

# GATE 2025 Life Sciences Question Paper with Solutions

**Time Allowed :180 Minutes**

**Maximum Marks :100**

**Total questions :122**

## General Instructions

**Read the following instructions very carefully and strictly follow them:**

- 1. Total Marks:** The GATE Statistics paper is worth 100 marks.
- 2. Question Types:** The paper consists of 122 questions, divided into:
  - General Aptitude (GA): 15 marks
  - Life Sciences: 85 marks
- 3. Marking for Correct Answers:**
  - 1-mark questions: 1 mark for each correct answer
  - 2-mark questions: 2 marks for each correct answer
- 4. Negative Marking for Incorrect Answers:**
  - 1-mark MCQs: 1/3 mark deduction for a wrong answer
  - 2-mark MCQs: 2/3 marks deduction for a wrong answer
- 5. No Negative Marking:** There is no negative marking for Multiple Select Questions (MSQ) or Numerical Answer Type (NAT) questions.
- 6. No Partial Marking:** There is no partial marking in MSQ.

## General Aptitude

**1. Even though I had planned to go skiing with my friends, I had to ..... at the last moment because of an injury.**

**Select the most appropriate option to complete the above sentence.**

- (A) back up
- (B) back of
- (C) back on
- (D) back out

**Correct Answer:** (D) back out

**Solution:**

The expression "back out" means to withdraw from a commitment, plan, or agreement. In the sentence, the speaker had initially made plans to go skiing but could not follow through because of an injury. Therefore, "back out" is the correct phrasal verb to describe this withdrawal.

Other options are incorrect:

"back up" means to support or reverse a vehicle.

"back of" is not a valid phrasal verb.

"back on" doesn't fit the sentence grammatically or idiomatically.

Thus, the most appropriate choice is "back out".

### Quick Tip

Phrasal verbs often change the meaning of the root verb entirely—always learn them in context.

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**2. The President, along with the Council of Ministers, ..... to visit India next week.**

**Select the most appropriate option to complete the above sentence.**

- (A) wish
- (B) wishes
- (C) will wish
- (D) is wishing

**Correct Answer:** (B) wishes

**Solution:**

The subject of the sentence is "The President", which is singular. The phrase "along with the Council of Ministers" is a modifying phrase and does not affect the subject-verb agreement.

Therefore, the verb should also be singular.

"wishes" is the singular form of the verb and agrees with the singular subject "The President".

"wish" is plural and would be incorrect here.

"will wish" changes the tense unnecessarily.

"is wishing" is awkward and not appropriate in this context.

Hence, the correct form is: "The President, along with the Council of Ministers, wishes to visit India next week."

**Quick Tip**

Ignore interrupting phrases like "along with", "as well as", etc., when determining subject-verb agreement.

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**3. An electricity utility company charges ₹7 per kWh. If a 40-watt desk light is left on for 10 hours each night for 180 days, what would be the cost of energy consumption? If the desk light is on for 2 more hours each night for the 180 days, what would be the percentage-increase in the cost of energy consumption?**

(A) ₹604.8; 10%

(B) ₹504; 20%

(C) ₹604.8; 12%

(D) ₹720; 15%

**Correct Answer:** (B) ₹504; 20%

**Solution:**

First, convert the power rating to kilowatts:

$$40 \text{ W} = \frac{40}{1000} = 0.04 \text{ kW}$$

**Case 1: Desk light used for 10 hours per day**

$$\text{Energy} = 0.04 \times 10 \times 180 = 72 \text{ kWh}$$

$$\text{Cost} = 72 \times 7 = ₹504$$

**Case 2: Desk light used for 12 hours per day**

$$\text{Energy} = 0.04 \times 12 \times 180 = 86.4 \text{ kWh}$$

$$\text{Cost} = 86.4 \times 7 = ₹604.8$$

**Percentage Increase:**

$$\frac{604.8 - 504}{504} \times 100 = \frac{100.8}{504} \times 100 \approx 20\%$$

Therefore, the percentage increase in cost is 20% and the original cost is ₹504.

**Quick Tip**

Always convert watts to kilowatts and use the formula: Energy = Power × Time × Days.  
Then multiply by rate to calculate cost.

**4. In the context of the given figure, which one of the following options correctly represents the entries in the blocks labelled (i), (ii), (iii), and (iv), respectively?**

N	U	F	(i)
21	14	9	6
H	L	(ii)	O
12	(iv)	15	(iii)

- (A) Q, M, 12 and 8
- (B) K, L, 10 and 14
- (C) I, J, 10 and 8

(D) L, K, 12 and 8

**Correct Answer:** (D) L, K, 12 and 8

**Solution:**

**Step 1:** Observing the pattern of the matrix, the sum of the numbers in the first column seems to follow a consistent pattern, and the same can be applied to the other columns. Let's investigate the patterns to find the values of (i), (ii), (iii), and (iv).

The first column values are:

$$N = 21, H = 12.$$

The sum of 21 and 12 gives us 33. Hence, (i) should be 6, as 33 minus 27 (the sum of the entries in the last row) gives 6.

The second column values are:

$$U = 14, L = \text{unknown}.$$

We find that the sum of 14 and 10 gives 24, so (ii) = 10.

The third column values are:

$$F = 9, O = 15.$$

The sum of 9 and 15 gives 24, so (iv) = 8.

**Step 2:** Based on the pattern above, the answer choices correspond to the following values for the blocks:

$$(i) = 6, (ii) = 10, (iii) = 15, (iv) = 8.$$

Thus, the correct answer is **B**.

#### Quick Tip

When solving letter-number reasoning grids, convert letters to their alphabet positions (A=1 to Z=26), then analyze the mathematical pattern row-wise or column-wise.

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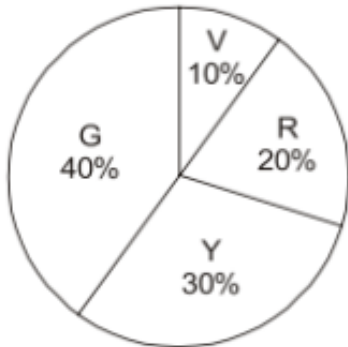
**5. A bag contains Violet (V), Yellow (Y), Red (R), and Green (G) balls. On counting them, the following results are obtained:**

- (i) The sum of Yellow balls and twice the number of Violet balls is 50.
- (ii) The sum of Violet and Green balls is 50.

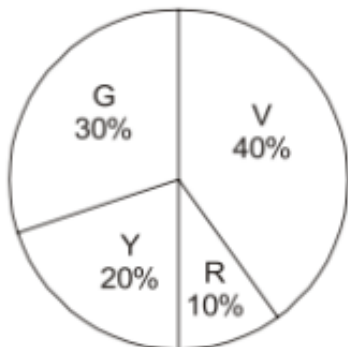
(iii) The sum of Yellow and Red balls is 50.

(iv) The sum of Violet and twice the number of Red balls is 50.

**Which one of the following Pie charts correctly represents the balls in the bag?**



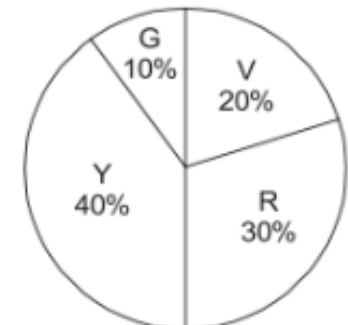
(A)



(B)



(C)



(D)

**Correct Answer:** (A) V: 10%, Y: 30%, R: 20%, G: 40%

**Solution:**

Let the total number of balls be 100 (since percentages are given). So, the actual number of

each type of ball in option (A) is:

$$V = 10, \quad Y = 30, \quad R = 20, \quad G = 40$$

Now verify the conditions:

(i)  $Y + 2V = 30 + 2 \times 10 = 30 + 20 = 50$  ,correct

(ii)  $V + G = 10 + 40 = 50$  , correct

(iii)  $Y + R = 30 + 20 = 50$  ,correct

(iv)  $V + 2R = 10 + 2 \times 20 = 10 + 40 = 50$  ,correct

All conditions are satisfied only in option (A). Other options do not verify all four conditions simultaneously.

#### Quick Tip

Assume the total is 100 when pie chart percentages are given. Translate each condition into equations and verify using actual values from the options.

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**6. “His life was divided between the books, his friends, and long walks. A solitary man, he worked at all hours without much method, and probably courted his fatal illness in this way. To his own name there is not much to show; but such was his liberality that he was continually helping others, and fruits of his erudition are widely scattered, and have gone to increase many a comparative stranger’s reputation.”**

**(From E.V. Lucas’s “A Funeral”)**

**Based only on the information provided in the above passage, which one of the following statements is true?**

- (A) The solitary man described in the passage is dead.
- (B) Strangers helped create a grand reputation for the solitary man described in the passage.
- (C) The solitary man described in the passage found joy in scattering fruits.
- (D) The solitary man worked in a court where he fell ill.

**Correct Answer:** (A) The solitary man described in the passage is dead.

**Solution:**

The title of the passage, “A Funeral,” and the use of past tense verbs such as “was divided,” “worked,” and “courted” indicate that the person being discussed is no longer alive. The

statement “he probably courted his fatal illness” also supports this inference, implying he ultimately succumbed to that illness. The passage is reflective and eulogistic in nature, pointing toward the man’s death.

The other options include unsupported claims. For instance, there is no mention of the man working in a court or finding joy in scattering fruits. The “fruits of his erudition” refers metaphorically to the impact of his knowledge, not literal joy or fruit scattering.

### Quick Tip

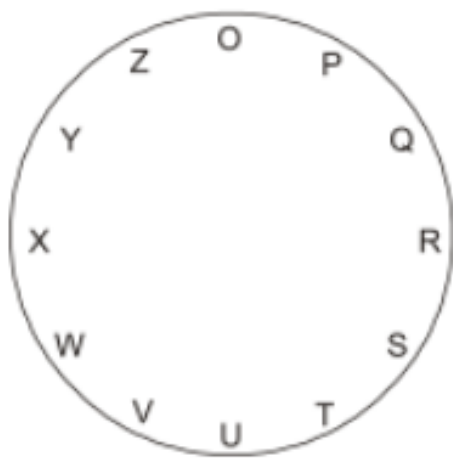
Pay attention to past tense usage and the title or source of a passage—it often provides key contextual clues for inference-based questions.

7. For the clock shown in the figure, if

**O = O Q S Z P R T, and**

**X = X Z P W Y O Q,**

then which one among the given options is most appropriate for P?



(A) P U W R T V X

(B) P R T O Q S U

(C) P T V Q S U W

(D) P S U P R T V

**Correct Answer:** (B) P R T O Q S U

**Solution:**

We are given two sequences of letters representing paths around a circular clock-like figure.

Each sequence starts from a reference letter and continues in a specific order:

- O = O Q S Z P R T - X = X Z P W Y O Q

These sequences follow a clockwise path on the circle. To find P, we need to start from P and trace a similar clockwise pattern.

Looking at the clock diagram, starting from P and moving clockwise gives the sequence:

$$P \rightarrow R \rightarrow T \rightarrow O \rightarrow Q \rightarrow S \rightarrow U$$

This matches option (B).

To verify, count each step from P in the figure:  $P \rightarrow R \rightarrow T \rightarrow O \rightarrow Q \rightarrow S \rightarrow U$  – all in clockwise direction, and all letters are unique with no repetitions, matching the style of the given sequences.

#### Quick Tip

For circular reasoning questions, sketch or trace the path visually on the diagram and ensure you're moving in a consistent direction (clockwise or counter-clockwise).

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**8. Consider a five-digit number PQRST that has distinct digits P, Q, R, S, and T, and satisfies the following conditions:**

1.  $P < Q$
2.  $S > P > T$
3.  $R < T$

**If integers 1 through 5 are used to construct such a number, the value of P is:**

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

**Correct Answer:** (C) 3

**Solution:**

We are given the constraints:

$$P < Q, \quad S > P > T, \quad R < T$$

We need to assign the digits 1 through 5 (each used only once) to P, Q, R, S, and T in a way that satisfies all the above conditions.

Let's try to assign values that satisfy these relations step-by-step:

From  $S > P > T$ , we can choose:

$$S = 5, \quad P = 3, \quad T = 2$$

This satisfies  $S > P > T$ . Now for  $P < Q$ , if  $P = 3$ , then  $Q$  must be greater than 3, so we can take:

$$Q = 4$$

That leaves only 1 unused, which can go to:

$$R = 1$$

Now check if all conditions are satisfied:  $P = 3 < Q = 4$ , correct

$S = 5 > P = 3 > T = 2$ , correct

$R = 1 < T = 2$ , correct

All conditions are satisfied.

Thus, the value of  $P$  is 3.

#### Quick Tip

When solving such logic puzzles with digit constraints, list available digits and test possible combinations systematically to satisfy all inequalities.

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**9. A business person buys potatoes of two different varieties P and Q, mixes them in a certain ratio and sells them at ₹192 per kg.**

**The cost of the variety P is ₹800 for 5 kg.**

**The cost of the variety Q is ₹800 for 4 kg.**

**If the person gets 8% profit, what is the P : Q ratio (by weight)?**

(A) 5 : 4

(B) 3 : 4

(C) 3 : 2

(D) 1 : 1

**Correct Answer:** (A) 5 : 4

**Solution:**

Given:

$$\text{Cost of 5 kg of variety P} = ₹800 \Rightarrow \text{Cost per kg} = ₹160$$

$$\text{Cost of 4 kg of variety Q} = ₹800 \Rightarrow \text{Cost per kg} = ₹200$$

Let the seller mix 5 kg of P and 4 kg of Q (to match the quantity from the cost data).

$$\text{Total cost} = ₹800 + ₹800 = ₹1600$$

$$\text{Total weight} = 5 + 4 = 9 \text{ kg}$$

$$\text{Selling price per kg} = ₹192 \Rightarrow \text{Total selling price} = 9 \times 192 = ₹1728$$

$$\text{Profit} = ₹1728 - ₹1600 = ₹128$$

$$\text{Profit \%} = \frac{128}{1600} \times 100 = 8\%$$

Thus, the assumed mixture gives exactly 8% profit, which matches the condition. Therefore, the weight ratio P : Q is:

$$5 : 4$$

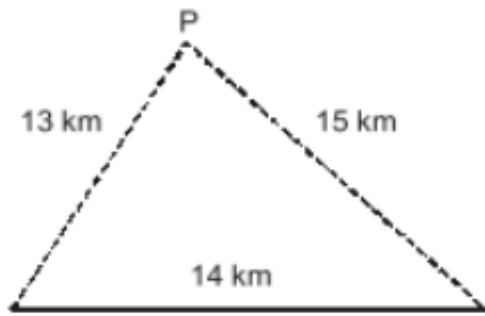
#### Quick Tip

In mixture problems involving profit, use assumed weights based on cost data to match the required profit percentage. Compare cost price and selling price for total quantity.

