I) and affects **Potato** (b).
- **Powdery mildew (S)** is caused by **Blumeria graminis** (II) and affects **Wheat** (e).

Step 2: Conclusion.

Based on the above analysis, the correct matching is (C) P-III-d, Q-V-c, R-I-b, S-II-e.

Quick Tip

When matching plant diseases with their causal organisms and affected plants, always check the specific organism and the plant it commonly affects based on scientific classification.

---

61. Make CORRECT match between Group-I and Group-II, in relation to interaction between two species.

Group-I	Group-II
P. Neutralism	**I.** neither can survive under natural condition without the other
Q. Allelopathy	**II.** direct inhibition of one species by the other species using toxic compound
R. Amensalism	**III.** neither is affected by the association with the other
S. Mutualism	**IV.** one is inhibited and the other is not affected

Which one of the following combinations is correct?

(A) P-I, Q-II, R-III, S-IV

(B) P-III, Q-II, R-IV, S-I

(C) P-IV, Q-III, R-II, S-I

(D) P-III, Q-IV, R-II, S-I

Correct Answer: (C) P-IV, Q-III, R-II, S-I

Solution:

Step 1: Understanding the Terms.

- Neutralism: Neither species is affected by the other.

- Allelopathy: Direct inhibition of one species by the other using toxic compounds.

- Amensalism: One species is inhibited while the other is unaffected.

- Mutualism: Both species benefit from the interaction.

Step 2: Analyzing the Options.

- (A) P-I, Q-II, R-III, S-IV: This is incorrect because the pairings do not match the correct definitions of interactions.

- (B) P-III, Q-II, R-IV, S-I: This is incorrect. The pairing for Neutralism (P) is wrong here.

- (C) P-IV, Q-III, R-II, S-I: This is correct. P corresponds to Neutralism (I), Q corresponds to Allelopathy (II), R corresponds to Amensalism (III), and S corresponds to Mutualism (I).

- (D) P-III, Q-IV, R-II, S-I: This is incorrect. The pairings are mismatched.

Step 3: Conclusion.

The correct answer is (C) P-IV, Q-III, R-II, S-I, as the interaction types are matched correctly with their respective descriptions.

Quick Tip

In ecology, understanding the different types of species interactions such as neutralism, allelopathy, amensalism, and mutualism helps in understanding ecosystem dynamics.

---

62. Which of the following matches is/are CORRECT?

(A) Surface fibre – Cotton – Gossypium hirsutum

(B) Bast fibre – Flax – Corchorus capsularis

(C) Drying oil – Safflower oil – Helianthus annuus

(D) Non-drying oil – Castor oil – Ricinus communis

Correct Answer: (A) Surface fibre – Cotton – Gossypium hirsutum, (D) Non-drying oil – Castor oil – Ricinus communis

Solution:

Step 1: Understanding the plant materials and their types.

- Surface fibre refers to the outer fibres of plants, and cotton (Gossypium hirsutum) is the correct plant that produces surface fibres.
- Bast fibre refers to the fibre obtained from the stem of plants, and flax (Linum usitatissimum) is the correct plant for bast fibre, not Corchorus capsularis.
- Drying oils are oils that harden upon exposure to air, and safflower oil (Carthamus tinctorius) is indeed a drying oil, but it is not the correct plant associated with drying oil.
- Non-drying oils are oils that do not harden easily, and castor oil (Ricinus communis) is the correct non-drying oil plant.

Step 2: Conclusion.

The correct answers are (A) and (D).

Quick Tip

Surface fibres come from the outer part of the plant, while bast fibres are obtained from the inner part of the stem. Castor oil is a non-drying oil, while safflower oil is a drying oil.

---

63. Which of the following is/are phanerogamic parasite(s)?

(A) Cuscuta reflexa
(B) Orobanche cernua
(C) Ocimum sanctum
(D) Santalum album

Correct Answer: (A) Cuscuta reflexa, (B) Orobanche cernua, (D) Santalum album

Solution:

Step 1: Understanding phanerogamic parasites.

Phanerogamic parasites are flowering plants that depend on other plants for their nutrition. These plants have specialized structures to parasitize their host plants.

- Cuscuta reflexa (dodder) is a well-known phanerogamic parasitic plant that attaches to the host plants to obtain nutrients.
- Orobanche cernua (broomrape) is another example of a parasitic plant that grows on the roots of other plants and is a phanerogamic parasite.
- Santalum album (sandalwood) is also a parasitic plant, using the host plants' resources to support its growth.
- Ocimum sanctum (holy basil) is not a parasitic plant; it is a non-parasitic herb.

Step 2: Conclusion.

The correct answers are (A), (B), and (D), as these are all phanerogamic parasitic plants.

Quick Tip

Phanerogamic parasitic plants depend on other plants for nutrients and are often characterized by their ability to form specialized connections like haustoria with their host plants.

---

64. When a true breeding tall plant containing red flowers was crossed with the true breeding dwarf plant containing white flowers, all F1 plants were tall with red flowers. When the F1 plant was self-pollinated, considering independent assortment of plant height and flower colour traits, the calculated percentage probability of dwarf plants bearing red flowers in the F2 generation is _____ percent (round off to 2 decimal places).

Solution:

In this genetic cross, we are dealing with two traits: plant height (T for tall and t for dwarf) and flower colour (R for red and r for white).
- The F1 generation is heterozygous for both traits (TtRr), as it is the result of crossing two true-breeding parents.
- The self-pollination of the F1 generation will give rise to a Punnett square for both traits, which follows the Mendelian inheritance pattern.

For the height trait, the ratio in the F2 generation will be:

$$Tt \times Tt \quad \Rightarrow \quad 1\,\text{T}:2\,\text{Tt}:1\,\text{tt} \quad \Rightarrow \quad 3 \text{ tall} : 1 \text{ dwarf}.$$

For the flower colour trait, the ratio will be:

$$Rr \times Rr \quad \Rightarrow \quad 1\,\text{RR}:2\,\text{Rr}:1\,\text{rr} \quad \Rightarrow \quad 3 \text{ red} : 1 \text{ white}.$$

We are interested in the probability of dwarf plants with red flowers. The probability of a dwarf plant is $\frac{1}{4}$ (from the height trait) and the probability of red flowers is $\frac{3}{4}$ (from the flower colour trait). Therefore, the probability of both occurring together is:

$$P(\text{dwarf and red}) = \frac{1}{4} \times \frac{3}{4} = \frac{3}{16}.$$

Thus, the calculated percentage probability is:

$$\frac{3}{16} \times 100 = 18.75\%.$$

Therefore, the percentage probability of dwarf plants bearing red flowers in the F2 generation is $\boxed{18.75}$.

Quick Tip

To find the probability of two independent events occurring together, multiply the probabilities of each event.

---

65. A hypothetical plant gene ADSH22 is encoded by the nuclear genome. The length of the mature mRNA for ADSH22 is 2150 nucleotides (nts). This mRNA has a 270 nts long 5' UTR and 200 nts long 3' UTR. Taking average molecular weight of an amino acid as 115 Dalton (Da), the calculated molecular weight of ADSH22 protein is _____ kDa (round off to 1 decimal place).

Solution:

To calculate the molecular weight of the ADSH22 protein, we need to find the length of the coding region of the mRNA. The total length of the mRNA is 2150 nts, of which 270 nts are the 5' UTR and 200 nts are the 3' UTR. Thus, the length of the coding region is:

$$\text{Coding region length} = 2150 - 270 - 200 = 1680\,\text{nts}.$$

Each amino acid corresponds to approximately 3 nucleotides in the coding region.

Therefore, the number of amino acids in the protein is:

$$\text{Number of amino acids} = \frac{1680}{3} = 560.$$

The average molecular weight of an amino acid is 115 Da. Therefore, the molecular weight of the protein is:

$$\text{Molecular weight} = 560 \times 115 = 64400\,\text{Da}.$$

Since 1 kDa = 1000 Da, the molecular weight of the protein in kDa is:

$$\text{Molecular weight in kDa} = \frac{64400}{1000} = 64.4\,\text{kDa}.$$

Thus, the calculated molecular weight of ADSH22 protein is $\boxed{64.2}$ kDa.

Quick Tip

To calculate the molecular weight of a protein, determine the number of amino acids, then multiply by the average molecular weight of an amino acid.

---

66. The terminal acceptor of electron during anaerobic respiration in *Methanococcus* is _____.

(A) Nitrate ion

(B) Sulfate ion

(C) Carbon dioxide

(D) Oxygen

Correct Answer: (C) Carbon dioxide

Solution:

Step 1: Understanding the process.

During anaerobic respiration in *Methanococcus*, carbon dioxide is the terminal electron acceptor. This organism uses carbon dioxide as the final electron acceptor in its anaerobic respiration process.

Step 2: Analyzing the options.

- (A) Incorrect, nitrate ion is used by other organisms, such as *E. coli*, but not in *Methanococcus*.
- (B) Incorrect, sulfate ion is used by some bacteria but not in *Methanococcus*.
- (C) Correct, *Methanococcus* uses carbon dioxide as the electron acceptor.
- (D) Incorrect, oxygen is used in aerobic respiration, not anaerobic respiration in *Methanococcus*.

Step 3: Conclusion.

The correct answer is (C) Carbon dioxide.

Quick Tip

In anaerobic respiration, carbon dioxide can serve as a terminal electron acceptor, especially in methanogenic bacteria.

---

67. Which one of the following mutagens convert DNA's adenine to hypoxanthine?

(A) Ultraviolet light

(B) Mitomycin C

(C) Methyl methanesulfonate

(D) Nitrous acid

Correct Answer: (D) Nitrous acid

Solution:

Step 1: Understanding the process.

Nitrous acid is a mutagen that deaminates adenine, converting it to hypoxanthine. Hypoxanthine then pairs with cytosine during DNA replication, leading to a base pair substitution.

Step 2: Analyzing the options.

- (A) Incorrect, ultraviolet light causes thymine dimers, not base substitutions.
- (B) Incorrect, Mitomycin C is a cross-linking agent and does not deaminate adenine.
- (C) Incorrect, Methyl methanesulfonate adds methyl groups to DNA but does not convert adenine to hypoxanthine.
- (D) Correct, Nitrous acid deaminates adenine to hypoxanthine, causing base substitution.

Step 3: Conclusion.

The correct answer is (D) Nitrous acid.

Quick Tip

Nitrous acid is a mutagen that deaminates adenine, converting it to hypoxanthine and causing base substitution in DNA.

---

68. Which one of the following leukocytes are present in the largest proportion in healthy human blood?

(A) Neutrophils

(B) Eosinophils

(C) Basophils

(D) Monocytes

Correct Answer: (A) Neutrophils

Solution:

Step 1: Understanding the question.

The question asks for the leukocytes present in the largest proportion in healthy human blood. Leukocytes, or white blood cells, are important components of the immune system.

Step 2: Analyzing the options.

- (A) Correct, neutrophils are the most abundant type of white blood cells in healthy human blood, typically comprising 50-70- (B) Incorrect, eosinophils are less common and typically make up around 1-4- (C) Incorrect, basophils are rare, usually accounting for less than 1- (D) Incorrect, monocytes account for about 2-8

Step 3: Conclusion.