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**10. Three villages P, Q, and R are located in such a way that the distance PQ = 13 km, QR = 14 km, and RP = 15 km, as shown in the figure. A straight road joins Q and R. It is proposed to connect P to this road QR by constructing another road. What is the minimum possible length (in km) of this connecting road?**

*Note: The figure shown is representative.*



- (A) 10.5
- (B) 11.0
- (C) 12.0
- (D) 12.5

**Correct Answer:** (C) 12.0

**Solution:**

Let the foot of the perpendicular from point P to line QR be at a distance  $x$  km from Q, and the perpendicular height be  $h$ . We can now apply the Pythagorean theorem to two right-angled triangles:

$$h^2 + x^2 = 13^2 = 169 \quad \text{(i)}$$

$$h^2 + (14 - x)^2 = 15^2 = 225 \quad \text{(ii)}$$

Now subtract equation (i) from (ii):

$$[h^2 + (14 - x)^2] - [h^2 + x^2] = 225 - 169$$

$$(14 - x)^2 - x^2 = 56$$

$$196 - 28x = 56 \Rightarrow 28x = 140 \Rightarrow x = 5$$

Substitute  $x = 5$  in equation (i):

$$h^2 + 25 = 169 \Rightarrow h^2 = 144 \Rightarrow h = \sqrt{144} = 12$$

Therefore, the minimum possible length of the connecting road is 12 km.

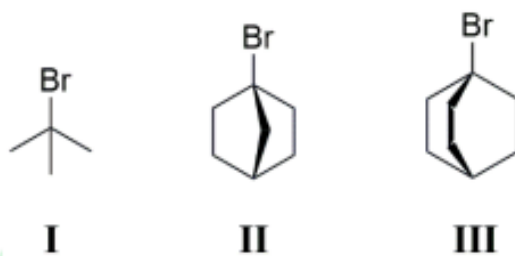
### Quick Tip

To find the shortest distance from a point to a line segment, drop a perpendicular and apply the Pythagorean theorem to form solvable right triangles.

## Chemistry

### Q.11 – Q.19 Carry ONE mark Each

11. The rate of solvolysis for the following tertiary halides in 80% aqueous ethanol at 25°C follows the order:



- (A)  $I < II < III$   
(B)  $II < III < I$   
(C)  $III < II < I$   
(D)  $I < III < II$

**Correct Answer:** (B)  $II < III < I$

### Solution:

The rate of solvolysis of tertiary halides depends primarily on the stability of the carbocation intermediate formed after the halide leaves. The more stable the carbocation, the faster the solvolysis rate. The stability of the carbocation is influenced by both inductive and resonance effects as well as the ability to relieve strain in cyclic structures.

Let us analyze each compound:

- For compound **I** (a simple alkyl tertiary halide), the carbocation formed after the halide leaves is relatively unstable since it only has the inductive stabilization from the surrounding alkyl groups. The solvolysis rate for **I** is slower compared to the others.

- For compound **II** (a cyclic tertiary halide), the carbocation formed is more stable due to the ability of the ring to relieve strain upon carbocation formation. This makes the solvolysis faster than compound **I**.

- For compound **III** (a tertiary halide with more alkyl groups), the resulting carbocation is highly stabilized due to both inductive effects from the alkyl groups and hyperconjugation. Therefore, compound **III** undergoes solvolysis faster than compound **II** and **I**.

Thus, the correct order of the solvolysis rate is:



#### Quick Tip

When analyzing solvolysis reactions, focus on the stability of the carbocation intermediate. More stable carbocations, such as those with resonance stabilization or hyperconjugation, lead to faster reactions.

## 12. The CORRECT order of boiling points for the hydrogen halides is:

- (A)  $HF > HI > HBr > HCl$
- (B)  $HF > HCl > HBr > HI$
- (C)  $HI > HBr > HCl > HF$
- (D)  $HI > HF > HBr > HCl$

**Correct Answer:** (A)  $HF > HI > HBr > HCl$

### Solution:

The boiling points of hydrogen halides are determined by the type of intermolecular forces that exist between the molecules. The primary factors affecting the boiling point of hydrogen halides are hydrogen bonding, size of the halide, and molecular weight.

#### 1. Hydrogen Bonding:

**HF** exhibits the strongest intermolecular forces among the hydrogen halides because of the strong hydrogen bonding between **HF** molecules. This leads to a significantly higher boiling point for **HF** compared to the others.

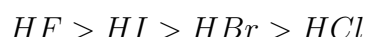
## 2. Molecular Size and Polarizability:

The other hydrogen halides, **HI**, **HBr**, and **HCl**, primarily rely on London dispersion forces. These forces increase with the size and polarizability of the molecules. Since iodine is the largest halogen, **HI** has the highest boiling point after **HF**.

## 3. Boiling Point Trend:

**HCl** and **HBr** have similar molecular sizes, but **HBr** has a slightly higher boiling point than **HCl** due to its larger size and greater polarizability.

Thus, the correct order of boiling points is:



### Quick Tip

In comparing the boiling points of hydrogen halides, remember that hydrogen bonding in **HF** greatly increases its boiling point. For the other hydrogen halides, molecular size and polarizability are the key factors.

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## 13. The bond order in $N_2^{2-}$ species is:

- (A) 2
- (B) 2.5
- (C) 3
- (D) 3.5

**Correct Answer:** (A) 2

### Solution:

The bond order in a molecular species can be calculated using the molecular orbital theory. The bond order is given by the formula:

$$\text{Bond order} = \frac{1}{2} (\text{Number of bonding electrons} - \text{Number of antibonding electrons})$$

For  $N_2^{2-}$ , the electronic configuration of the molecule in its molecular orbitals is as follows:

- The molecular orbital diagram for  $N_2$  (and ions) places the bonding and antibonding electrons in the  $\sigma_{2s}$ ,  $\sigma_{2s}^*$ ,  $\sigma_{2p_z}$ ,  $\pi_{2p_x} = \pi_{2p_y}$ , and  $\pi_{2p_x}^*$ ,  $\pi_{2p_y}^*$ ,  $\sigma_{2p_z}^*$  orbitals.
- The  $N_2^{2-}$  ion has 14 electrons, and by filling the molecular orbitals, we get 10 bonding electrons and 4 antibonding electrons.

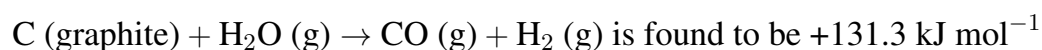
Thus, the bond order is:

$$\text{Bond order} = \frac{1}{2} (10 - 4) = 2$$

#### Quick Tip

To find the bond order, always count the number of bonding and antibonding electrons in the molecular orbital diagram and apply the formula.

#### 14. The standard enthalpy of the reaction,



and the  $\Delta_f H^\circ$  value for  $CO (g)$  is  $-110.5 \text{ kJ mol}^{-1}$ .

The value of  $\Delta_f H^\circ$  (in  $\text{kJ mol}^{-1}$ ) for  $H_2O (g)$  is:

- (A) +241.8
- (B) 0.0
- (C) -241.8
- (D) +20.8

**Correct Answer:** (C) -241.8

#### Solution:

The standard enthalpy change for a reaction can be calculated using the following equation:

$$\Delta_r H^\circ = \sum (\Delta_f H^\circ \text{ products}) - \sum (\Delta_f H^\circ \text{ reactants})$$

From the problem statement, we know the standard enthalpy change for the reaction is  $+131.3 \text{ kJ mol}^{-1}$ . The given values are:

$$- \Delta_f H^\circ (CO (g)) = -110.5 \text{ kJ mol}^{-1}$$

$-\Delta_f H^\circ(\text{H}_2(\text{g})) = 0.0 \text{ kJ mol}^{-1}$  (since  $\text{H}_2$  is in its standard state)

Substituting the values into the equation:

$$131.3 = [(-110.5) + (0.0)] - [\Delta_f H^\circ(\text{C}(\text{graphite})) + \Delta_f H^\circ(\text{H}_2\text{O}(\text{g}))]$$

Since the standard enthalpy of formation of graphite is zero:

$$131.3 = (-110.5) - \Delta_f H^\circ(\text{H}_2\text{O}(\text{g}))$$

Solving for  $\Delta_f H^\circ(\text{H}_2\text{O}(\text{g}))$ :

$$\Delta_f H^\circ(\text{H}_2\text{O}(\text{g})) = -241.8 \text{ kJ mol}^{-1}$$

Thus, the value of  $\Delta_f H^\circ$  for  $\text{H}_2\text{O}(\text{g})$  is  $-241.8 \text{ kJ mol}^{-1}$ .

#### Quick Tip

To solve enthalpy problems, use Hess's law and the standard enthalpies of formation to calculate the enthalpy change of the reaction.

**15. The temperature dependence of reaction rates is generally given by the Arrhenius equation. A plot of  $\ln k_r$  against  $1/T$  is a straight line from which the pre-exponential factor 'A' and the activation energy ' $E_a$ ' can be determined.**

**The CORRECT option regarding this plot is:**

- (A) Slope:  $-E_a/R$ ; Intercept on the y-axis:  $\ln A$
- (B) Slope:  $+E_a/2.303R$ ; Intercept on the y-axis:  $A$
- (C) Slope:  $+E_a/R$ ; Intercept on the y-axis:  $A$
- (D) Slope:  $-E_a/2.303R$ ; Intercept on the y-axis:  $\ln A$

**Correct Answer:** (A) Slope:  $-E_a/R$ ; Intercept on the y-axis:  $\ln A$

**Solution:**

**Step 1:** Start with the Arrhenius equation:

$$k = Ae^{-E_a/(RT)}$$

**Step 2:** Take the natural logarithm of both sides:

$$\ln k = \ln A - \frac{E_a}{R} \cdot \frac{1}{T}$$

**Step 3:** Compare this with the straight-line form  $y = mx + c$ :

$$\text{where } y = \ln k, \quad x = \frac{1}{T}, \quad m = -\frac{E_a}{R}, \quad c = \ln A$$

**Conclusion:** The plot of  $\ln k$  vs.  $1/T$  gives:

**Slope:**  $-E_a/R$

**Intercept on y-axis:**  $\ln A$

#### Quick Tip

Always express the Arrhenius equation in logarithmic form  $\ln k = \ln A - \frac{E_a}{RT}$  before identifying slope and intercept from a graph.

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**16. The isothermal expansion of one mole of an ideal gas from  $V_i$  to  $V_f$  at temperature  $T$  occurs in two ways:**

Path I: a reversible isothermal expansion;

Path II: free expansion against zero external pressure.

**The CORRECT option for the values of  $\Delta U$ ,  $q$ , and  $w$  for Path I and Path II is:**

(A) Path I:  $\Delta U = 0$ ,  $q > 0$ ,  $w < 0$

Path II:  $\Delta U = 0$ ,  $q = 0$ ,  $w = 0$

(B) Path I:  $\Delta U = 0$ ,  $q > 0$ ,  $w < 0$

Path II:  $\Delta U > 0$ ,  $q > 0$ ,  $w = 0$

(C) Path I:  $\Delta U = 0$ ,  $q < 0$ ,  $w > 0$

Path II:  $\Delta U = 0$ ,  $q > 0$ ,  $w < 0$

(D) Path I:  $\Delta U = 0$ ,  $q < 0$ ,  $w > 0$

Path II:  $\Delta U < 0$ ,  $q = 0$ ,  $w = 0$

**Correct Answer:** (A)

Path I:  $\Delta U = 0$ ,  $q > 0$ ,  $w < 0$

Path II:  $\Delta U = 0$ ,  $q = 0$ ,  $w = 0$

**Solution:**

**Step 1:** For an **isothermal process**,  $\Delta U = 0$  since internal energy of an ideal gas depends only on temperature, which is constant.

**Step 2:** In **Path I** (reversible isothermal expansion), the gas does work ( $w < 0$ ) and to maintain constant internal energy, heat must be absorbed ( $q > 0$ ) such that:

$$\Delta U = q + w \Rightarrow 0 = q + w \Rightarrow q = -w$$

**Step 3:** In **Path II** (free expansion), the gas expands against zero external pressure:

- No work is done ( $w = 0$ )
- No heat is exchanged ( $q = 0$ )
- Therefore,  $\Delta U = 0$

**Conclusion:** The correct values are:

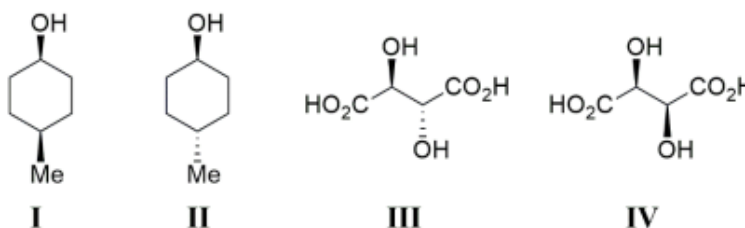
Path I:  $\Delta U = 0$ ,  $q > 0$ ,  $w < 0$

Path II:  $\Delta U = 0$ ,  $q = 0$ ,  $w = 0$

**Quick Tip**

In free expansion, there is no work done because external pressure is zero, and no heat is exchanged with surroundings.

**17. The CORRECT statement(s) regarding the given molecules is(are):**



- (A) Both I and II are achiral molecules.
- (B) Both II and III are chiral molecules.
- (C) IV is a chiral molecule.
- (D) Both III and IV are chiral molecules.

**Correct Answer:** (A), (C)

**Solution:**

To determine chirality, we check whether a molecule has a plane of symmetry or not. A molecule is **chiral** if it lacks any plane of symmetry and has at least one chiral center. A molecule with a plane of symmetry is **achiral**.

**Molecule I:** This molecule has a symmetrical substitution on the cyclohexane ring, with the methyl and hydroxyl groups in equivalent positions. There exists a plane of symmetry passing through the ring, making it **achiral**.

**Molecule II:** Similar to molecule I, the methyl and hydroxyl groups are placed symmetrically on the cyclohexane ring. Hence, a plane of symmetry exists, making this molecule also **achiral**.

**Molecule III:** Although there are two chiral centers, the molecule is symmetric. It contains an internal mirror plane, which divides the molecule into two equal halves. Such a molecule is a **meso compound**, which is **achiral despite having chiral centers**.

**Molecule IV:** This molecule has two chiral centers but lacks a plane of symmetry. The spatial arrangement of groups is asymmetric, which makes this molecule **chiral**.

Thus, only **I and II are achiral**, and **IV is chiral**.

**Quick Tip**

Always check for internal planes of symmetry before declaring a molecule chiral. Presence of chiral centers alone does not guarantee chirality — meso compounds are the perfect exception.

---

**18. The CORRECT statement(s) about  $[Ni(CN)_4]^{2-}$ ,  $[Ni(CO)_4]$  and  $[NiCl_4]^{2-}$  is(are):**

**(Given: Atomic number of Ni = 28)**

- (A) Both  $[Ni(CN)_4]^{2-}$  and  $[Ni(CO)_4]$  are square planar complexes.
- (B)  $[Ni(CN)_4]^{2-}$  is diamagnetic and  $[NiCl_4]^{2-}$  is paramagnetic.
- (C) Both  $[Ni(CO)_4]$  and  $[NiCl_4]^{2-}$  are paramagnetic.
- (D)  $[Ni(CN)_4]^{2-}$  is square planar and  $[NiCl_4]^{2-}$  is tetrahedral in shape.

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

**Solution:**

Nickel has atomic number 28, and its ground-state electron configuration is  $[Ar] 3d^8 4s^2$ . In its complexes, the oxidation state and ligand field strength determine geometry and magnetic properties.

**1. For  $[Ni(CN)_4]^{2-}$ :** The oxidation state of Ni is +2.  $CN^-$  is a **strong field ligand** and causes pairing of electrons. The complex adopts a **square planar geometry** due to  $dsp^2$  hybridization. Since all electrons pair up, the complex is **diamagnetic**.

**2. For  $[NiCl_4]^{2-}$ :** Ni is in the +2 oxidation state again, but  $Cl^-$  is a **weak field ligand**. There is no pairing of electrons, leading to **tetrahedral geometry** with  $sp^3$  hybridization. The presence of unpaired electrons makes it **paramagnetic**.

**3. For  $[Ni(CO)_4]$ :** The Ni is in the 0 oxidation state. CO is a strong field ligand and causes pairing of electrons. The complex forms a **tetrahedral geometry** with  $sp^3$  hybridization. It is **diamagnetic** because there are no unpaired electrons.

Hence,  $[Ni(CN)_4]^{2-}$  is **diamagnetic and square planar**, while  $[NiCl_4]^{2-}$  is **paramagnetic and tetrahedral**.

#### Quick Tip

The geometry and magnetic property of a complex depend on the oxidation state of the metal and whether the ligand is a strong or weak field ligand. Use Crystal Field Theory and hybridization to justify your answer.

---

**19. Consider the two  $pK_a$  values of valine as 2.32 and 9.62. The isoelectric point (pI) of this amino acid is ..... (rounded off to two decimal places)**

**Solution:**

To calculate the isoelectric point (pI) of an amino acid, we use the formula:

$$pI = \frac{pK_{a1} + pK_{a2}}{2}$$

where  $pK_{a1}$  and  $pK_{a2}$  are the dissociation constants for the carboxyl and amino groups of the amino acid.

For valine, the two  $pK_a$  values are given as:

$$pK_{a1} = 2.32 \quad \text{and} \quad pK_{a2} = 9.62.$$

Now, applying the formula for the isoelectric point:

$$pI = \frac{2.32 + 9.62}{2} = \frac{11.94}{2} = 5.97.$$

After rounding off to two decimal places, the isoelectric point of valine is:

$$pI = 5.97.$$

#### Quick Tip

The isoelectric point (pI) is a key property of amino acids. It is calculated as the average of the  $pK_a$  values corresponding to the ionizable groups of the amino acid.

**20. A few species are given in Column I. Column II contains the hybrid orbitals used by the central atom of the species for bonding.**

**The CORRECT match for the species to their central atom hybridization is:**

(Given: Atomic numbers of B: 5; C: 6; O: 8; F: 9; P: 15; Cl: 17; I: 53)

Column I Species	Column II Hybrid orbitals used by the central atom for bonding
i. $I_3^-$	a. $sp$
ii. $PCl_3$	b. $sp^2$
iii. $BF_3$	c. $sp^3$
iv. $CO_2$	d. $sp^3d$

(A) i–d, ii–c, iii–b, iv–a

(B) i–a, ii–d, iii–b, iv–c

(C) i–d, ii–c, iii–a, iv–b

(D) i–d, ii–b, iii–c, iv–b

**Correct Answer:** (A) i–d, ii–c, iii–b, iv–a

#### Solution:

To match the species in Column I with the correct hybrid orbitals from Column II, we need to analyze the bonding in each molecule:

- **i.**  $I_3^-$ : The central iodine atom has three bonding pairs and one lone pair, which corresponds to  $sp$  hybridization. Hence, the correct match is *i*–d.

- **ii.**  $PCl_3$ : Phosphorus has three bonding pairs and one lone pair, so it uses  $sp^2$  hybridization. Hence, the correct match is *ii-c*.
  - **iii.**  $BF_3$ : Boron forms three bonds with fluorine and has no lone pairs, so it uses  $sp^2$  hybridization. Hence, the correct match is *iii-b*.
  - **iv.**  $CO_2$ : Carbon in  $CO_2$  has two bonding pairs and no lone pairs, so it uses  $sp$  hybridization. Hence, the correct match is *iv-a*.
- Thus, the correct answer is option (A).

### Quick Tip

To determine the hybridization of the central atom, count the number of bonding pairs and lone pairs of electrons around the atom. The hybridization is typically  $sp$ ,  $sp^2$ , or  $sp^3$  depending on the number of regions of electron density.

**21. For product formation from only one type of reactant (e.g.  $A \rightarrow \text{product}$ ), the CORRECT match for the order of the reaction (given in Column I) with the half-life expression (given in Column II) is:**

( $[A]_0$  is the initial concentration and  $k_r$  is the rate constant)

Column I Order	Column II Half-life expression
i. Zero	P. $\frac{\ln 2}{k_r}$
ii. First	Q. $\frac{[A]_0}{2k_r}$
iii. Second	R. $\frac{1}{k_r[A]_0}$
	S. $\frac{2}{k_r[A]_0}$

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

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

### Solution:

To determine the correct matching, let's consider the half-life expressions for each order of reaction:

- **i. Zero Order:** For a zero-order reaction, the half-life is independent of the initial concentration and is given by the expression:

$$t_{1/2} = \frac{[A]_0}{2k_r}$$

Thus, the correct match for zero-order is *i-Q*.

- **ii. First Order:** For a first-order reaction, the half-life depends on the rate constant and is given by:

$$t_{1/2} = \frac{\ln 2}{k_r}$$

Thus, the correct match for first-order is *ii-P*.

- **iii. Second Order:** For a second-order reaction, the half-life is inversely proportional to the initial concentration and is given by:

$$t_{1/2} = \frac{1}{k_r[A]_0}$$

Thus, the correct match for second-order is *iii-R*.

Therefore, the correct answer is option (B).

#### Quick Tip

For a reaction of order  $n$ , the half-life expressions are different:

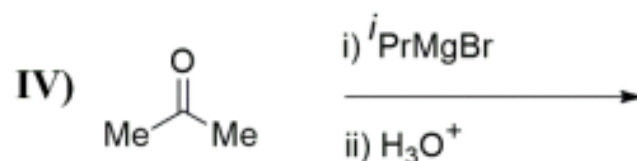
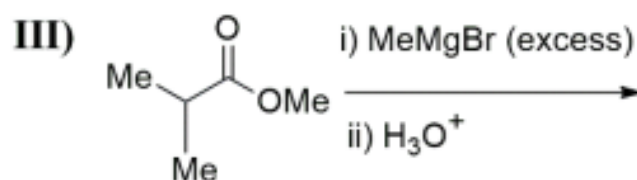
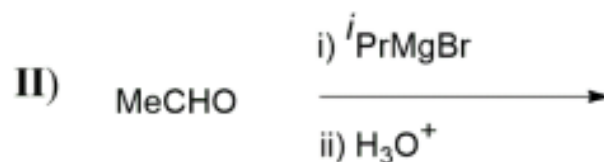
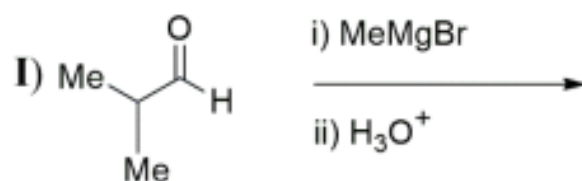
- Zero order:  $t_{1/2} = \frac{[A]_0}{2k_r}$ ,

- First order:  $t_{1/2} = \frac{\ln 2}{k_r}$ ,

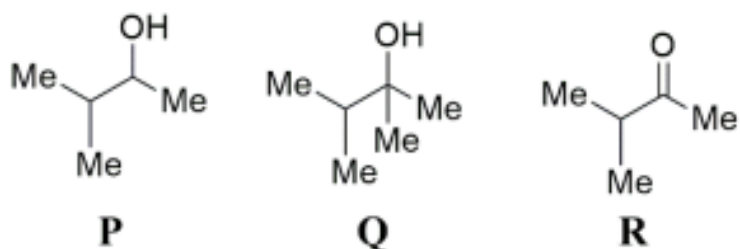
- Second order:  $t_{1/2} = \frac{1}{k_r[A]_0}$ .

22. The CORRECT statement(s) for the given reactions is(are):

Reactions:



Possible products:



- (A) P is formed as the major product in reaction I.  
 (B) P is formed as the major product in reaction II.  
 (C) Q is formed as the major product in reaction IV.  
 (D) R is formed as the major product in reaction III.

**Correct Answer:** (A), (B), (C)

**Solution:**

Let's analyze the reactions one by one:

- **Reaction I:** The reaction involves an aldehyde (MeCHO) and MeMgBr (Grignard reagent). Grignard reagents add to the carbonyl group of aldehydes to form a secondary alcohol, which on hydrolysis with  $H_3O^+$  will yield product P (MeCH(OH)Me). Therefore, the major product in reaction I is P.

Thus, the correct match for reaction I is A.

- **Reaction II:** In this case, a Grignard reagent (PrMgBr) is added to the aldehyde (MeCHO). The product formed is again a secondary alcohol, which is product P (MeCH(OH)Me).

Therefore, the major product in reaction II is also P.

Thus, the correct match for reaction II is B.

- **Reaction III:** Here, the reaction involves excess MeMgBr with an ester (MeCOOCH).

Excess Grignard reagent will attack the ester to form a tertiary alcohol, which corresponds to product Q (MeCOOMe).

Thus, the correct match for reaction III is C.

Thus, the correct answer is option (A), (B), (C).

#### Quick Tip

Grignard reagents add to carbonyl compounds (such as aldehydes and esters) to form alcohols. The excess reagent can lead to the formation of tertiary alcohols in the case of esters.

---

**23. Addition of a few drops of concentrated HCl to an aqueous solution of CoCl forms a dark blue complex X.**

**The CORRECT statement(s) for this reaction is(are):**

(Given: Atomic number of Co: 27)

(A) X is a centrosymmetric complex.

(B) The oxidation state of cobalt does not change in this reaction.

(C) The number of unpaired electrons on cobalt in X and in (CoCl<sub>2</sub>) (aqueous solution) are the same.

(D) The spin only magnetic moment value for X is 3.87 BM.

**Correct Answer:** (B), (C), (D)

**Solution:**

In this reaction, cobalt(II) chloride ( $\text{CoCl}_2$ ) reacts with  $\text{HCl}$ , forming a dark blue complex. The cobalt ion in the complex is in the +2 oxidation state, which remains unchanged throughout the reaction. Therefore, statement (B) is correct, as the oxidation state of cobalt does not change in this process.

Regarding the number of unpaired electrons, cobalt(II) in both the complex and the aqueous solution has the same electronic configuration, resulting in the same number of unpaired electrons in both species. Hence, statement (C) is also correct.

The spin-only magnetic moment is a measure of the unpaired electrons in a complex. For  $\text{Co}^{2+}$  in an octahedral complex with 3 unpaired electrons, the magnetic moment can be calculated using the formula:

$$\mu_{\text{sp}} = \sqrt{n(n+2)} \text{ BM}$$

where  $n$  is the number of unpaired electrons. With 3 unpaired electrons, the magnetic moment is approximately 3.87 BM, which confirms that statement (D) is correct.

Thus, the correct answers are (B), (C), and (D).

#### Quick Tip

The magnetic moment of a complex can be estimated using the spin-only formula, which depends on the number of unpaired electrons. For  $\text{Co}^{2+}$ , with 3 unpaired electrons, the magnetic moment is 3.87 BM.

---

#### 24. The CORRECT statement(s) regarding biomolecules is(are):

- (A) The N-terminal amino acid of a polypeptide can be identified by Edman's reagent (phenyl isothiocyanate).
- (B) L-Threonine has only one chiral center.
- (C) Cytosine is present both in RNA and DNA.
- (D) A mixture of different amino acids can be separated by ion-exchange chromatography.

**Correct Answer:** (A), (C), (D)

#### Solution:

Let's analyze the statements one by one:

- (A): Edman's reagent, which is phenyl isothiocyanate, is used to identify the N-terminal

amino acid in a polypeptide chain. This reagent reacts with the free amino group of the N-terminal residue to form a phenylthiohydantoin derivative, which can be identified and sequenced. This process is useful for determining the sequence of a polypeptide, so statement (A) is correct.

- (B): L-Threonine actually has two chiral centers, not just one. One is at the carbon attached to the hydroxyl group (-OH), and the other is at the central carbon (which is attached to the amino group, the carboxyl group, and the side chain). Therefore, statement (B) is incorrect.

- (C): Cytosine is a nitrogenous base that is found in both RNA and DNA. It pairs with guanine in both types of nucleic acids. Hence, statement (C) is correct.

- (D): Ion-exchange chromatography is a powerful method used to separate amino acids based on their net charge. In this technique, amino acids are separated by passing them through a column that contains charged groups. The amino acids will interact differently with the column based on their charge, making this statement correct.

Thus, the correct answers are (A), (C), and (D).

#### Quick Tip

Ion-exchange chromatography is a versatile technique that separates molecules based on their charge. In the case of amino acids, their separation depends on their differing pH and charge properties.

---

**25. Energy of the transition from  $n_h = 4$  to  $n_l = 2$  for hydrogen atom is  $E \times 10^3 \text{ cm}^{-1}$ .**

**Given: Rydberg constant for hydrogen:  $1.097 \times 10^7 \text{ m}^{-1}$**

**Value of E is ..... (rounded off to two decimal places)**

**Correct Answer: 20.57**

**Solution:**

The energy of the transition in a hydrogen atom can be calculated using the Rydberg formula:

$$E = R_H \left( \frac{1}{n_l^2} - \frac{1}{n_h^2} \right)$$

where  $R_H$  is the Rydberg constant for hydrogen, and  $n_l$  and  $n_h$  are the lower and higher quantum numbers, respectively. Substituting the given values:

$$E = (1.097 \times 10^7) \left( \frac{1}{2^2} - \frac{1}{4^2} \right)$$

$$E = (1.097 \times 10^7) \left( \frac{1}{4} - \frac{1}{16} \right)$$

$$E = (1.097 \times 10^7) \times \frac{3}{16}$$

$$E = 20.57 \times 10^3 \text{ cm}^{-1}$$

Thus, the correct value of  $E$  is  $20.57 \times 10^3 \text{ cm}^{-1}$ .