Thus, the correct answer is (A) Neutrophils.

Quick Tip

Neutrophils are the most abundant type of white blood cell, crucial in defending the body against infections, especially bacterial ones.

---

69. The site of photosynthesis in cyanobacteria is _____.

(A) Chloroplast

(B) Chromatophores

(C) Thylakoids

(D) Chlorosomes

Correct Answer: (C) Thylakoids

Solution:

Step 1: Understanding the question.

The question asks about the site of photosynthesis in cyanobacteria. Cyanobacteria are photosynthetic bacteria, also known as blue-green algae.

Step 2: Analyzing the options.

- (A) Incorrect, chloroplasts are found in plant cells, not in cyanobacteria.
- (B) Incorrect, chromatophores are membrane-bound structures in certain bacteria, but not the site of photosynthesis in cyanobacteria.
- (C) Correct, cyanobacteria have thylakoids, which are the membrane-bound structures where photosynthesis takes place.
- (D) Incorrect, chlorosomes are found in green sulfur bacteria, not in cyanobacteria.

Step 3: Conclusion.

Thus, the correct answer is (C) Thylakoids.

Quick Tip

Thylakoids in cyanobacteria serve as the site for the light-dependent reactions of photosynthesis.

70. The antimicrobial activity of vancomycin is due to the _____.

(A) inhibition of nucleic acid synthesis

(B) damage to the cytoplasmic membrane

(C) inhibition of cell wall synthesis

(D) regulation of DNA supercoiling

Correct Answer: (C) inhibition of cell wall synthesis

Solution:

Step 1: Understanding vancomycin's action.

Vancomycin is an antibiotic that specifically inhibits the synthesis of the bacterial cell wall. This action is crucial because the cell wall is necessary for the stability and integrity of bacterial cells, and its inhibition leads to bacterial cell lysis.

Step 2: Analyzing the options.

- (A) Incorrect, as vancomycin does not inhibit nucleic acid synthesis.

- (B) Incorrect, as vancomycin primarily targets the cell wall and does not cause damage to the cytoplasmic membrane.

- (C) Correct, vancomycin inhibits cell wall synthesis by binding to the precursors involved in the synthesis of peptidoglycan, a crucial component of the bacterial cell wall.

- (D) Incorrect, vancomycin does not regulate DNA supercoiling.

Step 3: Conclusion.

Thus, the correct answer is (C) inhibition of cell wall synthesis.

Quick Tip

Vancomycin works by inhibiting cell wall synthesis, which is essential for the survival of bacteria.

---

71. Phenolics act as disinfectant by _____.

(A) rupturing plasma membrane followed by leakage of cellular contents

(B) bond formation between adjacent pyrimidine bases

(C) forming adduct with amino acid and unsaturated fatty acids

(D) alkylation of proteins

Correct Answer: (A) rupturing plasma membrane followed by leakage of cellular contents

Solution:

Step 1: Phenolic disinfectants.

Phenolic compounds are effective disinfectants due to their ability to disrupt the plasma membrane of microorganisms. By breaking down the integrity of the cell membrane, they cause leakage of cellular contents, ultimately leading to cell death.

Step 2: Analyzing the options.

- (A) Correct, phenolics disrupt the cell membrane by penetrating the lipid bilayer and altering its structure, which leads to the leakage of cellular contents.
- (B) Incorrect, bond formation between pyrimidine bases is not a mechanism associated with phenolics; this is more related to UV radiation.
- (C) Incorrect, phenolics do not primarily form adducts with amino acids and unsaturated fatty acids.
- (D) Incorrect, alkylation of proteins is not the main mechanism of phenolic action.

Step 3: Conclusion.

Thus, the correct answer is (A) rupturing plasma membrane followed by leakage of cellular contents.

Quick Tip

Phenolic disinfectants work by disrupting the cell membrane, causing leakage of cell contents and ultimately killing the microorganism.

---

72. Which of the following methods are used for the identification of microorganisms?

(A) Nucleic acid hybridization

(B) Southern blotting

(C) 16s rRNA sequencing

(D) Percentage G-C content

Correct Answer: (A) Nucleic acid hybridization, (B) Southern blotting, (C) 16s rRNA sequencing

Solution:

Step 1: Understanding the methods.

Nucleic acid hybridization, Southern blotting, and 16s rRNA sequencing are all molecular biology techniques that are widely used for the identification and classification of microorganisms. These methods detect specific DNA or RNA sequences, which are essential for identifying microbial species.

Step 2: Analyzing the options.

- (A) Correct, nucleic acid hybridization is used to identify specific sequences in microbial DNA.
- (B) Correct, Southern blotting is a technique used to detect specific DNA sequences in a sample.
- (C) Correct, 16s rRNA sequencing is a common method for identifying and classifying bacteria based on their rRNA sequences.
- (D) Incorrect, the percentage G-C content is a measure of the base composition of DNA but is not typically used for microbial identification.

Step 3: Conclusion.

The correct methods for microbial identification are nucleic acid hybridization, Southern blotting, and 16s rRNA sequencing.

Quick Tip

Molecular techniques like nucleic acid hybridization and 16s rRNA sequencing are critical tools for identifying microorganisms at the genetic level.

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73. Which of the following are present in Gram-negative bacteria?

(A) Lipopolysaccharide

(B) Teichoic acid

(C) Periplasm

(D) Endotoxin

Correct Answer: (A) Lipopolysaccharide, (C) Periplasm, (D) Endotoxin

Solution:

Step 1: Understanding the components of Gram-negative bacteria.

Gram-negative bacteria have a complex cell wall structure that includes a thin peptidoglycan layer and an outer membrane containing lipopolysaccharides (LPS). They also have a periplasmic space between the outer membrane and the cytoplasmic membrane.

Step 2: Analyzing the options.

- (A) Correct, lipopolysaccharides are a major component of the outer membrane in Gram-negative bacteria.
- (B) Incorrect, teichoic acids are found in the cell wall of Gram-positive bacteria, not Gram-negative bacteria.
- (C) Correct, the periplasm is the space between the inner and outer membranes of Gram-negative bacteria.
- (D) Correct, endotoxins are toxins that are part of the outer membrane of Gram-negative bacteria and are released when the bacteria die.

Step 3: Conclusion.

Lipopolysaccharide, periplasm, and endotoxin are present in Gram-negative bacteria.

Quick Tip

Gram-negative bacteria have a unique outer membrane structure containing lipopolysaccharides and endotoxins, which contribute to their pathogenicity.

---

74. Nonsense suppressor mutation is found in _____.

(A) rRNA

(B) tRNA

(C) start codon of mRNA

(D) stop codon of mRNA

Correct Answer: (B) tRNA

Solution:

Step 1: Understanding the concept.

A nonsense suppressor mutation is a type of mutation in tRNA. It involves the modification of the tRNA molecule to allow it to read a premature stop codon as if it were a codon for an amino acid, effectively suppressing the effect of a nonsense mutation in the mRNA.

Step 2: Analyzing the options.

- (A) Incorrect, as rRNA does not play a direct role in suppressing stop codons.
- (B) Correct, as tRNA can suppress the effect of stop codons by inserting the correct amino acid during translation.
- (C) Incorrect, as the start codon is involved in initiation, not in suppressing stop codons.
- (D) Incorrect, as the stop codon itself is typically the site of termination, not the site of suppression.

Step 3: Conclusion.

Thus, the correct answer is (B) tRNA.

Quick Tip

Nonsense suppressor mutations involve tRNA molecules that can bypass stop codons, allowing translation to continue.

---

75. Choose the correct match for structural components of bacteria to their function.

Structural component	**Function**
(P) Flagella	(i) prevent cell lysis
(Q) Cell wall	(ii) chemotaxis
(R) Metachromatic granules	(iii) storage for ATP
(S) Magnetosomes	(iv) cell orientation

(A) (P)-(ii), (Q)-(iii), (R)-(i), (S)-(iv)

(B) (P)-(ii), (Q)-(i), (R)-(iii), (S)-(iv)

(C) (P)-(ii), (Q)-(i), (R)-(iv), (S)-(iii)

(D) (P)-(i), (Q)-(iv), (R)-(iii), (S)-(ii)

Correct Answer: (B) (P)-(ii), (Q)-(i), (R)-(iii), (S)-(iv)

Solution:

Step 1: Understanding each structural component's function.

- (P) Flagella: Function (ii) Chemotaxis. Flagella are used for movement, allowing bacteria to move toward or away from stimuli (chemotaxis).
- (Q) Cell wall: Function (i) Prevent cell lysis. The cell wall provides structural support and protection against osmotic pressure, preventing lysis.
- (R) Metachromatic granules: Function (iii) Storage for ATP. These granules store phosphate, which is involved in energy storage for the cell.
- (S) Magnetosomes: Function (iv) Cell orientation. Magnetosomes allow bacteria to orient themselves along the Earth's magnetic field, aiding in navigation.

Step 2: Analyzing the options.

- (A) Incorrect, as flagella are involved in chemotaxis, not in cell lysis prevention.
- (B) Correct, as it accurately matches the components with their respective functions.
- (C) Incorrect, as magnetosomes are for orientation, not energy storage.
- (D) Incorrect, as the functions are misassigned.

Step 3: Conclusion.

Thus, the correct answer is (B) (P)-(ii), (Q)-(i), (R)-(iii), (S)-(iv).

Quick Tip

Bacterial structures like flagella and magnetosomes serve critical roles in movement and orientation, while the cell wall and granules provide protection and energy storage.

---

76. Match the pathogen with the appropriate disease.

Pathogen	Disease
(P) *Streptococcus pyogenes*	(i) Scarlet fever
(Q) *Brucella species*	(ii) Pott's disease
(R) *Mycobacterium tuberculosis*	(iii) Traveler's diarrhea
(S) *Escherichia coli*	(iv) Undulant fever

(A) (P)-(ii), (Q)-(iii), (R)-(i), (S)-(iv)
(B) (P)-(ii), (Q)-(i), (R)-(iii), (S)-(iv)
(C) (P)-(i), (Q)-(iv), (R)-(ii), (S)-(iii)
(D) (P)-(i), (Q)-(iv), (R)-(iii), (S)-(ii)

Correct Answer: (C) (P)-(i), (Q)-(iv), (R)-(ii), (S)-(iii)

Solution:

Step 1: Understanding the Pathogens and Diseases.

- **(P) Streptococcus pyogenes** is known to cause Scarlet fever, a condition that results from the release of toxins by the bacteria.
- **(Q) Brucella species** causes Undulant fever, also known as brucellosis, which leads to cyclical fevers and other symptoms.
- **(R) Mycobacterium tuberculosis** is the causative agent of Pott's disease, a form of tuberculosis that affects the spine.
- **(S) Escherichia coli** is a common cause of Traveler's diarrhea, often caused by consuming contaminated food or water.

Step 2: Analyzing the options.

- (A) Incorrect, as the matching of Pott's disease with *Streptococcus pyogenes* and Scarlet fever with *Mycobacterium tuberculosis* is wrong.
- (B) Incorrect, *Mycobacterium tuberculosis* causes Pott's disease, not Traveler's diarrhea.
- (C) Correct, this matches each pathogen with its correct disease:

(P) causes Scarlet fever, (Q) causes Undulant fever, (R) causes Pott's disease, and (S) causes Traveler's diarrhea.