#### Quick Tip

To calculate the energy of a transition in the hydrogen atom, use the Rydberg formula, which accounts for the initial and final quantum numbers.

**26. A non-volatile solute has a molecular weight of  $180 \text{ g mol}^{-1}$ . Assume that the solute does not associate or dissociate in water, and the boiling-point constant (ebullioscopic constant) of water is  $0.51 \text{ K kg mol}^{-1}$ .**

**The amount (in g) of solute added to 500 g of water to elevate the boiling point by 0.153 K is ..... (answer in integer)**

**Correct Answer: 27**

**Solution:**

The elevation in boiling point ( $\Delta T_b$ ) is related to the amount of solute by the equation:

$$\Delta T_b = K_b \times m$$

where  $K_b$  is the ebullioscopic constant, and  $m$  is the molality of the solution. First, calculate the molality:

$$m = \frac{\Delta T_b}{K_b} = \frac{0.153}{0.51} = 0.3 \text{ mol/kg}$$

Next, calculate the number of moles of solute needed for 500 g of water (0.5 kg):

$$\text{moles of solute} = 0.3 \times 0.5 = 0.15 \text{ mol}$$

Now, calculate the mass of the solute using its molar mass:

$$\text{mass of solute} = 0.15 \times 180 = 27 \text{ g}$$

Thus, the amount of solute needed is 27 grams.

### Quick Tip

When calculating the amount of solute to elevate the boiling point, use the equation  $\Delta T_b = K_b \times m$ , where molality  $m$  is moles of solute per kilogram of solvent.

**27. The standard potentials ( $E^\circ$ ) for the  $\text{Fe}^{3+}/\text{Fe}$  and  $\text{Fe}^{3+}/\text{Fe}^{2+}$  couples are **-0.04 V** and **+0.76 V**, respectively.**

**Given: Faraday constant =  $96500 \text{ C mol}^{-1}$**

**The value for  $E^\circ (\text{Fe}^{2+}/\text{Fe})$  in V is ..... (rounded off to two decimal places)**

**Correct Answer: -0.46**

**Solution:**

We are given the standard electrode potentials for two half-reactions:

$$E^\circ(\text{Fe}^{3+}/\text{Fe}) = -0.04 \text{ V}, \quad E^\circ(\text{Fe}^{3+}/\text{Fe}^{2+}) = +0.76 \text{ V}$$

To calculate  $E^\circ(\text{Fe}^{2+}/\text{Fe})$ , we can use the Nernst equation, which relates the standard electrode potential for the two half-reactions:

$$E^\circ(\text{Fe}^{2+}/\text{Fe}) = E^\circ(\text{Fe}^{3+}/\text{Fe}) + E^\circ(\text{Fe}^{3+}/\text{Fe}^{2+})$$

Substituting the values:

$$E^\circ(\text{Fe}^{2+}/\text{Fe}) = -0.04 + 0.76 = -0.46 \text{ V}$$

Thus, the value of  $E^\circ(\text{Fe}^{2+}/\text{Fe})$  is **-0.46 V**.

### Quick Tip

The standard electrode potential for a redox couple can be calculated by using the known potentials for related half-reactions.

## Biochemistry

### Q.28 – Q.35 Carry ONE mark Each

#### 28. Zinc is essential for the function of

- (A) carboxypeptidase A.
- (B) chlorophyll a.
- (C) myoglobin.
- (D) vitamin  $B_{12}$ .

**Correct Answer:** (A) carboxypeptidase A.

#### **Solution:**

Zinc plays a crucial role as a cofactor in various enzymes. Carboxypeptidase A is a zinc-dependent enzyme that catalyzes the hydrolysis of peptide bonds at the carboxyl end of proteins. Zinc is involved in the enzyme's active site, facilitating the cleavage of peptide bonds. This makes statement (A) correct.

- **(B):** Chlorophyll a is a magnesium-containing pigment in plants and plays a central role in photosynthesis. Zinc is not involved in the function of chlorophyll a. Hence, statement (B) is incorrect.

- **(C):** Myoglobin is an oxygen-binding protein found in muscles and does not require zinc for its function. Therefore, statement (C) is incorrect.

- **(D):** Vitamin  $B_{12}$ , which contains the element cobalt at its core, does not require zinc for its activity. Thus, statement (D) is incorrect.

Thus, the correct answer is (A).

#### Quick Tip

Zinc is an essential trace element and is involved in numerous enzyme catalysis, particularly those related to protein digestion and the immune system.

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#### 29. Which one of the following molecules captures $CO_2$ in the $CO_4$ cycle?

- (A) 1,3-Bisphosphoglycerate.
- (B) Oxaloacetate.
- (C) Phosphoenolpyruvate.

(D) Ribulose-1,5-bisphosphate.

**Correct Answer:** (C) Phosphoenolpyruvate.

**Solution:**

In the  $C_4$  cycle, the molecule that captures  $CO_2$  is phosphoenolpyruvate (PEP). PEP, a three-carbon compound, reacts with  $CO_2$  in the presence of the enzyme PEP carboxylase to form oxaloacetate, a four-carbon compound. This reaction is the first step in the  $C_4$  pathway of photosynthesis, which helps in concentrating  $CO_2$  in plants, particularly in hot and arid climates. Therefore, statement (C) is correct.

- (A): 1,3-Bisphosphoglycerate is an intermediate in the Calvin cycle, but it does not capture  $CO_2$ . Therefore, statement (A) is incorrect.

- (B): Oxaloacetate is a product in the  $C_4$  cycle, but it does not capture  $CO_2$ . It is formed after phosphoenolpyruvate captures  $CO_2$ . Hence, statement (B) is incorrect.

- (D): Ribulose-1,5-bisphosphate is involved in the Calvin cycle, specifically in the fixation of  $CO_2$  in  $C_3$  plants, but not in the  $C_4$  cycle. Thus, statement (D) is incorrect.

Thus, the correct answer is (C).

#### Quick Tip

In the  $C_4$  cycle, phosphoenolpyruvate (PEP) is the molecule that captures  $CO_2$ , a step that is catalyzed by PEP carboxylase. This is an important adaptation in plants for efficiently fixing  $CO_2$  in hot climates.

---

**30. Which one of the following methods separates biomolecules based on their hydrodynamic volumes?**

(A) Anion-exchange chromatography

(B) Cation-exchange chromatography

(C) Size-exclusion chromatography

(D) Thin-layer chromatography

**Correct Answer:** (C) Size-exclusion chromatography

**Solution:**

Size-exclusion chromatography (also known as gel-filtration chromatography) separates

biomolecules based on their size and hydrodynamic volume. In this technique, larger molecules elute first because they cannot enter the small pores in the stationary phase, whereas smaller molecules take longer to elute as they enter the pores. This makes size-exclusion chromatography the method that separates biomolecules based on their hydrodynamic volumes. Therefore, statement (C) is correct.

- (A): Anion-exchange chromatography separates biomolecules based on their charge by using a stationary phase that attracts negatively charged particles. This is not based on hydrodynamic volume. Hence, statement (A) is incorrect.

- (B): Cation-exchange chromatography works similarly to anion-exchange but attracts positively charged particles. It also does not separate based on hydrodynamic volume, so statement (B) is incorrect.

- (D): Thin-layer chromatography separates molecules based on their affinity for the stationary phase, not based on size or hydrodynamic volume. Therefore, statement (D) is incorrect.

Thus, the correct answer is (C).

#### Quick Tip

Size-exclusion chromatography is an effective method for separating large molecules from smaller ones based on size and volume. It is widely used for protein purification.

---

**31. Which one of the following restriction endonucleases is a blunt cutter?**

(A) BamHI

(B) EcoRI

(C) HindIII

(D) EcoRV

**Correct Answer:** (D) EcoRV

**Solution:**

Restriction endonucleases are enzymes that cut DNA at specific sequences. They can generate either sticky ends (overhanging ends) or blunt ends (straight cuts). EcoRV is a restriction enzyme that cuts DNA in a blunt-ended fashion. It recognizes the palindromic

sequence 5'–GATATC–3' and cuts both strands of the DNA at the same position, generating blunt ends. Thus, statement (D) is correct.

- (A): BamHI is a restriction enzyme that produces sticky ends, not blunt ends. It recognizes the sequence 5'–GGATCC–3', cutting between the G and the A. Hence, statement (A) is incorrect.

- (B): EcoRI is another restriction enzyme that creates sticky ends. It cuts between the G and the A of the sequence 5'–GAATTC–3'. Therefore, statement (B) is incorrect.

- (C): HindIII also generates sticky ends. It recognizes the sequence 5'–AAGCTT–3' and cuts between the A and the A. Thus, statement (C) is incorrect.

Thus, the correct answer is (D).

#### Quick Tip

When working with restriction enzymes, it is important to know whether the enzyme generates sticky or blunt ends, as this affects how the DNA can be ligated with other fragments.

---

### 32. Which one of the following DNA repair systems requires DNA glycosylases?

(A) Base-excision

(B) Direct

(C) Mismatch

(D) Nucleotide-excision

**Correct Answer:** (A) Base-excision

#### **Solution:**

Base-excision repair (BER) is a DNA repair mechanism that specifically addresses single-base lesions in the DNA. This system requires the activity of DNA glycosylases, which recognize and remove damaged bases by cleaving the glycosidic bond between the base and the sugar-phosphate backbone. After the base is removed, the repair is completed by other enzymes that fill in the gap and ligate the strand. Hence, statement (A) is correct.

- (B): Direct repair does not involve glycosylases. It is a repair process that directly reverses certain types of DNA damage, such as the repair of O<sup>6</sup>-methylguanine through the action of

O6-methylguanine-DNA methyltransferase. Thus, statement (B) is incorrect.

- (C): Mismatch repair corrects errors that occur during DNA replication, such as base-pair mismatches and small insertions or deletions, but it does not require glycosylases. Therefore, statement (C) is incorrect.

- (D): Nucleotide-excision repair (NER) is a process that removes bulky DNA lesions, but it does not involve glycosylases. Instead, it involves the excision of a short single-stranded DNA segment containing the damage. Hence, statement (D) is incorrect.

Thus, the correct answer is (A).

#### Quick Tip

In base-excision repair, DNA glycosylases play a crucial role in recognizing and excising damaged bases. This is the first step in repairing single-base lesions.

---

**33. Which one of the following ion channels opens to repolarize the neuronal membrane when an action potential is generated?**

(A)  $\text{Ca}^{2+}$  channel

(B)  $\text{H}^+$  channel

(C)  $\text{Na}^+$  channel

(D)  $\text{K}^+$  channel

**Correct Answer:** (D)  $\text{K}^+$  channel

**Solution:**

During an action potential, the membrane potential of a neuron rapidly depolarizes, followed by repolarization. Repolarization occurs primarily due to the opening of potassium ( $\text{K}^+$ ) channels. When these channels open,  $\text{K}^+$  ions flow out of the cell, making the inside of the cell more negative and returning the membrane potential to its resting state. Hence, statement (D) is correct.

- (A): The  $\text{Ca}^{2+}$  channel opens during the depolarization phase of the action potential, but it does not contribute significantly to repolarization. Therefore, statement (A) is incorrect.

- (B): The  $\text{H}^+$  channel is not involved in the generation or repolarization of action potentials in neurons. Thus, statement (B) is incorrect.

- (C): The  $\text{Na}^+$  channel opens during depolarization, allowing  $\text{Na}^+$  to flow into the cell, which causes the membrane potential to become more positive. It does not play a direct role in repolarization. Hence, statement (C) is incorrect.

Thus, the correct answer is (D).

#### Quick Tip

During the action potential, the opening of  $\text{K}^+$  channels is essential for repolarization, while  $\text{Na}^+$  and  $\text{Ca}^{2+}$  channels primarily contribute to depolarization.

---

### 34. Which one of the following is the most sensitive immunoassay?

- (A) Immunoelectrophoresis
- (B) Immunofluorescence
- (C) Radial immunodiffusion
- (D) Radioimmunoassay

**Correct Answer:** (D) Radioimmunoassay

#### **Solution:**

Radioimmunoassay (RIA) is considered the most sensitive immunoassay technique among the listed options. It uses radioactively labeled antigens or antibodies to detect trace amounts of substances. The high sensitivity is due to the use of radioactive isotopes, which allows for the detection of very small quantities of analytes in biological samples. Hence, statement (D) is correct.

- (A): Immunoelectrophoresis is a technique that separates proteins based on their size and charge using an electric field. While it is useful for separating proteins, it is not as sensitive as radioimmunoassay. Thus, statement (A) is incorrect.

- (B): Immunofluorescence uses fluorescent-labeled antibodies to detect antigens. While sensitive, it is not as sensitive as radioimmunoassay due to lower signal intensity. Hence, statement (B) is incorrect.

- (C): Radial immunodiffusion is a method for quantifying antigens, but it is less sensitive compared to radioimmunoassay because it relies on a diffusion-based process rather than radioactive labeling. Therefore, statement (C) is incorrect.

Thus, the correct answer is (D).

#### Quick Tip

Radioimmunoassay (RIA) is highly sensitive due to the use of radioactive isotopes. It can detect very low concentrations of analytes, making it ideal for trace analysis.

### 35. Which of the following statements about antibodies is/are correct?

- (A) Different antibody classes have different effector functions.
- (B) Each antibody chain consists of an amino-terminal constant region and a carboxy-terminal variable region.
- (C) Variable domains harbor complementarity-determining regions.
- (D) All antibodies have the same half-life.

**Correct Answer:** (A), (C)

#### Solution:

- **(A):** Different antibody classes (IgG, IgA, IgM, etc.) do indeed have different effector functions. For example, IgG is involved in opsonization and neutralization, while IgE is associated with allergic responses. This makes statement (A) correct.
- **(B):** This statement is incorrect. Each antibody chain consists of a variable region (not constant) at the amino-terminal end and a constant region at the carboxy-terminal end. Thus, statement (B) is incorrect.
- **(C):** Variable domains in antibodies contain complementarity-determining regions (CDRs), which are regions of the variable domain that directly interact with the antigen. These regions are critical for the antibody's specificity. Hence, statement (C) is correct.
- **(D):** Antibody half-life varies depending on the class of the antibody. For example, IgG has a longer half-life compared to IgM, so statement (D) is incorrect.

Thus, the correct answers are (A) and (C).

#### Quick Tip

Antibodies exhibit great diversity in their structures and functions. The variable region determines antigen specificity, while the constant region defines effector functions.