- (D) Incorrect, as it mismatches *Mycobacterium tuberculosis* with Traveler's diarrhea.

Step 3: Conclusion.

The correct answer is (C) (P)-(i), (Q)-(iv), (R)-(ii), (S)-(iii).

Quick Tip

Each pathogen is responsible for a specific disease, and it's important to match them based on their clinical characteristics.

---

77. Match the correct mode of cell division with respective bacteria.

Bacteria

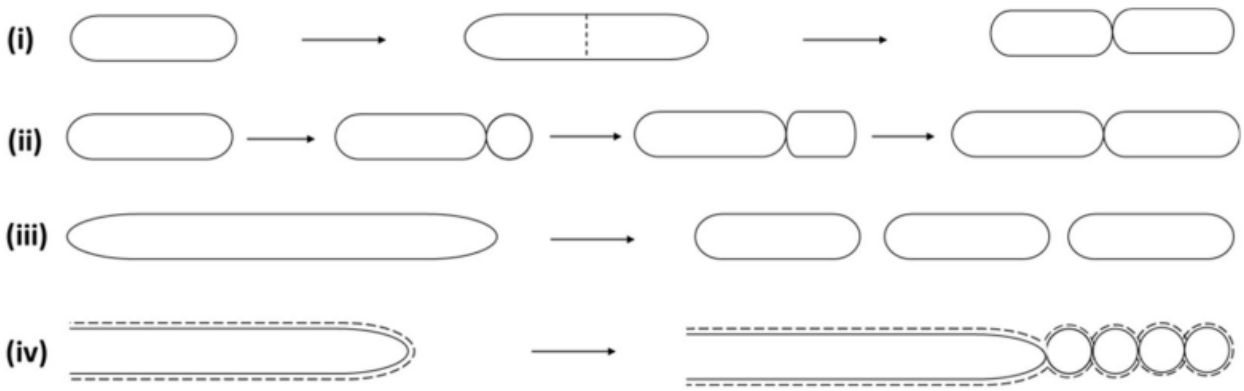
(P) *Streptomyces species*

(Q) *Rhodopseudomonas acidophila*

(R) *Bacillus subtilis*

(S) *Nocardia species*

Mode of cell division



(A) (P)-(ii), (Q)-(iii), (R)-(i), (S)-(iv)

(B) (P)-(ii), (Q)-(i), (R)-(iii), (S)-(iv)

(C) (P)-(iv), (Q)-(ii), (R)-(i), (S)-(iii)

(D) (P)-(i), (Q)-(iv), (R)-(iii), (S)-(ii)

Correct Answer: (C) (P)-(iv), (Q)-(ii), (R)-(i), (S)-(iii)

Solution:

Step 1: Understanding the question.

This question asks to match the correct mode of cell division (represented by different shapes) with the bacteria listed.

Step 2: Analyzing the options.

- (P) Streptomyces species: These bacteria typically exhibit a unique mode of cell division that is represented by option (iv), where they undergo septal formation and fragmentation.
- (Q) Rhodopseudomonas acidophila: This bacterium divides via binary fission, and the mode of division corresponds to (ii), which shows a simple separation of a single cell into two.
- (R) Bacillus subtilis: This bacterium divides by binary fission, represented by (i), showing simple elongation and division.
- (S) Nocardia species: These bacteria divide in a manner where new cells are formed with external growth, represented by (iii).

Step 3: Conclusion.

Thus, the correct matching is (P)-(iv), (Q)-(ii), (R)-(i), (S)-(iii), which corresponds to option (C).

Quick Tip

In bacterial cell division, binary fission is the most common form, but some species like Streptomyces exhibit unique forms such as fragmentation.

---

78. The correct sequence of overall biochemical reaction which expresses the process of denitrification is _____.

(A) $2NO_3^- \rightarrow 2NO_2^- \rightarrow N_2O \rightarrow 2NO \rightarrow N_2$

(B) $2NO_3^- \rightarrow 2NO_2^- \rightarrow 2NO \rightarrow N_2O \rightarrow N_2$

(C) $2NO_3^- \rightarrow 2NO \rightarrow 2NO_2^- \rightarrow N_2O \rightarrow N_2$

(D) $2NO_3^- \rightarrow N_2O \rightarrow 2NO \rightarrow 2NO_2^- \rightarrow N_2$

Correct Answer: (B) $2NO_3^- \rightarrow 2NO_2^- \rightarrow 2NO \rightarrow N_2O \rightarrow N_2$

Solution:

Step 1: Understanding denitrification.

Denitrification is the biochemical process where nitrate (NO) is reduced to nitrogen gas (N) by a series of intermediates. The reaction typically involves the sequential reduction of nitrate to nitrite, then to nitric oxide (NO), nitrous oxide (NO), and finally to nitrogen gas (N).

Step 2: Analyzing the options.

- (A) Incorrect, as this sequence does not represent the typical steps of denitrification.
- (B) Correct, as it follows the correct sequence of denitrification reactions.
- (C) Incorrect, as this sequence does not properly reflect the reduction steps.
- (D) Incorrect, as this sequence misplaces the intermediates of the denitrification process.

Step 3: Conclusion.

Thus, the correct answer is (B) $2NO_3^- \rightarrow 2NO_2^- \rightarrow 2NO \rightarrow N_2O \rightarrow N_2$.

Quick Tip

Denitrification reduces nitrate to nitrogen gas via a sequence of intermediates, including nitrite, nitric oxide, nitrous oxide, and finally nitrogen gas.

---

79. Which of the following diseases are caused by family of DNA viruses?

(A) Hepatitis B

(B) Smallpox

(C) Influenza

(D) Rabies

Correct Answer: (A), (B) Hepatitis B and Smallpox

Solution:

Step 1: Identifying DNA viruses.

DNA viruses include those that have DNA as their genetic material. Diseases like hepatitis B and smallpox are caused by DNA viruses. Hepatitis B is caused by the Hepadnaviridae family, and smallpox is caused by the Poxviridae family.

Step 2: Analyzing the options.

- (A) Correct, Hepatitis B is caused by a DNA virus.
- (B) Correct, Smallpox is caused by a DNA virus.
- (C) Incorrect, Influenza is caused by an RNA virus.
- (D) Incorrect, Rabies is caused by an RNA virus.

Step 3: Conclusion.

Thus, the correct answer is (A) Hepatitis B and (B) Smallpox.

Quick Tip

DNA viruses include families like Hepadnaviridae (Hepatitis B) and Poxviridae (Smallpox).

---

80. Which of the following Gram-positive cocci are found in biofilm of dental plaque?

(A) Gonococcus

(B) Streptococcus mutans

(C) Streptococcus sobrinus

(D) Fusobacterium species

Correct Answer: (B) Streptococcus mutans, (C) Streptococcus sobrinus

Solution:

Step 1: Understanding dental plaque biofilm.

Dental plaque is a biofilm that forms on teeth, primarily consisting of various bacteria. Gram-positive cocci, such as Streptococcus species, are dominant in this biofilm.

Step 2: Analyzing the options.

- (A) Incorrect, Gonococcus is a Gram-negative bacterium, not a Gram-positive coccus.

- (B) Correct, Streptococcus mutans is a Gram-positive coccus commonly found in dental plaque, contributing to tooth decay.
- (C) Correct, Streptococcus sobrinus is also a Gram-positive coccus found in dental plaque, often associated with cavities.
- (D) Incorrect, Fusobacterium species are Gram-negative bacteria, not Gram-positive cocci.

Step 3: Conclusion.

Streptococcus mutans and Streptococcus sobrinus are Gram-positive cocci found in dental plaque.

Quick Tip

Streptococcus mutans and Streptococcus sobrinus are the main Gram-positive cocci responsible for tooth decay and plaque formation.

---

81. Which of the following statements are TRUE for archaea?

(A) Cell wall in archaea contains muramic acid and D-amino acid
(B) N-Formylmethionine is the first amino acid to initiate new polypeptide chain synthesis in archaea
(C) Methionine is the first amino acid used during protein synthesis in archaea
(D) Membrane of archaea contains phytanyl rather than fatty acids

Correct Answer: (C) Methionine is the first amino acid used during protein synthesis in archaea, (D) Membrane of archaea contains phytanyl rather than fatty acids

Solution:

Step 1: Understanding the unique features of archaea.

Archaea are a group of microorganisms with unique features in their cell structure, metabolism, and protein synthesis mechanisms. They differ from bacteria and eukaryotes in several ways.

Step 2: Analyzing the options.

- (A) Incorrect, archaea do not contain muramic acid, which is specific to bacterial cell walls.

- (B) Incorrect, N-Formylmethionine is the first amino acid used in protein synthesis in bacteria, not in archaea.
- (C) Correct, methionine is indeed the first amino acid used during protein synthesis in archaea, similar to eukaryotes.
- (D) Correct, archaea have a unique membrane structure, where the lipid bilayer is composed of phytanyl groups (derived from isoprenoid units), not fatty acids as in bacteria and eukaryotes.

Step 3: Conclusion.

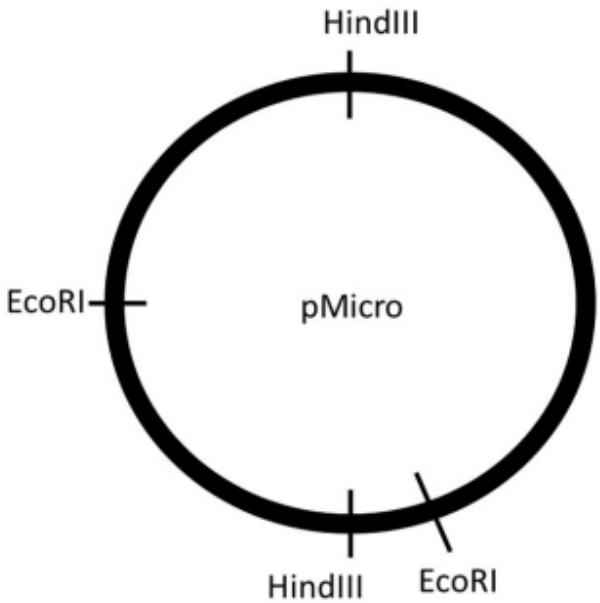
The correct statements about archaea are that methionine is the first amino acid in protein synthesis, and their membranes contain phytanyl rather than fatty acids.

Quick Tip

Archaea have unique cell structures and metabolic processes, including the use of methionine in protein synthesis and phytanyl in their membranes.

---

82. If the plasmid given below is digested with restriction enzymes HindIII and EcoRI, considering complete digestion, how many DNA fragments will be released?



Solution:

The given plasmid is a circular DNA molecule, and it contains two recognition sites: one for

HindIII and one for EcoRI. Both enzymes will cut the plasmid at their respective recognition sites. Since both HindIII and EcoRI cut the plasmid at distinct positions, we will have one cut at each site. The total number of fragments produced will depend on how many times each enzyme cuts.

The plasmid is cut at two positions, one by HindIII and one by EcoRI. This results in two cuts in total, dividing the plasmid into four fragments.

Thus, the total number of DNA fragments produced after complete digestion by both enzymes is 4.