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**Q.36 – Q.46 Carry TWO marks Each**

**36. Which one of the following molecules does NOT contain phosphoanhydride bond(s)?**

- (A) Adenosine diphosphate
- (B) Adenosine triphosphate
- (C) Fructose-1,6-bisphosphate
- (D) Pyrophosphate

**Correct Answer:** (C) Fructose-1,6-bisphosphate

**Solution:**

Phosphoanhydride bonds are high-energy bonds found in molecules like ATP (adenosine triphosphate) and ADP (adenosine diphosphate). These bonds link phosphate groups through oxygen atoms, and breaking these bonds releases a significant amount of energy.

- **(A):** Adenosine diphosphate (ADP) contains a phosphoanhydride bond between the second and third phosphate groups. Hence, statement (A) is incorrect.

- **(B):** Adenosine triphosphate (ATP) contains two phosphoanhydride bonds, one between the first and second phosphate groups and another between the second and third. Hence, statement (B) is incorrect.

- **(C):** Fructose-1,6-bisphosphate does not contain phosphoanhydride bonds. It has ester linkages between its phosphate groups, not phosphoanhydride bonds. Thus, statement (C) is correct.

- **(D):** Pyrophosphate consists of two linked phosphate groups by a phosphoanhydride bond. Therefore, statement (D) is incorrect.

Thus, the correct answer is (C).

**Quick Tip**

Phosphoanhydride bonds are typically found in high-energy molecules like ATP, ADP, and pyrophosphate, where they store energy. Fructose-1,6-bisphosphate, however, has ester bonds between phosphate groups.

**37. For an enzyme that follows Michaelis-Menten kinetics, a competitive inhibitor**

- (A) increases both  $K_m$  and  $V_{\max}$
- (B) decreases both  $K_m$  and  $V_{\max}$
- (C) increases  $K_m$  but does not affect  $V_{\max}$
- (D) decreases  $K_m$  but does not affect  $V_{\max}$

**Correct Answer:** (C) increases  $K_m$  but does not affect  $V_{\max}$

**Solution:**

In competitive inhibition, the inhibitor competes with the substrate for binding to the enzyme's active site. As a result, more substrate is required to reach half of the maximum reaction rate, which increases the Michaelis constant ( $K_m$ )—a measure of substrate affinity. However, the maximum reaction rate ( $V_{\max}$ ) remains unchanged because the inhibitor can be outcompeted by increasing substrate concentration. Thus, statement (C) is correct.

- (A): Competitive inhibition increases  $K_m$  but does not affect  $V_{\max}$ . Therefore, statement (A) is incorrect.
- (B): Competitive inhibition does not decrease  $V_{\max}$ , as increasing substrate concentration can overcome the inhibition. Hence, statement (B) is incorrect.
- (D): Competitive inhibition increases  $K_m$ , not decreases it. Therefore, statement (D) is incorrect.

Thus, the correct answer is (C).

**Quick Tip**

In competitive inhibition,  $V_{\max}$  remains the same, but  $K_m$  increases because the inhibitor reduces the enzyme's affinity for the substrate, requiring higher substrate concentrations to achieve the same rate.

---

**38. Förster Resonance Energy Transfer does NOT depend on the**

- (A) relative orientation of donor and acceptor
- (B) fluorescence quantum yield of acceptor
- (C) distance between donor and acceptor
- (D) overlap between donor's emission and acceptor's absorption spectra

**Correct Answer:** (B) fluorescence quantum yield of acceptor

**Solution:**

Förster Resonance Energy Transfer (FRET) is a process by which energy is transferred non-radiatively from a donor molecule to an acceptor molecule. FRET efficiency depends on several factors:

- (A): The relative orientation of the donor and acceptor molecules affects the FRET efficiency. This is because FRET depends on the dipole-dipole interaction between the donor and acceptor, and the efficiency increases when the molecules are properly aligned. Hence, statement (A) is incorrect.
- (B): The fluorescence quantum yield of the acceptor does not directly affect the FRET efficiency. FRET primarily depends on the donor's emission and the acceptor's absorption, not on the quantum yield of the acceptor. Therefore, statement (B) is correct.
- (C): The distance between the donor and acceptor is a key factor in FRET. FRET efficiency decreases with the sixth power of the distance between the donor and acceptor molecules. Thus, statement (C) is incorrect.
- (D): The overlap between the donor's emission spectrum and the acceptor's absorption spectrum is a critical factor for efficient energy transfer. A larger overlap increases the likelihood of FRET. Hence, statement (D) is incorrect.

Thus, the correct answer is (B).

**Quick Tip**

In Förster resonance energy transfer, the efficiency is inversely related to the distance between donor and acceptor, and depends on the overlap between donor emission and acceptor absorption.

---

**39. Phospholipid vesicles prepared in 50 mM KCl were diluted in water. Based on this information, statements P and Q are made.**

**P: The diluted vesicles will develop membrane potential.**

**Q: There is a  $K^+$  concentration difference across the vesicular membrane.**

**Which one of the following options is correct?**

- (A) Both P and Q are true.

- (B) P is true but Q is false.
- (C) P is false but Q is true.
- (D) Both P and Q are false.

**Correct Answer:** (C) P is false but Q is true.

**Solution:**

- **P:** The dilution of phospholipid vesicles in water does not automatically lead to the development of a membrane potential. The vesicles would have to have a pre-existing ion gradient (such as  $\text{Na}^+$  or  $\text{K}^+$ ) for a membrane potential to be generated. Dilution in water alone would likely cause the ions to diffuse and equalize, thus preventing membrane potential development. Therefore, statement P is false.

- **Q:** If phospholipid vesicles are prepared in 50 mM KCl and then diluted in water, the dilution will cause a concentration gradient of  $\text{K}^+$  ions across the membrane. This concentration difference would lead to the development of a  $\text{K}^+$  gradient, which is true.

Thus, statement Q is true.

Thus, the correct answer is (C).

**Quick Tip**

When vesicles are diluted in water, the concentration of ions such as  $\text{K}^+$  changes, leading to a concentration gradient that can result in membrane potential development, depending on the permeability of the membrane to specific ions.

---

**40. Peptide-binding cleft in MHC-I is formed by**

- (A)  $\alpha_1$  and  $\alpha_2$  domains.
- (B)  $\alpha_1$  and  $\alpha_3$  domains.
- (C)  $\alpha_1$  domain and  $\beta_2$ -microglobulin.
- (D)  $\alpha_2$  domain and  $\beta_2$ -microglobulin.

**Correct Answer:** (A)  $\alpha_1$  and  $\alpha_2$  domains.

**Solution:**

In MHC-I molecules, the peptide-binding cleft is formed by the  $\alpha_1$  and  $\alpha_2$  domains of the  $\alpha$ -chain. These domains work together to form a groove in which peptides bind. The

$\beta_2$ -microglobulin supports the structure but does not directly contribute to the peptide-binding cleft. Therefore, statement (A) is correct.

- **(B)**: The  $\alpha_1$  and  $\alpha_3$  domains are not involved in forming the peptide-binding cleft. The  $\alpha_3$  domain contributes to the overall structural stability but not to the peptide binding site.

Hence, statement (B) is incorrect.

- **(C)**: The  $\alpha_1$  domain and  $\beta_2$ -microglobulin are not responsible for the peptide-binding cleft. While  $\beta_2$ -microglobulin is essential for the stability of MHC-I, it does not form the cleft.

Hence, statement (C) is incorrect.

- **(D)**: The  $\alpha_2$  domain and  $\beta_2$ -microglobulin do not form the peptide-binding cleft. The  $\alpha_2$  domain is involved in interaction with T-cell receptors but not in the peptide binding itself.

Hence, statement (D) is incorrect.

Thus, the correct answer is (A).

#### Quick Tip

In MHC-I molecules, the peptide-binding cleft is formed by the  $\alpha_1$  and  $\alpha_2$  domains.  $\beta_2$ -microglobulin supports the structure but does not contribute to the binding cleft.

---

**41. Which of the following peptides do/does NOT absorb ultraviolet light above 250 nm wavelength?**

(A) MQRTVWG

(B) YDEIGVL

(C) PLASNGK

(D) GSQTKRL

**Correct Answer:** (C), (D)

**Solution:**

Peptides absorb ultraviolet (UV) light at wavelengths around 280 nm due to the presence of aromatic amino acids like tryptophan, tyrosine, and phenylalanine. When examining peptides for UV absorbance, we look for these aromatic residues.

- **(A)**: MQRTVWG contains tryptophan (W), which absorbs UV light around 280 nm. Thus, it does absorb UV light above 250 nm. Hence, statement (A) is incorrect.

- **(B)**: YDEIGVL contains tyrosine (Y), which absorbs UV light around 280 nm. Thus, it does absorb UV light above 250 nm. Therefore, statement (B) is incorrect.
  - **(C)**: PLASNGK does not contain any aromatic residues. Therefore, it does not absorb UV light above 250 nm. Hence, statement (C) is correct.
  - **(D)**: GSQTKRL does not contain any aromatic residues either. Hence, it does not absorb UV light above 250 nm. Therefore, statement (D) is correct.
- Thus, the correct answers are (C) and (D).

#### Quick Tip

Peptides that absorb UV light above 250 nm typically contain aromatic amino acids like tryptophan (W), tyrosine (Y), or phenylalanine (F). Peptides without these residues do not absorb UV light in this range.

---

#### 42. Which of the following is/are peptide hormone(s)?

- (A) Calcitonin
- (B) Glucagon
- (C) Serotonin
- (D) Thyroxine

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

#### **Solution:**

Peptide hormones are composed of amino acid chains and function as signaling molecules in the body. Let's analyze the options:

- **(A)**: Calcitonin is a peptide hormone produced by the thyroid gland. It helps regulate calcium levels in the blood by inhibiting bone resorption. Thus, statement (A) is correct.
- **(B)**: Glucagon is a peptide hormone produced by the pancreas. It raises blood glucose levels by promoting the conversion of glycogen to glucose. Hence, statement (B) is correct.
- **(C)**: Serotonin is a neurotransmitter, not a peptide hormone. It is derived from the amino acid tryptophan but is not classified as a peptide hormone. Therefore, statement (C) is incorrect.
- **(D)**: Thyroxine (T4) is a thyroid hormone but is derived from tyrosine and iodine, not from

peptides. Therefore, statement (D) is incorrect.

Thus, the correct answers are (A) and (B).

#### Quick Tip

Peptide hormones are made up of chains of amino acids. Examples include glucagon and calcitonin. Thyroxine, however, is not a peptide hormone, as it is derived from tyrosine.

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### 43. Which of the following is/are heteropolysaccharide(s)?

- (A) Chondroitin-4-sulfate
- (B) Chitin
- (C) Cellulose
- (D) Heparin

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

**Solution:**

Heteropolysaccharides are polysaccharides made up of different types of monosaccharide units. Let's analyze the options:

- **(A):** Chondroitin-4-sulfate is a heteropolysaccharide composed of alternating sugar units, including glucuronic acid and N-acetylgalactosamine, with sulfate groups attached. Hence, statement (A) is correct.
- **(B):** Chitin is a homopolysaccharide composed of N-acetylglucosamine, a single type of monosaccharide. Therefore, statement (B) is incorrect.
- **(C):** Cellulose is also a homopolysaccharide, made up of repeating units of glucose. Hence, statement (C) is incorrect.
- **(D):** Heparin is a highly sulfated heteropolysaccharide composed of disaccharide units with varying sulfation patterns. Hence, statement (D) is correct.

Thus, the correct answers are (A) and (D).

### Quick Tip

Heteropolysaccharides are composed of different types of monosaccharides, while homopolysaccharides are made up of one type of monosaccharide unit. Examples of heteropolysaccharides include heparin and chondroitin sulfate.

**44. The equilibrium dissociation constant of acetic acid is  $1.74 \times 10^{-5}$  M. The  $pK_a$  of acetic acid (rounded off to one decimal place) is .....**

**Solution:**

To calculate the  $pK_a$  of acetic acid, we use the formula:

$$pK_a = -\log K_a$$

where  $K_a$  is the equilibrium dissociation constant of acetic acid.

Given that  $K_a = 1.74 \times 10^{-5}$ , we can substitute this value into the equation:

$$pK_a = -\log(1.74 \times 10^{-5})$$

Now, applying the logarithmic properties:

$$pK_a = -\log(1.74) - \log(10^{-5})$$

We know that  $\log(10^{-5}) = -5$ , so:

$$pK_a = -\log(1.74) + 5$$

Using the value  $\log(1.74) \approx 0.240$ , we get:

$$pK_a = -0.240 + 5 = 4.760$$

Rounding this value to one decimal place, we obtain:

$$pK_a \approx 4.8$$

Thus, the  $pK_a$  of acetic acid is approximately 4.8.

### Quick Tip

To calculate the  $pK_a$  of a weak acid, use the formula  $pK_a = -\log K_a$ . The smaller the  $K_a$ , the weaker the acid, and the larger the  $pK_a$ .

---

**45. The DNA double helix measures 0.34 nm/bp. The diameter of a nucleosome core particle is 11 nm. If the ratio of wrapped DNA length to nucleosome diameter is 4.51, the length of DNA around the nucleosome (to the nearest integer) is ..... bp.**

**Solution:**

We are given: - The DNA double helix measures 0.34 nm/bp. - The diameter of the nucleosome core particle is 11 nm. - The ratio of wrapped DNA length to nucleosome diameter is 4.51.

The wrapped DNA length around the nucleosome can be calculated by multiplying the nucleosome diameter by the ratio:

$$\text{Wrapped DNA length} = 4.51 \times 11 = 49.61 \text{ nm}$$

Now, to find the number of base pairs (bp) wrapped around the nucleosome, we divide the wrapped DNA length by the length of DNA per base pair:

$$\text{Length of DNA} = \frac{49.61 \text{ nm}}{0.34 \text{ nm/bp}} = 146.5 \text{ bp}$$

Rounding to the nearest integer, the length of DNA around the nucleosome is approximately:

$$\boxed{146 \text{ bp}}$$

Thus, the length of DNA wrapped around the nucleosome is 146 bp.

#### Quick Tip

To calculate the length of DNA wrapped around a nucleosome, multiply the nucleosome diameter by the ratio of wrapped DNA length to nucleosome diameter, and divide by the length per base pair.

---

**46. E. coli is grown exclusively in a medium containing  $^{15}\text{NH}_4\text{Cl}$  as the sole nitrogen source. Subsequently, the cells were shifted to a medium containing  $^{14}\text{NH}_4\text{Cl}$ . The molar ratio of hybrid DNA ( $^{15}\text{N} - ^{14}\text{N}$ ) to light DNA ( $^{14}\text{N} - ^{14}\text{N}$ ) after four generations (rounded off to two decimal places) will be .....**

**Solution:**

In this experiment, *E. coli* is grown first in  $^{15}\text{NH}_4\text{Cl}$  (heavy nitrogen) and then shifted to  $^{14}\text{NH}_4\text{Cl}$  (light nitrogen). Initially, all the DNA is labeled with  $^{15}\text{N}$ , and after the shift, new DNA is synthesized with  $^{14}\text{N}$ .