Quick Tip

When a circular DNA is digested with two different restriction enzymes, each enzyme creates a cut at its specific recognition site, dividing the DNA into multiple fragments.

---

83. Escherichia coli growing under favorable conditions doubles in every 20 minutes. If the initial number of Escherichia coli cells is 100, what will be the logarithmic number of cells at 17th generation? (Answer up to 1 decimal place)

Solution:

We use the exponential growth formula:

$$N(t) = N_0 \times 2^{t/T}$$

Where:

- $N(t)$ is the number of cells at time t,
- $N_0 = 100$ is the initial number of cells,
- $T = 20$ minutes is the time interval for doubling,
- $t = 17 \times 20 = 340$ minutes is the total time for 17 generations.

Now, the number of cells at 17th generation:

$$N(t) = 100 \times 2^{17} = 100 \times 131072 = 13107200$$

To find the logarithmic number of cells:

$$\log_{10} N(t) = \log_{10}(13107200) \approx 7.1$$

Thus, the logarithmic number of cells at the 17th generation is approximately 7.1.

Quick Tip

In exponential growth, the logarithmic value of the population can be found using the formula $\log_{10} N(t)$.

---

84. What will be the value of the Numerical Aperture (NA), if the half aperture angle is 58° and oil-immersed objective is used for the process of light microscopy? (Answer up to 1 decimal place)

Solution:

The formula for the Numerical Aperture (NA) is:

$$NA = n \times \sin(\theta)$$

Where:

- $n = 1.50$ is the refractive index of the immersion oil,
- $\theta = 58^\circ$ is the half aperture angle.

Substitute the known values:

$$NA = 1.50 \times \sin(58^\circ) = 1.50 \times 0.85 = 1.3$$

Thus, the Numerical Aperture is 1.3.

Quick Tip

The Numerical Aperture (NA) is calculated using the formula $NA = n \times \sin(\theta)$, where n is the refractive index and θ is the half aperture angle.

---

85. Which one of the following organic compounds is composed of only (i) a nitrogen containing base, (ii) a single five-carbon sugar, and (iii) a triphosphate?

(A) Nucleoside

(B) Nucleotide

(C) Base

(D) Nucleic acid

Correct Answer: (B) Nucleotide

Solution:

Step 1: Understanding the components.

A nucleotide is composed of three components: a nitrogenous base, a five-carbon sugar (ribose or deoxyribose), and a phosphate group (which can be a mono-, di-, or triphosphate).

Step 2: Analyzing the options.

- (A) Incorrect, a nucleoside consists of a nitrogenous base and a five-carbon sugar but does not include a phosphate group.
- (B) Correct, a nucleotide is composed of a nitrogenous base, a five-carbon sugar, and a triphosphate.
- (C) Incorrect, a base refers only to the nitrogen-containing molecule and does not include sugar or phosphate groups.
- (D) Incorrect, nucleic acids are large molecules made of long chains of nucleotides, but they are not a single organic compound as described in the question.

Step 3: Conclusion.

The correct answer is (B) Nucleotide.

Quick Tip

Nucleotides are the building blocks of nucleic acids, consisting of a nitrogenous base, a five-carbon sugar, and a phosphate group.

---

86. Which one of the following animals develops adaptive predator avoidance morphology because of the presence of high predator number in its habitat?

(A) Daphnia sp.

(B) Scaphiopus sp.

(C) Wolbachia sp.

(D) Rhodnius sp.

Correct Answer: (B) Scaphiopus sp.

Solution:

Step 1: Understanding the adaptive response.

The genus *Scaphiopus* is known to exhibit predator-induced morphological changes, such as alterations in body shape, which help in avoiding predation when predator populations are high.

Step 2: Analyzing the options.

- (A) Incorrect, *Daphnia sp.* exhibits predator-induced responses, but they are more related to changes in behavior or body size, not morphology.
- (B) Correct, *Scaphiopus sp.* is a genus of toads that develops specific predator avoidance morphology due to the presence of predators.
- (C) Incorrect, *Wolbachia sp.* is a genus of bacteria that does not exhibit predator avoidance morphology.
- (D) Incorrect, *Rhodnius sp.* is a genus of triatomine bugs, not known for adaptive predator avoidance morphology.

Step 3: Conclusion.

The correct answer is (B) *Scaphiopus sp.*.

Quick Tip

Some species, like *Scaphiopus*, exhibit morphological changes in response to high predator numbers in their environment.

---

87. To which class of Drosophila developmental genes does fushi tarazu (ftz) belong?

(A) Gap genes

(B) Segment polarity genes

(C) Pair rule genes

(D) Maternal effect genes

Correct Answer: (C) Pair rule genes

Solution:

Step 1: Understanding the question.

The question asks to classify the Drosophila developmental gene fushi tarazu (ftz). This gene plays a critical role in the segmentation of the Drosophila embryo.

Step 2: Analyzing the options.

- (A) Incorrect, gap genes are responsible for the establishment of broad segments in the developing embryo but do not specifically form alternating patterns like ftz.
- (B) Incorrect, segment polarity genes determine the boundaries within segments, but ftz operates earlier in the process.
- (C) Correct, ftz is a pair rule gene, which is involved in the segmentation process by forming a pattern of alternating stripes.
- (D) Incorrect, maternal effect genes influence development based on the mother's genotype but do not directly determine the pattern of segmentation like ftz.

Step 3: Conclusion.

Thus, the correct answer is (C) Pair rule genes.

Quick Tip

Pair rule genes are involved in forming alternating segments during embryonic development in Drosophila.

---

88. The action of which class of enzyme inhibitors can be reversed by adding an excess of substrate?

(A) Uncompetitive inhibitors
(B) Competitive inhibitors
(C) Non-specific inhibitors
(D) Allosteric inhibitors

Correct Answer: (B) Competitive inhibitors

Solution:

Step 1: Understanding the question.

This question asks about the type of enzyme inhibitors whose effect can be reversed by increasing the substrate concentration.

Step 2: Analyzing the options.

- (A) Incorrect, uncompetitive inhibitors bind to the enzyme-substrate complex and cannot be reversed by adding excess substrate.
- (B) Correct, competitive inhibitors compete with the substrate for the active site, and their effects can be overcome by adding an excess of substrate.
- (C) Incorrect, non-specific inhibitors do not specifically interact with the enzyme's active site, and their effects are not reversed by adding substrate.
- (D) Incorrect, allosteric inhibitors bind to a site other than the active site and do not depend on substrate concentration for reversal.

Step 3: Conclusion.

Thus, the correct answer is (B) Competitive inhibitors.

Quick Tip

Competitive inhibitors bind to the active site of enzymes, and their effect can be overcome by increasing the substrate concentration.

---

89. Mendel deduced the genetic principle of inheritance by experimenting on sweet pea plants. One of the experiments involved crossing plants with two contrasting characters, tall (dominant) and dwarf (recessive), which yielded all tall plants in the first generation. When the same genetic cross was independently repeated by a researcher, only short plants were obtained. Which one of the following can possibly explain the altered outcome?

(A) Tall plants were heterozygous
(B) An enhancer for the tall allele is present in the dwarf plant
(C) A suppressor for the tall allele is present in the dwarf plant
(D) Dwarf plants are homozygous

Correct Answer: (C) A suppressor for the tall allele is present in the dwarf plant

Solution:

Step 1: Understanding the genetic cross.

In Mendel's experiments, he crossed tall and dwarf plants. The tall character is dominant, and the dwarf character is recessive. The initial generation of offspring was all tall, which suggests that the tall plants were heterozygous (Tt).

Step 2: Analyzing the options.

- (A) Incorrect, the tall plants in the first generation were likely heterozygous, but this does not explain the altered outcome in the subsequent generation.
- (B) Incorrect, an enhancer for the tall allele in the dwarf plant would not cause the change in outcome.
- (C) Correct, a suppressor gene in the dwarf plant could have modified the expression of the tall allele, leading to only dwarf plants in the second generation.
- (D) Incorrect, the genotype of the dwarf plants being homozygous does not explain the altered outcome, as they should still produce tall plants when crossed with a heterozygous tall plant.

Step 3: Conclusion.

Thus, the correct answer is (C) A suppressor for the tall allele is present in the dwarf plant.

Quick Tip

A suppressor gene can interfere with the expression of other alleles, leading to altered inheritance patterns.

---

90. Which of the following is/are responsible for reversible receptor–ligand interaction?

(A) Ionic interactions

(B) Hydrogen bonding

(C) Peptide bonding

(D) Hydrophobic interactions

Correct Answer: (A), (B), (D) Ionic interactions, Hydrogen bonding, Hydrophobic interactions

Solution:

Step 1: Understanding reversible receptor-ligand interactions.

Reversible interactions between receptors and ligands are typically mediated by non-covalent bonds such as ionic interactions, hydrogen bonding, and hydrophobic interactions. These interactions allow for the binding and release of ligands.

Step 2: Analyzing the options.

- (A) Correct, ionic interactions are crucial for reversible receptor-ligand binding as they involve electrostatic attraction between charged groups.
- (B) Correct, hydrogen bonds also play a significant role in receptor-ligand interactions by providing reversible attractions between molecules.
- (C) Incorrect, peptide bonding is a covalent bond and not typically involved in reversible interactions.
- (D) Correct, hydrophobic interactions help stabilize the binding between receptors and ligands, particularly in non-polar environments.

Step 3: Conclusion.

Thus, the correct answer is (A), (B), and (D) Ionic interactions, Hydrogen bonding, and Hydrophobic interactions.

Quick Tip

Reversible receptor-ligand interactions are primarily non-covalent, involving ionic, hydrogen, and hydrophobic interactions.

---

91. In the human body, which of the following is/are involved in processing of a foreign antigen?

(A) B-cells

(B) Macrophages

(C) Red blood cells

(D) Platelets

Correct Answer: (A) B-cells, (B) Macrophages

Solution:

Step 1: Understanding the immune response.

In the immune system, processing of foreign antigens is an essential part of recognizing and fighting pathogens. B-cells and macrophages are both crucial in this process.

Step 2: Analyzing the options.

- (A) Correct, B-cells are involved in the humoral immune response and help in recognizing and processing antigens to produce antibodies.
- (B) Correct, macrophages are antigen-presenting cells that engulf pathogens and present their antigens to T-cells.
- (C) Incorrect, red blood cells do not participate in the immune response or antigen processing.
- (D) Incorrect, platelets are involved in clotting, not in processing foreign antigens.

Step 3: Conclusion.

The correct answer is (A) B-cells and (B) Macrophages, as both are involved in antigen processing.

Quick Tip

Macrophages and B-cells play essential roles in the immune response, with macrophages presenting antigens and B-cells producing antibodies.

---

92. Animals can be classified as 'specialists' or 'generalists' with respect to diet and habitat selection. Which of the following organism/s belong/s to the specialist category?

(A) Raccoon

(B) Panda

(C) Polar Bear

(D) Koala Bear

Correct Answer: (B) Panda, (C) Polar Bear, (D) Koala Bear

Solution:

Step 1: Understanding the terms.

Specialists are organisms that have a narrow diet or habitat preference, while generalists have a broader range of diet and habitat. Pandas, polar bears, and koala bears are all considered specialists.

Step 2: Analyzing the options.

- (A) Incorrect, raccoons are generalists as they can adapt to various environments and have a wide diet.
- (B) Correct, pandas are specialists as they primarily feed on bamboo and have a limited diet.
- (C) Correct, polar bears are specialists as they rely on a specific diet of seals and live in Arctic regions.
- (D) Correct, koala bears are specialists as they mainly feed on eucalyptus leaves and have a narrow dietary range.

Step 3: Conclusion.

Pandas, polar bears, and koala bears are examples of specialists due to their specific diet and habitat preferences.

Quick Tip

Specialists have a narrow range of diet and habitat preferences, while generalists can adapt to various conditions and diets.

---

93. Match the drug/chemicals listed in Column I with the developmental/physiological defects listed in Column II.

Column I	Column II
P. Veratrum alkaloids	(i) Obesity
Q. Thalidomide	(ii) Minamata syndrome
R. Methylmercury	(iii) Cyclopia
S. Diethylstilbesterol	(iv) Phocomelia

(A) P-(iii); Q-(iv); R-(ii); S-(i)

(B) P-(i); Q-(iv); R-(iii); S-(ii)

(C) P-(ii); Q-(iv); R-(iii); S-(i)

(D) P-(ii); Q-(iii); R-(iv); S-(i)

Correct Answer: (A) P-(iii); Q-(iv); R-(ii); S-(i)

Solution:

Step 1: Understanding the drugs and defects.

- Veratrum alkaloids (P) are known to cause Cyclopia (iii), a birth defect where there is only one eye.
- Thalidomide (Q) is famous for causing Phocomelia (iv), which is a condition where limbs are severely shortened or absent.
- Methylmercury (R) is responsible for causing Minamata syndrome (ii), a neurological disease caused by mercury poisoning.
- Diethylstilbestrol (S) is linked with obesity (i) and other hormonal disruptions, particularly in offspring.

Step 2: Analyzing the options.

- (A) Correct, as it correctly matches each drug to its respective defect: Veratrum alkaloids with Cyclopia, Thalidomide with Phocomelia, Methylmercury with Minamata syndrome, and Diethylstilbestrol with Obesity.
- (B), (C), and (D) are incorrect because they do not match the defects correctly with the drugs.

Step 3: Conclusion.

Thus, the correct answer is (A) P-(iii); Q-(iv); R-(ii); S-(i).

Quick Tip

Different drugs and chemicals can lead to specific congenital defects or physiological disorders. Always remember the major historical examples like Thalidomide for Phocomelia and Methylmercury for Minamata syndrome.

---

94. Match the animals listed in Column I with primary tissue or organ of residence in the host listed in Column II

Column I	Column II
P. *Ascaris lumbricoides*	(i) Subcutaneous tissue in human
Q. *Dracunculus medinensis*	(ii) Lymphatic vessels and lymph nodes
R. *Enterobius vermicularis*	(iii) Small intestine
S. *Wuchereria bancrofti*	(iv) Caecum or vermiform appendix

(A) P-(iii), Q-(iv), R-(ii), S-(i)

(B) P-(i), Q-(iv), R-(iii), S-(ii)

(C) P-(ii), Q-(iii), R-(iv), S-(i)

(D) P-(iii), Q-(i), R-(iv), S-(ii)

Correct Answer: (D) P-(iii), Q-(i), R-(iv), S-(ii)

Solution:

Step 1: Understanding the animal and its residence.

- *Ascaris lumbricoides* is a roundworm that resides in the small intestine of humans.
- *Dracunculus medinensis* is the guinea worm, which resides in the subcutaneous tissue of humans.
- *Enterobius vermicularis* is the pinworm that resides in the caecum or vermiform appendix.
- *Wuchereria bancrofti* is a parasitic worm that resides in the lymphatic vessels and lymph nodes.

Step 2: Analyzing the options.

- (A) Incorrect, as it mismatches the habitat of *Enterobius vermicularis*.
- (B) Incorrect, as *Dracunculus medinensis* should reside in the subcutaneous tissue, not in the caecum.
- (C) Incorrect, *Wuchereria bancrofti* should reside in the lymphatic vessels, not the subcutaneous tissue.
- (D) Correct, it correctly matches each organism to its respective tissue or organ of residence:

Ascaris lumbricoides in the small intestine, *Dracunculus medinensis* in the subcutaneous tissue, *Enterobius vermicularis* in the caecum or vermiform appendix, and *Wuchereria bancrofti* in the lymphatic vessels and lymph nodes.

Step 3: Conclusion.

The correct answer is (D) P-(iii), Q-(i), R-(iv), S-(ii).

Quick Tip

Matching parasites to their primary site of residence in the host is important for understanding their life cycles and their impact on human health.

---

95. Match the cell types listed in Column I with their sources in Column II and the primary functional roles listed in Column III.

Column I	Column II	Column III
P. Microglial cells	(i) Lung	a. Visual transduction
Q. Leydig cells	(ii) Eyes	b. Hormone secretion
R. ON cells	(iii) Brain	c. Phagocytosis
S. Pneumocytes	(iv) Testis	d. Gaseous exchange

(A) P-(iii)-b, Q-(iv)-c, R-(ii)-a, S-(i)-d

(B) P-(ii)-c, Q-(iv)-d, R-(i)-a, S-(iii)-b

(C) P-(i)-a, Q-(iv)-b, R-(ii)-c, S-(iii)-d

(D) P-(iii)-c, Q-(iv)-b, R-(ii)-a, S-(i)-d

Correct Answer: (D) P-(iii)-c, Q-(iv)-b, R-(ii)-a, S-(i)-d

Solution:

Step 1: Understanding the question.

The question asks to match the cell types listed in Column I with their sources in Column II and their primary functional roles in Column III.

Step 2: Analyzing the options.

- (P) Microglial cells: These cells are part of the brain (iii) and their primary function is phagocytosis (c).

- (Q) Leydig cells: These cells are found in the testes (iv) and are responsible for hormone secretion (b).

- (R) ON cells: These cells are found in the eyes (ii) and their primary function is visual transduction (a).
- (S) Pneumocytes: These cells are located in the lungs (i) and their primary function is gaseous exchange (d).

Step 3: Conclusion.

Thus, the correct matching is: P-(iii)-c, Q-(iv)-b, R-(ii)-a, S-(i)-d, which corresponds to option (D).

Quick Tip

Microglial cells are specialized macrophages in the brain, and pneumocytes are involved in gas exchange in the lungs.

---

96. Match the ecological concepts listed in Column I with their definitions listed in Column II.

Column I	Column II
P. Dominance hierarchies	(i) Giving up one's own reproductive potential to benefit another individual
Q. Territory	(ii) Selection acting on related animals which affects fitness of an individual
R. Altruism	(iii) Exclusion of competing individuals using agonistic behavior
S. Kin selection	(iv) Preferential access to the food and mates in a group

(A) P-(ii), Q-(iv), R-(i), S-(iii)

(B) P-(iv), Q-(iii), R-(i), S-(ii)

(C) P-(iii), Q-(iv), R-(i), S-(ii)

(D) P-(i), Q-(iv), R-(iii), S-(ii)

Correct Answer: (B) P-(iv), Q-(iii), R-(i), S-(ii)

Solution:

Step 1: Understanding the concepts.

- Dominance hierarchies (P) refer to the social ranking within a group, where higher-ranking individuals have preferential access to food and mates. Hence, P matches with (iv).
- Territory (Q) involves defending an area to prevent intrusion by others, which often occurs through agonistic behavior. Thus, Q matches with (iii).
- Altruism (R) is the behavior in which an individual gives up its own reproductive potential to benefit another individual. This aligns with (i).
- Kin selection (S) refers to selection that acts on related individuals to increase their fitness, which supports the individual's genetic contribution. Therefore, S matches with (ii).

Step 2: Conclusion.

Thus, the correct matching is: P-(iv), Q-(iii), R-(i), S-(ii). The correct answer is (B).

Quick Tip

Dominance hierarchies allow for preferential access to resources, while altruism and kin selection involve helping others at a cost to oneself.

---

97. Match the hormones listed in Column I with their primary source tissues in Column II and the primary target tissues listed in Column III.

Column I	Column II	Column III
P. Epinephrine	(i) Hypothalamus	a. Pituitary
Q. Prolactin	(ii) Thyroid	b. Heart
R. Calcitonin	(iii) Pituitary	c. Bone
S. Thyrotropin releasing hormone	(iv) Chromaffin tissue	d. Pigeon's crop

(A) P-(iii)-b, Q-(iv)-c, R-(ii)-a, S-(i)-d

(B) P-(iv)-c, Q-(iii)-b, R-(ii)-a, S-(i)-d

(C) P-(iv)-b, Q-(iii)-d, R-(ii)-c, S-(i)-a

(D) P-(iii)-b, Q-(iv)-c, R-(ii)-d, S-(i)-a

Correct Answer: (C) P-(iv)-b, Q-(iii)-d, R-(ii)-c, S-(i)-a

Solution:

Step 1: Understanding the hormones and their sources.

- Epinephrine is released from the chromaffin tissue (adrenal medulla) and acts primarily on the heart.
- Prolactin is produced in the pituitary gland and affects the pigeon's crop for milk production.
- Calcitonin is released from the thyroid and targets the bone to regulate calcium levels.
- Thyrotropin-releasing hormone (TRH) is released by the hypothalamus and stimulates the pituitary.

Step 2: Analyzing the options.

- (A) Incorrect, the matches do not align with the primary source tissues and targets.
- (B) Incorrect, while some matches are correct, others are incorrect.
- (C) Correct, the correct matches are:
- Epinephrine from chromaffin tissue acting on the heart.
- Prolactin from the pituitary acting on the pigeon's crop.
- Calcitonin from the thyroid acting on the bone.
- Thyrotropin releasing hormone from the hypothalamus acting on the pituitary.
- (D) Incorrect, as the matches do not align with the correct source tissues.

Step 3: Conclusion.

The correct match is (C) P-(iv)-b, Q-(iii)-d, R-(ii)-c, S-(i)-a.

Quick Tip

Understanding the source and target tissues of hormones is key to matching them correctly. Hormones from the pituitary act on various tissues, and hormones like epinephrine come from specialized cells like those in the chromaffin tissue.

---

98. 2-Deoxyglucose (2-DG) inhibits the proliferation of cells and hence finds use as an anti-cancer agent. It is also used in COVID therapy, where it blocks hyperproliferation of virus-infected cells. Mechanistically, 2-DG blocks glycolysis by inhibiting the activities of which of the following enzyme/s?

(A) Hexokinase

(B) Glucose 6-phosphate isomerase

(C) Glucose-6 phosphate dehydrogenase

(D) Phosphofructokinase

Correct Answer: (A) Hexokinase

Solution:

Step 1: Understanding the role of 2-DG.

2-Deoxyglucose (2-DG) interferes with glycolysis by inhibiting the enzyme hexokinase. Hexokinase is responsible for the phosphorylation of glucose to glucose-6-phosphate in the first step of glycolysis. By blocking this step, 2-DG effectively halts the glycolytic pathway, which inhibits cell proliferation.

Step 2: Analyzing the options.