After four generations, the following DNA types will be present:

- Generation 0: All DNA is heavy,  $^{15}\text{N} - ^{15}\text{N}$ .
- Generation 1: Half the DNA will be hybrid ( $^{15}\text{N} - ^{14}\text{N}$ ) and the other half will be light ( $^{14}\text{N} - ^{14}\text{N}$ ).
- Generation 2: Half of the hybrid DNA from Generation 1 will become  $^{14}\text{N} - ^{14}\text{N}$ , and the other half will remain hybrid ( $^{15}\text{N} - ^{14}\text{N}$ ).
- Generation 3: The ratio of hybrid DNA to light DNA will be 1:3.
- Generation 4: The ratio of hybrid DNA to light DNA will be 1:7.

Thus, after four generations, the molar ratio of hybrid DNA ( $^{15}\text{N} - ^{14}\text{N}$ ) to light DNA ( $^{14}\text{N} - ^{14}\text{N}$ ) is:

$$\frac{1}{7} \approx 0.14$$

Thus, the molar ratio of hybrid DNA to light DNA after four generations is 0.14.

#### Quick Tip

In a DNA labeling experiment, the ratio of hybrid to light DNA decreases with each generation as more new DNA is synthesized with light nitrogen ( $^{14}\text{N}$ ).

### Botany

**Q.47 – Q.54 Carry ONE mark Each**

**47. Correctly match the names of the plant taxonomists (Group I) with the titles of the books they authored (Group II):**

Group I	Group II
(P) John Hutchinson	(1) Classification of Flowering Plants
(Q) Adolf Engler and Karl Prantl	(2) Evolution and Classification of Flowering Plants
(R) Arthur Cronquist	(3) Die Natürlichen Pflanzenfamilien
(S) Alfred Barton Rendle	(4) The Families of Flowering Plants

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

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

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

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

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

**Solution:**

Let's match the plant taxonomists with their books:

- **(P) John Hutchinson:** Hutchinson is known for his work "The Families of Flowering Plants," which is considered a comprehensive guide to plant taxonomy. Hence, P-4 is the correct match.

- **(Q) Adolf Engler and Karl Prantl:** This pair authored the classic "Die Natürlichen Pflanzenfamilien," a multi-volume work that describes the natural families of plants. Hence, Q-3 is the correct match.

- **(R) Arthur Cronquist:** Cronquist is famous for his book "Evolution and Classification of Flowering Plants," which presents a new classification of plants based on evolutionary relationships. Hence, R-2 is the correct match.

- **(S) Alfred Barton Rendle:** Rendle is known for his book "Classification of Flowering Plants," which is a significant contribution to plant classification. Hence, S-1 is the correct match.

Thus, the correct answer is (A).

**Quick Tip**

Famous works in plant taxonomy, such as those by Hutchinson, Engler and Prantl, Cronquist, and Rendle, have significantly shaped our understanding of plant classification. Make sure to remember key contributions when studying taxonomy.

**Q.48 Which one of the following mature cell types is live but usually lacks nucleus?**

- (A) Phloem parenchyma
- (B) Phloem companion
- (C) Phloem sieve element
- (D) Phloem-pole pericycle

**Correct Answer:** (C) Phloem sieve element

**Solution:**

Phloem consists of several types of cells including sieve elements, companion cells, phloem parenchyma, and fibers.

Among these, **phloem sieve elements** are unique because they are **living at maturity** but **lack a nucleus**.

This structural adaptation allows for more efficient translocation of sugars and other organic substances throughout the plant.

However, the loss of the nucleus also makes them dependent on adjacent companion cells, which provide metabolic support.

Other phloem cells like phloem parenchyma and companion cells retain their nuclei and perform different functions.

**Quick Tip**

Sieve elements are the only living plant cells without a nucleus, relying on companion cells for survival and function.

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**49. Correctly match the carnivorous plants (Group I) with the organs (Group II) they modify to trap the prey:**

<b>Group I</b>	<b>Group II</b>
(P) Pitcher plant (Nepenthes)	(1) Leaf
(Q) Bladderwort (Utricularia)	(2) Fruit
(R) Sundew (Drosera)	(3) Stem
(S) Venus flytrap (Dionaea)	(4) Tendril

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

**Correct Answer:** (B) P-1, Q-1, R-1, S-1

**Solution:**

Let's analyze the matching between the carnivorous plants and their modified organs:

- **(P) Pitcher plant (Nepenthes):** The pitcher plant modifies its leaf into a pitcher-shaped structure, which it uses to trap prey. Hence, the correct match for P is  $P - 1$ .
- **(Q) Bladderwort (Utricularia):** Bladderworts have modified leaves in the form of small bladders that trap prey. Thus, the correct match for Q is  $Q - 1$ .
- **(R) Sundew (Drosera):** Sundew plants have modified leaves covered in glandular hairs that secrete sticky substances to trap prey. Hence, the correct match for R is  $R - 1$ .
- **(S) Venus flytrap (Dionaea):** The Venus flytrap modifies its leaf into a structure with hinged lobes that trap insects. Hence, the correct match for S is  $S - 1$ .

Thus, the correct answer is (B).

**Quick Tip**

Carnivorous plants modify their leaves or stems to form structures that trap prey. These adaptations are essential for their survival in nutrient-poor environments.

---

**50. Which one of the following commercially important carbohydrates is naturally produced only by the members of the plant kingdom?**

- (A) Cellulose
- (B) Pectin
- (C) Chitin
- (D) Starch

**Correct Answer:** (B) Pectin

**Solution:**

Pectin is a commercially important carbohydrate that is naturally produced only by members

of the plant kingdom. It is found in the cell walls of plants, particularly in the fruits, and is widely used in the food industry as a gelling agent for jams and jellies. Hence, statement (B) is correct.

- (A): Cellulose is a carbohydrate that is present in both plants and some bacteria (like cyanobacteria) and fungi. Therefore, it is not produced exclusively by plants. Hence, statement (A) is incorrect.

- (C): Chitin is a polysaccharide found in the exoskeletons of arthropods and fungi, not in plants. Hence, statement (C) is incorrect.

- (D): Starch is produced by both plants and some algae, making it not exclusive to the plant kingdom. Hence, statement (D) is incorrect.

Thus, the correct answer is (B).

#### Quick Tip

Pectin is unique to plants and is mainly found in fruits. It plays a significant role in the food industry as a natural gelling agent, unlike other carbohydrates such as starch and cellulose.

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**51. Which one of the following agents causes the necrotic ring spot disease in stone fruits?**

(A) Fungi

(B) Bacteria

(C) Virus

(D) Nematodes

**Correct Answer:** (C) Virus

**Solution:**

Necrotic ring spot disease, affecting stone fruits like cherries, peaches, and apricots, is caused by a viral pathogen. Specifically, the necrotic ring spot virus (NRSV) is responsible for this disease. It is transmitted through infected plant material and can cause significant damage to fruit trees by inducing characteristic symptoms like ring-shaped lesions on leaves and fruits. Since this disease is viral, it does not result from fungi, bacteria, or nematodes, making option (C) the correct choice.

- (A): Fungi can cause a variety of plant diseases, but they are not responsible for necrotic ring spot disease. Fungal diseases in plants include powdery mildew, rusts, and blights, but necrotic ring spot is caused by a virus. Therefore, statement (A) is incorrect.
- (B): Bacteria cause diseases like bacterial leaf spot, bacterial wilt, and crown gall, but they are not the cause of necrotic ring spot disease in stone fruits. Hence, statement (B) is incorrect.
- (D): Nematodes are parasitic worms that affect plant roots, causing diseases like root knot nematode infection, but they do not cause necrotic ring spot disease. Thus, statement (D) is also incorrect.

Therefore, the correct answer is (C), as necrotic ring spot disease is caused by a virus.

#### Quick Tip

When studying plant diseases, it is crucial to identify the pathogen type, whether it's a virus, bacterium, fungus, or nematode, as treatment methods and prevention strategies vary accordingly.

## 52. Identify the correct statement(s) with respect to plant disease:

- (A) Hairy root disease in tobacco is caused by *Agrobacterium tumefaciens*.
- (B) Loose smut of barley is caused by *Ustilago nuda*.
- (C) Stem rust of grape is caused by *Plasmopara viticola*.
- (D) Fire blight in pear is caused by *Erwinia amylovora*.

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

### Solution:

- (A): Hairy root disease is a plant disease caused by the bacterium *Agrobacterium rhizogenes*, not *Agrobacterium tumefaciens*. *Agrobacterium tumefaciens* is responsible for crown gall disease, characterized by the formation of tumors on the roots and stems. Hairy root disease results in the formation of abnormal root structures and is caused by a different species of *Agrobacterium*. Hence, statement (A) is incorrect.
- (B): Loose smut of barley is indeed caused by the fungal pathogen *Ustilago nuda*. This disease is characterized by the formation of smut balls, which consist of fungal spores, in the

heads of barley plants. *Ustilago nuda* is a common pathogen that affects barley and other grasses, making statement (B) correct.

- (C): Stem rust of grape is caused by the fungus *Puccinia graminis*, not *Plasmopara viticola*. *Plasmopara viticola* is the causal agent of downy mildew in grapevines, not stem rust.

Therefore, statement (C) is incorrect.

- (D): Fire blight in pear is indeed caused by the bacterium *Erwinia amylovora*. This bacterial pathogen infects the flowers, twigs, and branches of pear trees, causing wilting and dieback. The disease is highly destructive and can spread rapidly under favorable conditions, making statement (D) correct.

Thus, the correct answers are (B) and (D), as they accurately describe the pathogens responsible for loose smut of barley and fire blight in pear.

#### Quick Tip

Understanding the specific pathogen responsible for a plant disease is essential for choosing the appropriate control measures. For example, bacterial infections require different treatments compared to fungal diseases.

---

### 53. Which of the following molecular approaches can be used to generate complete knock-out of a target gene in plants?

- (A) Homologous recombination
- (B) CRISPR-Cas9
- (C) Antisense RNA technique
- (D) Activation tagging

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

#### **Solution:**

To generate a complete knock-out of a target gene in plants, two powerful molecular approaches are commonly used: homologous recombination and CRISPR-Cas9. Let's discuss each option in detail.

- (A) **Homologous recombination:** This technique allows the replacement or disruption of a target gene through recombination with a construct containing a mutated version of the gene

or a non-functional allele. It is a well-established method for generating gene knockouts in plants, making statement (A) correct.

- **(B) CRISPR-Cas9:** CRISPR-Cas9 is a revolutionary gene-editing technique that can be used to create gene knockouts by introducing double-strand breaks at specific locations in the target gene. The repair process often leads to frameshift mutations that disrupt the gene, making statement (B) correct.

- **(C) Antisense RNA technique:** This technique involves introducing RNA molecules that are complementary to the target gene's mRNA, reducing its expression. While effective in down-regulating gene expression, it does not completely "knock out" the gene as CRISPR-Cas9 or homologous recombination does. Hence, statement (C) is incorrect.

- **(D) Activation tagging:** This technique involves the insertion of strong enhancer sequences near a target gene, leading to its overexpression rather than its knockout. Therefore, statement (D) is incorrect.

Thus, the correct answers are (A) and (B).

#### Quick Tip

For complete gene knock-outs in plants, CRISPR-Cas9 and homologous recombination are the most widely used methods, while other techniques like antisense RNA and activation tagging are useful for gene regulation rather than complete knock-out.

**54. If an egg cell of a diploid plant species has 10 chromosomes, the expected number of chromosomes in a double trisomic somatic cell of this species would be .....**

**(Answer in integer).**

**Correct Answer: 22**

**Solution:**

To solve this problem, we need to understand the concepts of diploid, haploid, trisomy, and double trisomy. Let's break it down:

- In a diploid species, an organism has two sets of chromosomes: one set from the mother and one from the father. A diploid plant species with 10 chromosomes means it has 10 chromosomes in total in its diploid somatic cells. In this case, the number of chromosomes in its diploid somatic cells is 20 (2 sets of 10 chromosomes).

- The egg cell, which is haploid, contains only one set of chromosomes. Therefore, since the diploid number is 10, the haploid egg cell would have 10 chromosomes.

Now, let's consider the concept of a "double trisomic" cell. A double trisomic cell is a somatic cell that contains two extra chromosomes, one from each of two different chromosomes. So, if we take a diploid somatic cell (which has 20 chromosomes) and add 2 extra chromosomes (one from each of two chromosomes), we end up with a total of:

$$\text{Chromosome count in double trisomic cell} = 20 + 2 = 22$$

Thus, the number of chromosomes in the double trisomic somatic cell will be 22 chromosomes. This is because the cell has one extra chromosome from each of two chromosomes.

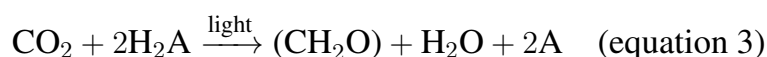
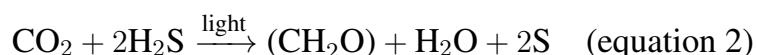
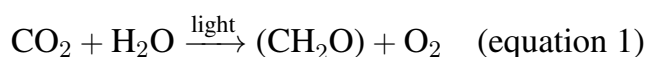
Therefore, the correct answer is 22.

#### Quick Tip

In a trisomic condition, there is an extra chromosome for one chromosome pair. In a double trisomic condition, two extra chromosomes are present. The total chromosome count increases by 2 from the normal diploid number.

**Q.55– Q.65 Carry TWO marks Each**

**55. In the history of photosynthetic research, the empirical reaction of photosynthesis was first proposed for green plants (equation 1), followed by another reaction for purple sulfur bacteria (equation 2), leading to a generalized equation for photosynthesis (equation 3), where H<sub>2</sub>A in equation 3 is a generalized electron donor.**



Where H<sub>2</sub>A in equation 3 is a generalized electron donor.

**Which one of the following statements is DISPROVEN by equation 3?**

- (A) The source of oxygen produced in photosynthesis in green plants is CO<sub>2</sub>
- (B) The source of oxygen produced in photosynthesis in green plants is H<sub>2</sub>O
- (C) Light is essential in every form of photosynthesis
- (D) Glucose is the end product in all forms of photosynthesis

**Correct Answer:** (A) The source of oxygen produced in photosynthesis in green plants is CO<sub>2</sub>

**Solution:**

In equation 3, the generalized equation for photosynthesis, it is clear that the oxygen produced is not derived from carbon dioxide (CO<sub>2</sub>) but from the electron donor H<sub>2</sub>A. This disproves the statement that oxygen comes from CO<sub>2</sub>, which is true for the original green plant photosynthesis equation (equation 1). Therefore, statement (A) is disproven.

Let's analyze the other options:

- **(B) The source of oxygen produced in photosynthesis in green plants is H<sub>2</sub>O:** This statement is true for green plants. In the empirical reaction for green plants (equation 1), oxygen is released from water (H<sub>2</sub>O) as the electron donor, not from CO<sub>2</sub>. Hence, statement (B) is not disproven.
- **(C) Light is essential in every form of photosynthesis:** Light is indeed essential for all forms of photosynthesis, as shown in equations (1), (2), and (3), where the reactions are driven by light energy. Hence, statement (C) is not disproven.

- **(D) Glucose is the end product in all forms of photosynthesis:** While glucose is the major product of photosynthesis in green plants, in certain forms of photosynthesis (like in purple sulfur bacteria, equation 2), the end product is a simple carbohydrate ( $\text{CH}_2\text{O}$ ), not glucose. However, the statement is more related to the generalized nature of photosynthesis and is not disproven.

Thus, the correct answer is (A), as equation 3 disproves the idea that oxygen comes from  $\text{CO}_2$  in photosynthesis.

#### Quick Tip

In photosynthesis, the source of oxygen in green plants is water, not carbon dioxide. Remember that oxygen is released during the splitting of water molecules in the light-dependent reactions of photosynthesis.

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**56. Consider a diploid plant species where the cells in the epidermis (the outermost single cell layer) always divide in the anticlinal orientation. If one such cell within the central zone of the shoot apical meristem (SAM) spontaneously becomes tetraploid at the seedling stage, which one of the following cellular arrangements would be most likely observed if the meristem is examined at the adult stage?**

- (A) Only one tetraploid cell in the epidermis
- (B) Many tetraploid cells in the epidermis
- (C) All cells in the entire SAM tetraploid
- (D) All cells in the entire SAM diploid

**Correct Answer:** (B) Many tetraploid cells in the epidermis

#### **Solution:**

In the given situation, a single cell in the epidermis of a diploid plant becomes tetraploid at the seedling stage. The key point here is that the cells in the epidermis divide in an anticlinal orientation, meaning that the division occurs perpendicular to the surface of the plant. When one of these epidermal cells becomes tetraploid, its daughter cells will also be tetraploid as they divide, leading to a clonal expansion of tetraploid cells in the epidermis. Therefore, we would expect many tetraploid cells to be present in the epidermis as a result of the clonal

division of the initial tetraploid cell. Hence, statement (B) is correct.

- (A): If only one tetraploid cell were present in the epidermis, this would imply that the tetraploid cell did not divide or proliferate, which contradicts the scenario described in the question. Hence, statement (A) is incorrect.

- (C): The question specifically mentions that the tetraploid cell is in the epidermis, not the entire SAM (shoot apical meristem). Therefore, the entire SAM becoming tetraploid is unlikely. Hence, statement (C) is incorrect.

- (D): If all cells in the SAM were diploid, there would be no tetraploid cells present, which contradicts the assumption that one epidermal cell is tetraploid. Hence, statement (D) is incorrect.

Thus, the correct answer is (B), as many tetraploid cells in the epidermis would most likely be observed at the adult stage due to clonal proliferation.

#### Quick Tip

When a tetraploid cell arises in a plant meristem, it typically proliferates and results in multiple tetraploid cells in the affected tissue, especially when divisions occur in an anticlinal orientation.

**57. Correctly match the photosynthetic pathways (Group I) with their first stable products (Group II) in respective plants (Group III):**

Group I	Group II	Group III
(P) C3 cycle	(1) 3-Phosphoglycerate	(a) Wheat
(Q) C4 cycle	(2) Glyceraldehyde-3-phosphate	(b) Sugarcane
(R) CAM	(3) Oxaloacetate	(c) Pineapple

(A) P-1-a; Q-3-b; R-3-c

(B) P-1-a; Q-2-b; R-3-c

(C) P-1-b; Q-3-a; R-2-c

(D) P-1-b; Q-2-c; R-2-a

**Correct Answer:** (A) P-1-a; Q-3-b; R-3-c

**Solution:**

Let's go through the photosynthetic pathways and their first stable products in respective plants:

- **(P) C3 cycle:** In C3 plants such as wheat (Group III, a), the first stable product formed in the Calvin cycle is 3-Phosphoglycerate (Group II, 1). This is characteristic of the C3 cycle, where CO<sub>2</sub> is fixed into 3-Phosphoglycerate, making the correct match  $P - 1 - a$ .
- **(Q) C4 cycle:** In C4 plants like sugarcane (Group III, b), the first stable product formed during the initial fixation of CO<sub>2</sub> is Oxaloacetate (Group II, 3). This occurs before the further processing of Oxaloacetate into other intermediates, making the correct match  $Q - 3 - b$ .
- **(R) CAM:** In CAM plants like pineapple (Group III, c), the first stable product formed is Oxaloacetate (Group II, 3) during the initial fixation of CO<sub>2</sub> at night when stomata are open. Therefore, the correct match is  $R - 3 - c$ .

Thus, the correct answer is (A), as the correct matching for the first stable products in the respective plants is  $P - 1 - a$ ,  $Q - 3 - b$ , and  $R - 3 - c$ .

#### Quick Tip

The first stable products in photosynthesis vary depending on the pathway. C3 plants form 3-Phosphoglycerate, C4 plants form Oxaloacetate, and CAM plants also initially form Oxaloacetate, but with a temporal separation of CO<sub>2</sub> fixation.

**58. The following table summarizes the flowering time behavior (days to flower) and the transcript levels in four genotypes of a plant species.**

Genotype	Days to flower	Transcript level of gene A	Transcript level of gene B
Wild type	30	Normal	Normal
a mutant	15	Nil	Increased
b mutant	60	Normal	Nil
ab double mutant	60	Nil	Nil

**Which one of the following genetic pathways best explains the observations shown in the table?**

- (A) A gene activates B, which suppresses flowering transition.

- (B) A gene suppresses B, which promotes flowering transition.
- (C) B gene activates A, which suppresses flowering transition.
- (D) B gene suppresses A, which promotes flowering transition.

**Correct Answer:** (B) A gene suppresses B, which promotes flowering transition.

**Solution:**

Let's analyze the data in the table:

- Wild type: The wild type has a normal flowering time of 30 days, with normal transcript levels for both gene A and gene B. This suggests that both genes are functioning properly in the wild type, and there is no interference between their activities.
- a mutant: In the a mutant, the days to flower are reduced to 15 days, with gene A showing no transcript levels (Nil) and gene B showing an increased transcript level. This suggests that when gene A is inactive, gene B is upregulated, leading to a faster flowering time. Hence, the activity of gene A seems to suppress gene B, and in its absence, gene B becomes more active, promoting flowering.
- b mutant: In the b mutant, the days to flower are delayed to 60 days, with normal transcript levels for gene A and no transcript for gene B. This suggests that gene B is crucial for the proper timing of flowering, and its absence leads to a delayed flowering time. The normal transcript level of gene A indicates that gene A alone does not prevent the flowering transition in the absence of gene B.
- ab double mutant: In the double mutant, the days to flower are still 60, with both genes showing Nil transcript levels. This suggests that both gene A and gene B are required for the normal regulation of flowering time, and their absence leads to a complete disruption of the flowering transition process.

Based on these observations, the pathway that best explains the data is that gene A suppresses gene B, and the absence of gene A leads to the upregulation of gene B, which accelerates the flowering transition. This supports option (B), which states that A gene suppresses B, which promotes flowering transition.

- (A): This option would suggest that gene A activates gene B and suppresses flowering, which is not supported by the data. Hence, statement (A) is incorrect.
- (C): This option would imply that gene B activates gene A and suppresses flowering, but the data shows that gene B's absence (in the b mutant) leads to delayed flowering, not accelerated. Hence,

statement (C) is incorrect. - (D): This option suggests that gene B suppresses gene A, but the data suggests that the lack of gene A leads to upregulation of gene B, not the other way around. Hence, statement (D) is incorrect.

Thus, the correct answer is (B).

#### Quick Tip

In genetic pathways, the interaction between genes can be complex. In this case, the suppression of one gene by another (gene A suppressing gene B) results in a different flowering time phenotype.

**59. Correctly match the economically important specialized metabolites (Group I) with their broad chemical classes (Group II):**

Group I	Group II
(P) Azadirachtin	(1) Monoterpene
(Q) Saponin	(2) Alkaloid
(R) Gallocatechin	(3) Triterpene glycoside
(S) Cocaine	(4) Polyphenol
(T) Menthol	(5) Triterpene

(A) P-5, Q-3, R-2, S-4, T-1

(B) P-2, Q-4, R-3, S-1, T-5

(C) P-5, Q-4, R-3, S-2, T-1

(D) P-3, Q-5, R-4, S-2, T-1

**Correct Answer:** (C) P-5, Q-4, R-3, S-2, T-1

#### Solution:

Let's break down the correct matches between the metabolites and their chemical classes:

- **(P) Azadirachtin:** Azadirachtin is a complex triterpenoid compound derived from the neem tree, known for its insecticidal properties. It belongs to the class of Triterpenes (Group II, 5), making the correct match  $P - 5$ .

- **(Q) Saponin:** Saponins are glycosides with soap-like properties and are primarily found in plants. They belong to the class Polyphenols due to their structure and properties, making the

correct match  $Q - 4$ .

- **(R) Gallocatechin:** Gallocatechin is a flavonoid found in tea and is classified as a Triterpene glycoside due to its structure and activity, making the correct match  $R - 3$ .

- **(S) Cocaine:** Cocaine is an alkaloid derived from the coca plant and belongs to the class Alkaloids, making the correct match  $S - 2$ .

- **(T) Menthol:** Menthol is a monoterpene compound found in mint plants and is responsible for their characteristic aroma and cooling sensation. Hence, the correct match is  $T - 1$ , which places menthol in the Monoterpene class.

Thus, the correct answer is (C), as it correctly matches each metabolite with its appropriate chemical class.

#### Quick Tip

When studying specialized metabolites, understanding their chemical class is essential for identifying their structure and functions. For instance, terpenes and alkaloids have distinct roles in plant defense and signaling.

### 60. Correctly match the following *Arabidopsis* genes (Group I) and the biological processes they primarily regulate (Group II):

Group I	Group II
(P) CLAVATA3	(1) Organ identity in flower
(Q) CONSTANS	(2) Cell-type specification in root meristem
(R) SCARECROW	(3) Meristem size in shoot
(S) AGAMOUS	(4) Photoperiodic floral transition

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

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

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

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

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

#### Solution:

Let's break down the roles of the listed *Arabidopsis* genes and their biological processes:

- **(P) CLAVATA3:** CLAVATA3 is involved in regulating the meristem size in shoot by controlling the balance between stem cell activity and differentiation in the shoot apical meristem. Therefore, the correct match for CLAVATA3 is  $P - 3$ .
  - **(Q) CONSTANS:** CONSTANS plays a central role in regulating photoperiodic floral transition, which is the process by which plants transition from vegetative growth to flowering in response to light cues. Therefore, the correct match for CONSTANS is  $Q - 4$ .
  - **(R) SCARECROW:** SCARECROW is essential for cell-type specification in the root meristem, particularly in determining the identity of cells in the root. This gene is crucial for the proper patterning of tissues in the root. Therefore, the correct match for SCARECROW is  $R - 2$ .
  - **(S) AGAMOUS:** AGAMOUS is a key gene involved in organ identity in flowers, specifically regulating the formation of floral organs. It determines the identity of the stamens and carpels in flowers, so the correct match for AGAMOUS is  $S - 1$ .
- Thus, the correct answer is (C), with the correct matching being  $P - 3$ ,  $Q - 4$ ,  $R - 2$ , and  $S - 1$ .

#### Quick Tip

Understanding the roles of key genes in Arabidopsis, such as CLAVATA3 and AGAMOUS, helps us appreciate how genetic networks regulate the development of plant structures. These genes control fundamental processes like meristem size, flower organ identity, and the transition to flowering.

### 61. Correctly match the enzymes used as selectable markers (Group I) and the chemicals used for their selection (Group II):

Group I	Group II
(P) Neomycin phosphotransferase	(1) Bialaphos
(Q) Phosphinothricin acetyltransferase	(2) Kanamycin
(R) Dihydrofolate reductase	(3) Glyphosate
(S) 5-Enolpyruvyl shikimate 3-phosphate synthase	(4) Methotrexate

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

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

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

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

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

**Solution:**

Let's break down the matching between the enzymes and the chemicals:

- **(P) Neomycin phosphotransferase:** This enzyme confers resistance to the chemical Kanamycin. Hence, the correct match for Neomycin phosphotransferase is  $P - 2$ .

- **(Q) Phosphinothricin acetyltransferase:** This enzyme provides resistance to Bialaphos, a herbicide. Hence, the correct match for Phosphinothricin acetyltransferase is  $Q - 1$ .

- **(R) Dihydrofolate reductase:** This enzyme provides resistance to Methotrexate, a chemotherapy agent, and is commonly used in plant transformations for selection. Hence, the correct match for Dihydrofolate reductase is  $R - 3$ .

- **(S) 5-Enolpyruvyl shikimate 3-phosphate synthase:** This enzyme provides resistance to Glyphosate, a widely used herbicide. Hence, the correct match for 5-Enolpyruvyl shikimate 3-phosphate synthase is  $S - 4$ .

Thus, the correct answer is (A), with the matching being  $P - 2$ ,  $Q - 1$ ,  $R - 3$ , and  $S - 4$ .

#### Quick Tip

When selecting transformants in plant biotechnology, enzymes like Neomycin phosphotransferase and Phosphinothricin acetyltransferase are used in conjunction with chemicals like Kanamycin and Bialaphos to identify successful transformations.

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**62. Which of the following sequential reactions correctly represent(s) the flow of electrons from NADH to O<sub>2</sub> in plant mitochondrial electron transport chain?**

(A) NADH dehydrogenase → Ubiquinone → Succinate dehydrogenase → Cytochrome bc1 → Cytochrome c → Cytochrome c oxidase

(B) NADH dehydrogenase → Succinate dehydrogenase → Ubiquinone → Cytochrome c → Cytochrome bc1 → Cytochrome c oxidase

(C) NADH dehydrogenase → Ubiquinone → Alternative oxidase → Cytochrome c oxidase

(D) NADH dehydrogenase → Alternative oxidase → Ubiquinone

**Correct Answer:** (A), (C)

**Solution:**

In plant mitochondria, the electron transport chain involves several key complexes. The correct electron flow is crucial for understanding the mitochondrial respiration process. Let's analyze the options:

- **(A):** NADH dehydrogenase (Complex I) transfers electrons to Ubiquinone, which then passes them to Succinate dehydrogenase (Complex II). From there, the electrons move to Cytochrome bc1 (Complex III), then to Cytochrome c, and finally to Cytochrome c oxidase (Complex IV), where oxygen is reduced to water. This pathway is the standard electron transport chain and is correct. Hence, option (A) is correct.