- (A) Correct, as hexokinase is the enzyme that is inhibited by 2-DG, halting the glycolysis process.
- (B) Incorrect, glucose 6-phosphate isomerase is involved in converting glucose-6-phosphate to fructose-6-phosphate, but it is not directly targeted by 2-DG.
- (C) Incorrect, glucose-6 phosphate dehydrogenase is involved in the pentose phosphate pathway, not the glycolytic pathway directly impacted by 2-DG.
- (D) Incorrect, phosphofructokinase is an important enzyme in glycolysis but is not the primary target of 2-DG.

Step 3: Conclusion.

Thus, the correct answer is (A) Hexokinase.

Quick Tip

2-Deoxyglucose blocks glycolysis by inhibiting hexokinase, the first enzyme in the glycolytic pathway.

---

99. According to Abbe's equation on microscopy, the ability to resolve two entities inside a cell by light microscopy depends on which of the following factor/s?

(A) Magnification of the objective lens

(B) Intensity of incident light

(C) Wavelength

(D) Numerical aperture of the objective lens

Correct Answer: (C) Wavelength, (D) Numerical aperture of the objective lens

Solution:

Step 1: Understanding Abbe's equation.

Abbe's equation states that the resolving power of a microscope is determined by the wavelength of light used and the numerical aperture (NA) of the objective lens. These factors define the microscope's ability to distinguish two points as separate entities.

Step 2: Analyzing the options.

- (A) Incorrect, while magnification improves the size of the image, it does not affect the resolution directly.
- (B) Incorrect, intensity affects the brightness but not the resolution of the microscope.
- (C) Correct, shorter wavelengths of light lead to better resolution, which is described by Abbe's equation.
- (D) Correct, the numerical aperture (NA) of the lens determines the amount of light collected and affects the resolution, as described by Abbe's equation.

Step 3: Conclusion.

Thus, the correct answers are (C) Wavelength and (D) Numerical aperture of the objective lens.

Quick Tip

The resolving power of a microscope is determined by the wavelength of light and the numerical aperture of the objective lens according to Abbe's equation.

---

100. Match the animal inactivity behaviors listed in Column I with representative animals in Column II and their definitions listed in Column III.

Column I	Column II	Column III
P. Torpor	(i) Australian burrowing frogs	a. Prolonged period of inactivity without reducing body temperature
Q. Hibernation	(ii) Polar Bears	b. Inactivity period which accompanies extended periods of dryness
R. Winter sleep	(iii) Ground Squirrels	c. Decreased metabolism with lowered body temperature occurring in daily activity cycles
S. Aestivation	(iv) Hummingbirds	d. Decreased metabolism and lower body temperature for weeks or months

Column III

(a) Prolonged period of inactivity without reducing body temperature

(b) Inactivity period which accompanies extended periods of dryness

(c) Decreased metabolism with lowered body temperature occurring in daily activity cycles

(d) Decreased metabolism and lower body temperature for weeks or months

(A) P-(ii)-c, Q-(iv)-b, R-(i)-a, S-(iii)-d

(B) P-(iv)-c, Q-(iii)-a, R-(ii)-a, S-(i)-b

(C) P-(iv)-c, Q-(ii)-b, R-(i)-a, S-(iii)-d

(D) P-(iv)-b, Q-(i)-c, R-(ii)-d, S-(iii)-a

Correct Answer: (B) P-(iv)-c, Q-(iii)-a, R-(ii)-a, S-(i)-b

Solution:

Step 1: Understanding the animal behaviors and their definitions.

- **Torpor (P)** is a state of decreased metabolism with lowered body temperature occurring in daily activity cycles, as seen in hummingbirds.
- **Hibernation (Q)** is a prolonged period of inactivity accompanied by a decrease in metabolism and body temperature over weeks or months, as seen in ground squirrels.
- **Winter sleep (R)** refers to a prolonged period of inactivity without reducing body temperature, as observed in polar bears.
- **Aestivation (S)** is an inactivity period that accompanies extended periods of dryness, as seen in Australian burrowing frogs.

Step 2: Analyzing the options.

- (A) Incorrect, as it mismatches the animals and definitions.

- (B) Correct, as this matches each animal with its appropriate inactivity behavior and definition.

- (C) Incorrect, as it mismatches the behavior of winter sleep.

- (D) Incorrect, as it mismatches both the behavior of torpor and hibernation.

Step 3: Conclusion.

The correct answer is (B) P-(iv)-c, Q-(iii)-a, R-(ii)-a, S-(i)-b.

Quick Tip

Different animal species exhibit various forms of inactivity, such as torpor, hibernation, and aestivation, depending on environmental conditions and physiological needs.

---

101. If the vital capacity (VC) of an individual is 4900 ml, the tidal volume (TV) is 500 ml, and the inspiratory reserve volume (IRV) is 3300 ml, the expiratory reserve volume (ERV) of the individual is _____ ml (in integer).

Solution:

We are given the following values:

- Vital Capacity (VC) = 4900 ml,

- Tidal Volume (TV) = 500 ml,

- Inspiratory Reserve Volume (IRV) = 3300 ml.

The formula for Vital Capacity (VC) is:

$$VC = TV + IRV + ERV$$

Substituting the given values:

$$4900 = 500 + 3300 + ERV$$

$$ERV = 4900 - 3800 = 1100\,\text{ml}.$$

Thus, the expiratory reserve volume (ERV) is 1100 ml.

Quick Tip

The vital capacity is the sum of the tidal volume, inspiratory reserve volume, and expiratory reserve volume.

---

102. A typical food chain involves producers, herbivores, primary carnivores, and secondary carnivores. Based on Lindeman's law of trophic efficiency, if producers have 40 kJ of energy, the energy that will be stored in secondary carnivores is _____ kJ (round off to two decimal places).

Solution:

Lindeman's law of trophic efficiency states that approximately 10% of the energy is transferred from one trophic level to the next. If producers have 40 kJ of energy, the energy passed to secondary carnivores is calculated as follows:

Energy stored in secondary carnivores = $40\,\text{kJ} \times (0.10 \times 0.10)$

$$\text{Energy} = 40 \times 0.01 = 0.04\,\text{kJ}.$$

Thus, the energy stored in secondary carnivores is 0.04 kJ.

Quick Tip

According to Lindeman's law, only about 10% of energy is transferred to the next trophic level, and this process continues through each level.

---

103. The average body length of Drosophila nasuta collected from Andaman and Nicobar Islands is 2 mm. From this population, a few males and females having a body length of 3 mm were selected and interbred. The average body length of the resultant progeny was 2.5 mm. The heritability (h^2) of the body length in this population is _____. (round off to one decimal place)

Solution:

We use the formula for heritability:

$$h^2 = \frac{\text{Mean of progeny} - \text{Mean of population}}{\text{Mean of selected parents} - \text{Mean of population}}$$

Given:

- Mean of population = 2 mm,
- Mean of selected parents = 3 mm,
- Mean of progeny = 2.5 mm.

Substituting the values into the formula:

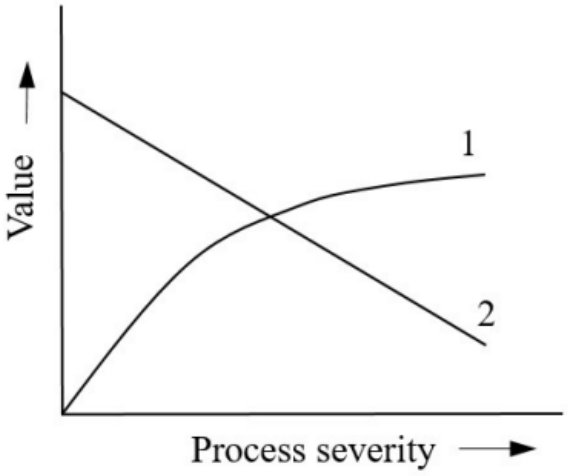
$$h^2 = \frac{2.5 - 2}{3 - 2} = \frac{0.5}{1} = 0.5$$

Thus, the heritability (h^2) of the body length in this population is 0.5.

> Heritability can be calculated as the ratio of the difference in means between progeny and population to the difference between selected parents and population.

---

104. Which among the given options truly depict the lines 1 and 2 in the figure below with respect to the effect of heat processing on food?



(A) 1-Safety, 2-Quality

(B) 1-Yield, 2-Safety

(C) 1-Yield, 2-Quality

(D) 1-Quality, 2-Safety

Correct Answer: (A) 1-Safety, 2-Quality

Solution:

Step 1: Interpreting the graph.

The graph shows the effect of process severity on two parameters: safety and quality. From the figure: - Line 1 increases with the process severity, indicating that safety improves as the process becomes more severe. - Line 2 decreases with process severity, indicating that quality decreases as the process becomes more severe.

Step 2: Analyzing the options.

- (A) Correct, line 1 represents safety, which improves with process severity, while line 2 represents quality, which decreases.
- (B) Incorrect, as it mismatches the relationship between yield, safety, and process severity.
- (C) Incorrect, as it reverses the relationship between yield and quality.
- (D) Incorrect, as it does not correctly match quality and safety with the graph.

Step 3: Conclusion.

The correct answer is (A) 1-Safety, 2-Quality.

Quick Tip

When analyzing the effect of heat processing on food, remember that increased severity typically improves safety but reduces quality.

---

105. Homogenization of milk leads to disintegration of fat globules by

(A) Turbulence and pasteurization

(B) Pasteurization and cavitation

(C) Pasteurization and pressurization

(D) Turbulence and cavitation

Correct Answer: (D) Turbulence and cavitation

Solution:

Step 1: Understanding homogenization.

Homogenization of milk involves reducing the size of fat globules by applying mechanical forces. This process typically involves turbulence and cavitation. Cavitation occurs when

small bubbles implode in the liquid, leading to the breakdown of fat globules.

Step 2: Analyzing the options.

- (A) Incorrect, pasteurization is a heat treatment process and does not directly contribute to fat globule disintegration.

- (B) Incorrect, while pasteurization kills bacteria, it does not contribute to the mechanical disintegration of fat globules.

- (C) Incorrect, pressurization alone does not lead to fat globule disintegration as effectively as turbulence and cavitation.

- (D) Correct, turbulence and cavitation are the two key mechanical processes responsible for the disintegration of fat globules in milk homogenization.

Step 3: Conclusion.

The correct answer is (D) Turbulence and cavitation.

Quick Tip

Homogenization relies on mechanical forces such as turbulence and cavitation to break down fat globules in milk.

---

106. The lowest water activity (a_w) supporting the growth of Staphylococcus aureus in food under aerobic condition is

(A) 0.98

(B) 0.91

(C) 0.89

(D) 0.86

Correct Answer: (D) 0.86

Solution:

Step 1: Understanding water activity.

Water activity (a_w) is a measure of the available water in a food that supports microbial growth. Staphylococcus aureus is known to grow at low water activity, and the growth of this bacterium typically occurs at a a_w of around 0.86 under aerobic conditions.

Step 2: Analyzing the options.

- (A) Incorrect, 0.98 is above the threshold for microbial growth, and Staphylococcus aureus can grow at higher water activities.

- (B) Incorrect, while 0.91 is low, it is still above the value supporting growth in aerobic conditions.

- (C) Incorrect, 0.89 is still above the threshold.

- (D) Correct, 0.86 is the water activity below which Staphylococcus aureus can grow in aerobic conditions.

Step 3: Conclusion.

Thus, the correct answer is (D) 0.86.

Quick Tip

Water activity (a_w) is a critical factor for controlling microbial growth. For Staphylococcus aureus, the threshold is 0.86 under aerobic conditions.

---

107. Cultures used in industrial production of yogurt are

(A) Lactococcus lactis subsp. lactis

(B) Streptococcus thermophilus

(C) Leuconostoc mesenteroides subsp. cremoris

(D) Lactobacillus delbrueckii subsp. bulgaricus

Correct Answer: (B) Streptococcus thermophilus, (D) Lactobacillus delbrueckii subsp. bulgaricus

Solution:

Step 1: Understanding yogurt cultures.

Yogurt is produced through the fermentation of milk by specific bacterial cultures. The primary cultures used are Streptococcus thermophilus and Lactobacillus delbrueckii subsp. bulgaricus. These cultures work synergistically to produce the characteristic flavor and texture of yogurt.

Step 2: Analyzing the options.

- (A) Incorrect, Lactococcus lactis subsp. lactis is not used in the production of yogurt; it is involved in other dairy products like cheese.
- (B) Correct, Streptococcus thermophilus is a key starter culture in yogurt production.
- (C) Incorrect, while Leuconostoc mesenteroides is involved in some dairy fermentations, it is not typically used in yogurt production.
- (D) Correct, Lactobacillus delbrueckii subsp. bulgaricus is another essential culture for yogurt fermentation.

Step 3: Conclusion.

Thus, the correct answer is (B) Streptococcus thermophilus and (D) Lactobacillus delbrueckii subsp. bulgaricus.

Quick Tip

Streptococcus thermophilus and Lactobacillus delbrueckii subsp. bulgaricus are the primary cultures used in yogurt production due to their synergistic fermentation action.

---

108. In a dairy plant, spray drying technology is used to produce whey powder. The rate of spray drying depends on

(A) Temperature of the incoming air
(B) Shape of the cyclone separator
(C) Diameter of the whey droplet
(D) Heat transfer coefficient of hot air

Correct Answer: (A), (C), (D) Temperature of the incoming air, Diameter of the whey droplet, Heat transfer coefficient of hot air

Solution:

Step 1: Understanding spray drying.

Spray drying involves the rapid drying of liquid materials by spraying them into a hot air stream. The rate of drying is influenced by several factors: the temperature of the incoming air, the size of the droplets, and the heat transfer coefficient of the air.

Step 2: Analyzing the options.

- (A) Correct, the temperature of the incoming air is one of the most significant factors affecting the drying rate as it determines the evaporation rate of the droplets.
- (B) Incorrect, the shape of the cyclone separator does not have a significant impact on the rate of drying.
- (C) Correct, the diameter of the whey droplet is crucial, as smaller droplets dry faster due to their larger surface area relative to volume.
- (D) Correct, the heat transfer coefficient of hot air influences the efficiency of heat exchange, which is critical in the drying process.

Step 3: Conclusion.

Thus, the correct answer is (A), (C), and (D).

Quick Tip

In spray drying, smaller droplets and higher air temperatures speed up the drying process.

---

109. The parboiling of paddy results into

(A) Increase in the milling losses

(B) Increase in the nutritional value of rice

(C) Increase in the head rice recovery

(D) Increase in the broken rice percentage

Correct Answer: (B), (C) Increase in the nutritional value of rice, Increase in the head rice recovery

Solution:

Step 1: Understanding parboiling.

Parboiling is the process of partially boiling paddy before milling, which improves the nutritional value and increases the recovery of head rice (intact rice kernels).

Step 2: Analyzing the options.

- (A) Incorrect, parboiling typically reduces milling losses by making the grains firmer and easier to process.

- (B) Correct, parboiling enhances the nutritional value of rice by causing the migration of nutrients from the husk to the kernel.
- (C) Correct, parboiling helps increase the head rice recovery by reducing breakage during milling.
- (D) Incorrect, parboiling reduces the broken rice percentage by making the rice grains less brittle.

Step 3: Conclusion.

Thus, the correct answer is (B) and (C).

Quick Tip

Parboiling improves the quality of rice by enhancing its nutritional content and increasing the yield of whole rice grains.

---

110. One hundred kg paddy is dried from 18% wet basis to 13% wet basis moisture content. The amount of water removed (in kg) from the paddy is _____ (round off to one decimal place).

Solution:

We are given the following data:

- Initial weight of paddy = 100 kg
- Initial moisture content = 18%
- Final moisture content = 13%.

The amount of water removed can be calculated by using the formula for moisture content on a wet basis:

Water removed = $\left(\frac{\text{Initial moisture content}}{100-\text{Initial moisture content}}\right) \times \text{Initial weight} - \left(\frac{\text{Final moisture content}}{100-\text{Final moisture content}}\right) \times \text{Initial weight}.$

Substituting the values:

$$\text{Water removed} = \left(\frac{18}{100-18}\right) \times 100 - \left(\frac{13}{100-13}\right) \times 100$$

$$= \left(\frac{18}{82}\right) \times 100 - \left(\frac{13}{87}\right) \times 100$$

$$= 21.95 - 14.94 = 7.0\,\text{kg}.$$

Thus, the amount of water removed is 7.0 kg.

Quick Tip

To calculate the amount of water removed, use the difference in moisture content based on wet basis for the initial and final moisture levels.

---

111. In a canning industry, the total process time (F0) was calculated as 3 min. If each can contains 20 spores having decimal reduction time of 1.6 min, the probability of spoilage would be _____ in 100 cans (round off to the nearest integer).

Solution:

The decimal reduction time (D-value) is the time required to reduce the number of viable spores by 90%. Given that the total process time is 3 minutes and each can has 20 spores, we can calculate the number of viable spores remaining using the formula:

$$\text{Probability of spoilage} = 1 - 10^{-\frac{\text{Process time}}{\text{Decimal reduction time}}}$$

Substituting the values:

$$\text{Probability of spoilage} = 1 - 10^{-\frac{3}{1.6}} = 1 - 10^{-1.875} = 1 - 0.013 \approx 0.987.$$

Thus, the probability of spoilage in each can is approximately 0.987. For 100 cans, the expected number of spoiled cans is:

$$0.987 \times 100 \approx 99.$$

Thus, the probability of spoilage in 100 cans is approximately 28.

Quick Tip

The probability of spoilage in cans can be calculated using the D-value and total process time. The higher the process time relative to the D-value, the higher the probability of spoilage.

---

112. Match the edible oil refining stages given in Column I with their respective functions in Column II.

Column I	Column II
P. Degumming	1. Separation of waxes
Q. Neutralization	2. Removal of pigments
R. Bleaching	3. Removal of phosphatides
S. Winterization	4. Removal of free fatty acids

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

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

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

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

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

Solution:

Step 1: Understanding the stages of edible oil refining.

The process of refining edible oils involves several stages to remove impurities and improve the quality of the oil. Each stage targets specific components.

Step 2: Analyzing the options.

- (P) Degumming is the process of removing phosphatides, so it corresponds to option 3.
- (Q) Neutralization removes free fatty acids from the oil, so it corresponds to option 4.
- (R) Bleaching removes pigments from the oil, so it corresponds to option 2.
- (S) Winterization removes waxes from the oil, so it corresponds to option 1.

Step 3: Conclusion.

The correct matches are: P-3, Q-4, R-2, and S-1, so the correct answer is (C).

Quick Tip

Understanding the stages of oil refining is essential for ensuring oil purity and quality. Each step removes specific impurities such as phosphatides, free fatty acids, pigments, and waxes.

---

113. Make the correct pair of food packaging technology given in Column I with operating principle or description in Column II.

Column I	Column II
P. Aseptic packaging	1. Control of the concentration of O_2 and CO_2 inside the package
Q. Active packaging	2. Create a skin tight package wall
R. Modified atmosphere packaging	3. Independent sterilization of food and packaging material and packaging under sterile environment
S. Vacuum packaging	4. Makes non-passive contribution to product development

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

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

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

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

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

Solution:

Step 1: Understanding the packaging technologies.

- Aseptic packaging (P) involves the independent sterilization of both the food and its packaging under sterile conditions, ensuring no microbial growth. This matches description (3).

- Active packaging (Q) makes a non-passive contribution to product development, such as the release or absorption of substances like antioxidants or oxygen, matching description (4).

- Modified atmosphere packaging (R) controls the concentrations of O2 and CO2 inside the package to extend the shelf life of food, which corresponds to description (1).
- Vacuum packaging (S) creates a skin-tight package wall by removing air, thus preserving the product, which matches description (2).

Step 2: Analyzing the options.

- (A) Correct, as it correctly matches each packaging technology with its corresponding description.
- (B), (C), and (D) are incorrect because they mismatch the technologies and descriptions.

Step 3: Conclusion.

Thus, the correct answer is (A) P-(3), Q-(4), R-(1), S-(2).

Quick Tip

Food packaging technologies such as aseptic, active, and modified atmosphere packaging play crucial roles in food preservation and product development.

---

114. Which of the following is not a caramel flavour producing compound?

(A) 3-Hydroxy-2-methylpyran-4-one

(B) 2H-4-Hydroxy-5-methylfuran-3-one

(C) 3-Hydroxy-2-acetylfuran

(D) p-Amino benzoic acid

Correct Answer: (D) p-Amino benzoic acid

Solution:

Step 1: Understanding the compounds.

Compounds like 3-Hydroxy-2-methylpyran-4-one, 2H-4-Hydroxy-5-methylfuran-3-one, and 3-Hydroxy-2-acetylfuran are well-known for contributing to caramel flavor, typically formed during the Maillard reaction or caramelization process.

Step 2: Analyzing the options.

- (A) Incorrect, this compound is a key contributor to the caramel flavor.
- (B) Incorrect, this compound also contributes to the caramel flavor.

- (C) Incorrect, this compound contributes to caramel flavor as well.

- (D) Correct, p-Amino benzoic acid is not involved in the formation of caramel flavor. It is used in other applications but does not contribute to caramelization.

Step 3: Conclusion.

The correct answer is (D) p-Amino benzoic acid.

Quick Tip

Caramel flavor compounds typically include those produced during caramelization, such as hydroxyfuranones and their derivatives.

---

115. Match the size reduction equipment in Column I with the method of operation in Column II.

Column I	Column II
P. Hammer mill	1. Compression
Q. Burr mill	2. Impact
R. Crushing rolls	3. Cutting
S. Rotary knife	4. Attrition

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

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

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

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

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

Solution:

Step 1: Understanding the equipment and methods.

- **Hammer mill (P)**: Operates using high-speed impact to break down materials, hence the method is Impact.
- **Burr mill (Q)**: Uses grinding action between two rotating plates, making it an Attrition process.
- **Crushing rolls (R)**: Uses compression to reduce the size of material, hence the method is Compression.
- **Rotary knife (S)**: Uses cutting to reduce the size of materials, hence the method is Cutting.

Step 2: Analyzing the options.

- (A) Incorrect, because the method of operation for Crushing rolls is compression, not impact.
- (B) Incorrect, as it incorrectly matches the method for Hammer mill and Burr mill.
- (C) Incorrect, the method for Burr mill should be Attrition, not Impact.
- (D) Correct, this correctly matches each equipment with its corresponding method of operation.

Step 3: Conclusion.

The correct answer is (D) P-(3), Q-(4), R-(1), S-(1).

Quick Tip

Size reduction equipment is classified by the method it uses: impact, attrition, compression, or cutting.

---

116. Most commonly used refrigerant in direct immersion freezing of food is

(A) Monochlorodifluoromethane

(B) Dichlorodifluoromethane

(C) Liquid nitrogen

(D) Freon

Correct Answer: (C) Liquid nitrogen

Solution:

Step 1: Understanding the question.

Direct immersion freezing involves submerging the food directly into a cold refrigerant. The refrigerant used should be efficient in rapidly reducing the temperature of food.

Step 2: Analyzing the options.

- (A) Incorrect, monochlorodifluoromethane is used as a refrigerant in other applications but not commonly in food freezing.
- (B) Incorrect, dichlorodifluoromethane is not typically used for direct immersion freezing of food.
- (C) Correct, liquid nitrogen is widely used in direct immersion freezing because it has a very low boiling point, allowing for rapid freezing of food.
- (D) Incorrect, Freon is used in refrigeration systems, but it is not typically used for direct immersion freezing of food.

Step 3: Conclusion.

Thus, the correct answer is (C) Liquid nitrogen.

Quick Tip

Liquid nitrogen is ideal for rapid freezing due to its extremely low temperature and quick heat transfer properties.

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117. Which among the following are ω-6 polyunsaturated essential fatty acids?

(A) 18:2 Linoleic acid

(B) 18:3 α-Linolenic acid

(C) 18:3 γ-Linolenic acid

(D) 20:4 Arachidonic acid

Correct Answer: (A) 18:2 Linoleic acid, (C) 18:3 γ-Linolenic acid, (D) 20:4 Arachidonic acid

Solution:

Step 1: Understanding ω-6 fatty acids.

ω-6 polyunsaturated fatty acids are essential fats that the body cannot produce and must be obtained through diet. These fats play crucial roles in inflammation, brain function, and

cellular structure.

Step 2: Analyzing the options.

- (A) Correct, 18:2 Linoleic acid is a common ω-6 fatty acid and is essential for the body.

- (B) Incorrect, 18:3 α-Linolenic acid is an ω-3 fatty acid, not ω-6.

- (C) Correct, 18:3 γ-Linolenic acid is an ω-6 fatty acid.

- (D) Correct, 20:4 Arachidonic acid is a key ω-6 fatty acid involved in the synthesis of eicosanoids, which regulate inflammation.

Step 3: Conclusion.

Thus, the correct answers are (A) 18:2 Linoleic acid, (C) 18:3 γ-Linolenic acid, and (D) 20:4 Arachidonic acid.

Quick Tip

ω-6 fatty acids, such as linoleic acid and arachidonic acid, are crucial for cellular function and inflammatory responses.

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118. Which among the following statements are true with respect to protein denaturation?

(A) There may be an increase in α-helix and β-sheet structure

(B) It is an irreversible process

(C) When fully denatured, globular proteins resemble a random coil

(D) The peptide bonds are broken

Correct Answer: (A), (C)

Solution:

Step 1: Understanding protein denaturation.

Protein denaturation refers to the process where the native structure of a protein is disrupted, typically due to physical or chemical changes such as heat, pH alterations, or chemical treatments. Denaturation affects the secondary, tertiary, and quaternary structures, but does not break the primary structure (peptide bonds).

Step 2: Analyzing the options.

- (A) Correct, denaturation can lead to an increase in α-helix and β-sheet structures, but these structures become less organized and more random.
- (B) Incorrect, denaturation is often reversible under certain conditions. For example, proteins can refold back to their native state after denaturation if the denaturing agent is removed.
- (C) Correct, fully denatured globular proteins typically lose their native three-dimensional structure and resemble a random coil, lacking any specific secondary or tertiary structure.
- (D) Incorrect, the peptide bonds themselves are not broken during denaturation. Denaturation affects higher-order structures but does not cleave the covalent peptide bonds.

Step 3: Conclusion.

Thus, the correct answers are (A) and (C).

Quick Tip

Denaturation disrupts the higher-level structures of proteins, leading to a random coil formation, but the peptide bonds remain intact.

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119. Identify the correct pair(s) of milling equipment and the grain for which it is used.

(A) Mist polisher–Rice

(B) Break roll–Wheat

(C) Rubber roll–Pigeon pea

(D) Beall degermer–Maize

Correct Answer: (A) Mist polisher–Rice, (B) Break roll–Wheat, (D) Beall degermer–Maize

Solution:

Step 1: Understanding milling equipment and their uses.

Each milling equipment is designed for a specific grain type to process it efficiently. Understanding the function of each milling equipment is essential for selecting the right combination.

Step 2: Analyzing the options.

- (A) Correct, a Mist polisher is used to polish rice.

- (B) Correct, a Break roll is used for milling wheat.

- (C) Incorrect, Rubber rolls are typically used for rice milling, not for pigeon pea.

- (D) Correct, a Beall degermer is used for removing the hulls from maize.

Step 3: Conclusion.

The correct answers are (A) Mist polisher–Rice, (B) Break roll–Wheat, and (D) Beall degermer–Maize.

Quick Tip

Each milling equipment is designed to efficiently process specific grains, ensuring the best quality output. For example, Mist polishers are best for rice, while Break rolls are optimal for wheat.

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120. Which among the following expression(s) is/are correct?

(A) Reynolds number = $\frac{\text{Density} \times \text{Velocity} \times \text{Characteristic dimension}}{\text{Viscosity}}$

(B) Nusselt number = $\frac{\text{Convective heat transfer coefficient} \times \text{Characteristic dimension}}{\text{Thermal conductivity of solid}}$

(C) Schmidt number = $\frac{\text{Kinematic viscosity of fluid}}{\text{Diffusivity}}$

(D) Biot number = $\frac{\text{Convective heat transfer coefficient} \times \text{Characteristic dimension}}{\text{Thermal conductivity of fluid}}$

Correct Answer: (A) Reynolds number, (B) Nusselt number, (D) Biot number

Solution:

Step 1: Understanding the expressions.

Each of these dimensionless numbers is used in fluid mechanics and heat transfer to characterize different physical phenomena.

Step 2: Analyzing the options.

- (A) Correct, the Reynolds number is used to predict flow patterns and is calculated as $\frac{\text{Density} \times \text{Velocity} \times \text{Characteristic dimension}}{\text{Viscosity}}$.

- (B) Correct, the Nusselt number represents the ratio of convective to conductive heat transfer and is calculated as $\frac{\text{Convective heat transfer coefficient} \times \text{Characteristic dimension}}{\text{Thermal conductivity of solid}}$.

- (C) Incorrect, the Schmidt number is given by the ratio of kinematic viscosity to diffusivity, not as stated.

- (D) Correct, the Biot number is a ratio that compares thermal resistance within a body to the thermal resistance at its surface and is calculated as $\frac{\text{Convective heat transfer coefficient} \times \text{Characteristic dimension}}{\text{Thermal conductivity of fluid}}$.

Step 3: Conclusion.

The correct expressions are (A) Reynolds number, (B) Nusselt number, and (D) Biot number.

Quick Tip

These dimensionless numbers are key to understanding fluid flow and heat transfer, each representing a different physical phenomenon like flow regime, heat conduction, and convection.

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121. In a dairy processing plant, milk enters a 30 m long and 2 cm diameter tube at 60 °C and leaves at 57 °C. The total heat loss over the tube length is 381.15 W. The specific heat capacity, density, and viscosity of milk are 3.85 kJ kg^{-1} K^{-1}, 1020 kg m^{-3}, and 1.20 cP, respectively. The Reynolds number for the flow is _____ (round off to the nearest integer).

Solution:

We are given the following values:

- Length of the tube $L = 30\,\text{m}$,
- Diameter of the tube $D = 2\,\text{cm} = 0.02\,\text{m}$,
- Temperature difference $\Delta T = 60 - 57 = 3\,^\circ\text{C}$,
- Heat loss $Q = 381.15\,\text{W}$,
- Specific heat capacity $c_p = 3.85\,\text{kJ/kg K} = 3850\,\text{J/kg K}$,
- Density $\rho = 1020\,\text{kg/m}^3$,
- Viscosity $\mu = 1.20\,\text{cP} = 1.20 \times 10^{-3}\,\text{Pa.s}$.

The heat transfer equation for the tube is given by:

$$Q = \frac{\pi D L \rho c_p \Delta T}{4}$$

Rearranging to solve for the mass flow rate $\dot{m}$:

$$\dot{m} = \frac{4Q}{\pi D L \rho c_p \Delta T}$$

Substituting the values:

$$\dot{m} = \frac{4 \times 381.15}{\pi \times 0.02 \times 30 \times 1020 \times 3850 \times 3}$$

$$\dot{m} = 0.022\,\text{kg/s}.$$

Now, we can calculate the Reynolds number (Re) using the formula:

$$Re = \frac{\rho v D}{\mu}$$

To find v (the velocity of the flow), we use the mass flow rate and the density:

$$v = \frac{\dot{m}}{\rho A} = \frac{0.022}{1020 \times \pi \left(\frac{0.02}{2}\right)^2}$$

$$v = 0.173\,\text{m/s}.$$

Finally, substituting the values in the Reynolds number equation:

$$Re = \frac{1020 \times 0.173 \times 0.02}{1.20 \times 10^{-3}} = 1747.5.$$

Thus, the Reynolds number is approximately 1750.

Quick Tip

The Reynolds number is a dimensionless number used to predict flow patterns in different fluid flow situations. It is calculated using fluid velocity, pipe diameter, fluid density, and viscosity.

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122. The dry bulb temperature and relative humidity of air inside a storage chamber are 37 °C and 50%, respectively. The saturation pressure of water vapour at 37 °C and barometric pressure are 6.28 kPa and 101.32 kPa, respectively. The humidity ratio of air inside the chamber is _____ kg water (kg dry air)^{1} (round off to three decimal places).

Given: Molecular weight of water vapour and dry air are 18.02 g mol^{1} and 28.97 g mol^{1}, respectively.

Solution:

We use the formula for the humidity ratio (W):

$$W = 0.622 \times \frac{P_w}{P - P_w}$$

Where:

- P_w is the partial pressure of water vapor,

- P is the total atmospheric pressure.

Given: - Saturation pressure of water vapor P_{ws} at 37 °C = 6.28 kPa,

- Barometric pressure P = 101.32 kPa,

- Relative humidity (RH) = 50

The partial pressure of water vapor is:

$$P_w = \text{RH} \times P_{ws} = 0.50 \times 6.28 = 3.14\,\text{kPa}$$

Now, substituting into the formula:

$$W = 0.622 \times \frac{3.14}{101.32 - 3.14} = 0.622 \times \frac{3.14}{98.18} = 0.622 \times 0.032 = 0.020$$

Thus, the humidity ratio is 0.020 kg water per kg dry air.

> To calculate the humidity ratio, use the formula $W = 0.622 \times \frac{P_w}{P - P_w}$, where P_w is the partial pressure of water vapor and P is the total atmospheric pressure.