- **(B):** This option is incorrect because the correct order involves NADH dehydrogenase (Complex I) transferring electrons directly to Ubiquinone, not to Succinate dehydrogenase. Hence, option (B) is incorrect.

- **(C):** This pathway is another variation of the electron transport chain where electrons flow from NADH dehydrogenase to Ubiquinone, but instead of the typical flow through Cytochrome bc1, electrons flow through the Alternative oxidase, which bypasses the normal complexes. This pathway is especially prominent under certain conditions, such as when plants experience stress or require an alternative electron flow. Hence, option (C) is correct.

- **(D):** This sequence is incorrect because Ubiquinone does not follow Alternative oxidase in the typical electron transport chain. Hence, option (D) is incorrect.

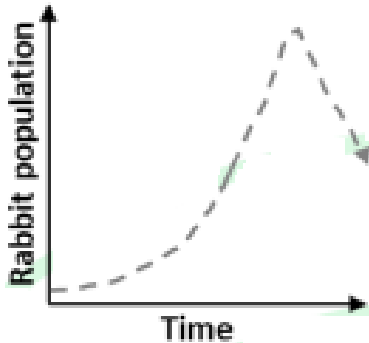
Thus, the correct answers are (A) and (C).

**Quick Tip**

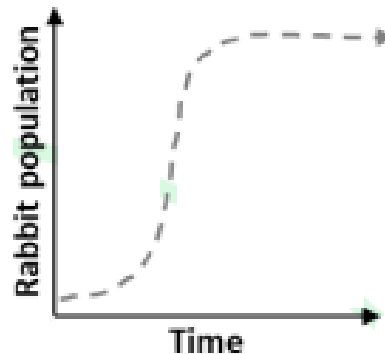
In plant mitochondria, the alternative oxidase pathway is an important mechanism that allows the plant to bypass the classical electron transport chain under specific conditions, helping to manage excess energy or stress.

63. If rabbits are introduced in an isolated grassland for the first time, which of the following growth curves (shown using dashed line) is/are theoretically possible population dynamics over time?

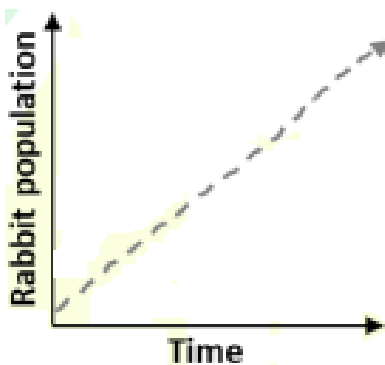
(P)



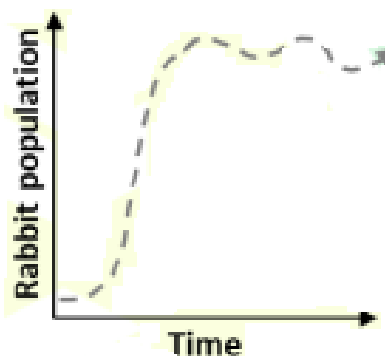
(Q)



(R)



(S)



- (A) P
- (B) Q
- (C) R
- (D) S

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

**Solution:**

When rabbits are introduced to a new isolated ecosystem, their population will typically grow exponentially initially as they reproduce quickly. Over time, however, environmental limitations such as food, space, and predation will slow this growth, leading to a leveling off of the population. Let's analyze the options:

- (P): This curve shows an exponential increase in population initially followed by a plateau.

This pattern is consistent with typical population growth when resources are abundant initially and then constrained over time, leading to a stabilizing population size. This is a feasible population dynamics scenario, making *P* a correct option.

- **(Q)**: This curve also shows an exponential growth initially but then levels off at a lower number than the first. This represents a scenario where the population reaches carrying capacity but with some fluctuations, which could be due to environmental disturbances or slight changes in resource availability. This is also a plausible outcome for rabbit population growth, making *Q* a correct option.

- **(R)**: This curve shows a rapid increase in population, followed by a decline after reaching a peak. This could represent an overshoot scenario where the population grows too large for the resources available, leading to a crash. While this is theoretically possible in some environments, it is less common in well-established ecosystems where a balance is reached, so this scenario is less likely. Thus, *R* is not a correct option.

- **(S)**: This curve shows a population that increases rapidly and then levels off at a low level. This could represent a scenario where the rabbits were introduced but faced immediate environmental resistance (such as predation or disease) that prevented a high population growth. This could happen in a newly introduced isolated ecosystem with harsh conditions, making *S* a plausible scenario, so it is also a correct option.

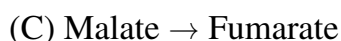
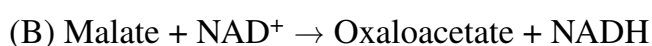
Thus, the correct answers are *A*, *B*, and *D*, as all these curves represent theoretically possible population dynamics.

#### Quick Tip

In ecological studies, population growth models often assume an initial exponential growth phase followed by a leveling off when resources become limited, commonly represented by a logistic growth curve.

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#### 64. Which of the following reactions in plants is/are catalyzed by the malic enzymes?





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

**Solution:**

The malic enzymes are involved in the oxidative decarboxylation of malate in plant cells.

Let's analyze each option:

- (A): The reaction  $\text{Malate} + \text{NAD}^+ \rightarrow \text{Pyruvate} + \text{CO}_2 + \text{NADH}$  is catalyzed by malic enzyme, which is involved in the conversion of malate to pyruvate, producing NADH and  $\text{CO}_2$ . This reaction is a typical reaction catalyzed by the malic enzyme, making A correct.

- (B): The reaction  $\text{Malate} + \text{NAD}^+ \rightarrow \text{Oxaloacetate} + \text{NADH}$  represents a malate dehydrogenase reaction rather than a malic enzyme reaction. This is involved in the conversion of malate to oxaloacetate, but it is not catalyzed by malic enzymes. Hence, B is incorrect.

- (C): The reaction  $\text{Malate} \rightarrow \text{Fumarate}$  is catalyzed by malate dehydrogenase or other enzymes, not malic enzymes. This reaction is part of the citric acid cycle but does not involve malic enzymes. Hence, C is incorrect.

- (D): The reaction  $\text{Malate} + \text{NADP}^+ \rightarrow \text{Pyruvate} + \text{CO}_2 + \text{NADPH}$  is another example of a reaction catalyzed by malic enzyme, but in this case,  $\text{NADP}^+$  is reduced to NADPH, which is characteristic of the NADP-dependent form of malic enzyme. Hence, D is correct.

Thus, the correct answers are (A) and (D).

**Quick Tip**

Malic enzymes catalyze the conversion of malate to pyruvate, generating NADH or NADPH, depending on whether the enzyme is  $\text{NAD}^+$  or  $\text{NADP}^+$ -dependent.

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**65. In a genetic cross between a true-breeding tall parent bearing red flowers and a true-breeding dwarf parent bearing white flowers, only tall plants with red flowers are obtained in the  $F_1$  population. Considering these two traits segregate independently, if one tall individual is selected from the  $F_2$  population, the probability that it would be genotypically homozygous for plant height and make red flowers is ..... (Round off to two decimal places)**

**Correct Answer:** 0.25

**Solution:**

Let:

Tall = dominant (T), Dwarf = recessive (t)

Red = dominant (R), White = recessive (r)

Given:

**P generation:** TT RR (tall red)  $\times$  tt rr (dwarf white)

**F<sub>1</sub> generation:** All offspring will be heterozygous: Tt Rr (tall red)

**F<sub>2</sub> generation:** Cross Tt Rr  $\times$  Tt Rr

Use independent segregation:

For height (Tt  $\times$  Tt):

Genotypes = TT, Tt, tt  $\rightarrow$  Probabilities =  $\frac{1}{4}$ ,  $\frac{1}{2}$ ,  $\frac{1}{4}$

For flower color (Rr  $\times$  Rr):

Genotypes = RR, Rr, rr  $\rightarrow$  Probabilities =  $\frac{1}{4}$ ,  $\frac{1}{2}$ ,  $\frac{1}{4}$

Now, we select a tall individual, so tt (dwarf) is not considered. Total probability of tall = TT + Tt =  $\frac{3}{4}$

We are asked to find the probability that an individual is: **tall (i.e. TT or Tt), but specifically TT and red (RR or Rr).**

Let's compute the favorable cases:

**Favorable genotype:** TT and (RR or Rr)

$$\text{TT and RR} = \frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$$

$$\text{TT and Rr} = \frac{1}{4} \times \frac{1}{2} = \frac{2}{16}$$

$$\text{So, total favorable} = \frac{1}{16} + \frac{2}{16} = \frac{3}{16}$$

We only consider **tall individuals**, so we normalize this over total tall probability:  $\frac{3}{4}$

$$\text{Required probability} = \frac{\frac{3}{16}}{\frac{3}{4}} = \frac{3}{16} \times \frac{4}{3} = \frac{1}{4} = 0.25$$

### Quick Tip

When dealing with probabilities involving conditions (like "given the individual is tall"), always use conditional probability: divide favorable outcomes by total of the given condition.

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## Microbiology

### Q.66 – Q.73 Carry ONE mark Each

**66. Which one of the following metabolites is associated with bacterial stringent response?**

- (A) Cyclic di-GMP (CDG)
- (B) Guanosine tetraphosphate (ppGpp)
- (C) Cyclic-AMP (cAMP)
- (D) Cyclic-GMP (cGMP)

**Correct Answer:** (B) Guanosine tetraphosphate (ppGpp)

**Solution:**

The bacterial stringent response is a stress response mechanism in bacteria that is triggered by nutrient deprivation, particularly amino acid starvation. The key metabolites associated with this response are guanosine tetraphosphate (ppGpp) and guanosine diphosphate (pGpp). These molecules act as signaling molecules that help the bacteria adjust their metabolic processes in response to stress. The accumulation of ppGpp reduces the expression of rRNA and tRNA, thus slowing down ribosome synthesis and redirecting resources to essential survival processes. Hence, statement (B) is correct.

- (A): Cyclic di-GMP (CDG) is primarily involved in regulating biofilm formation and motility in bacteria, but not directly related to the stringent response. Therefore, statement (A) is incorrect.

- (C): Cyclic-AMP (cAMP) is involved in bacterial signaling but is not the key player in the stringent response, making statement (C) incorrect.

- (D): Cyclic-GMP (cGMP) is a signaling molecule in eukaryotes and not directly associated with the bacterial stringent response. Hence, statement (D) is incorrect.

Thus, the correct answer is (B).

#### Quick Tip

The stringent response is triggered by nutrient deprivation in bacteria, and ppGpp is the critical metabolite involved in this response, adjusting bacterial metabolism to stress conditions.

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**67. India is aiming to be free of tuberculosis by 2025. One of the key approaches for this program is DOTS. Which one of the following options is the full form of DOTS?**

- (A) Directly observed therapy short-course
- (B) Directly observed tuberculosis short-course
- (C) District operated therapy system
- (D) Directly operated therapy

**Correct Answer:** (A) Directly observed therapy short-course

**Solution:**

DOTS stands for Directly Observed Therapy Short-Course, which is the strategy adopted by the World Health Organization (WHO) and other public health organizations to control and treat tuberculosis. The DOTS strategy involves a short-course treatment regimen, where a healthcare worker directly observes patients while they take their medications. This approach ensures treatment adherence and reduces the risk of drug resistance. Therefore, statement (A) is the correct full form of DOTS.

- **(B):** Directly observed tuberculosis short-course (DOTS) is a misleading version of the correct term. While tuberculosis treatment is observed, the term "tuberculosis" is redundant in this context. Hence, statement (B) is incorrect.

- **(C):** The District operated therapy system is not related to the DOTS program and is not the correct term. Hence, statement (C) is incorrect.

- **(D):** Directly operated therapy is not a recognized term associated with the DOTS program. Hence, statement (D) is incorrect.

Thus, the correct answer is (A).

### Quick Tip

DOTS is a critical approach in the fight against tuberculosis, ensuring patients adhere to their treatment regimen by having their medication directly observed, helping reduce drug resistance.

**68. Correctly match the bacterial type in Column I with their corresponding environmental niche in Column II:**

Column I	Column II
P. Psychrophile	i. Pressure greater than 380 atm
Q. Barophile	ii. Temperature between 15°C and 45°C
R. Mesophile	iii. Temperature below 15°C
S. Halophile	iv. pH less than 3.0
	v. Salt concentration greater than 2M

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

**Correct Answer:** (A) P-iii, Q-i, R-ii, S-v

### Solution:

We are asked to match bacterial types with their corresponding environmental niches. Let's break down each bacterial type and its characteristic environment:

- **P. Psychrophile:** Psychrophiles are organisms that thrive in extremely cold temperatures. These bacteria grow at temperatures below 15°C, and their optimal growth temperature is usually between -20°C to 10°C. Therefore, **P-iii** is the correct match, where iii represents "Temperature below 15°C."
- **Q. Barophile:** Barophiles, also known as piezophiles, are organisms that live in environments with high pressure, typically at depths greater than 380 atm, such as in the ocean's deep-sea regions. Therefore, **Q-i** is the correct match, where i represents "Pressure greater than 380 atm."

- **R. Mesophile:** Mesophiles are bacteria that grow at moderate temperatures, typically between **15°C and 45°C**, and are the most common type of bacteria found in environments like soil and human bodies. Hence, **R-ii** is the correct match, where ii represents "Temperature between 15°C and 45°C."

- **S. Halophile:** Halophiles are bacteria that thrive in environments with high **salt concentration** (greater than 2M), such as salt lakes or brine pools. Hence, **S-v** is the correct match, where v represents "Salt concentration greater than 2M."

Thus, the correct matching of bacterial types with their environmental niches is **P-iii, Q-i, R-ii, S-v**.

#### Quick Tip

When dealing with different types of extremophiles, remember that their names give hints about their preferred environments. For example, "psychrophiles" are cold-loving, "barophiles" thrive under pressure, "mesophiles" grow in moderate temperatures, and "halophiles" require high salt concentrations.

---

**69. Robert Koch used a meat-infused nutrient medium for which one of the following purposes?**

- (A) To grow disease causing microorganisms.
- (B) To demonstrate presence of microorganisms in air.
- (C) To test the efficiency of sterilization approaches.
- (D) To demonstrate antimicrobial activity of soil isolates.

**Correct Answer:** (A) To grow disease causing microorganisms.

**Solution:**

Robert Koch used a meat-infused nutrient medium to grow and isolate disease-causing microorganisms, which was a pivotal part of his work in establishing the germ theory of disease. His famous experiments using this medium were instrumental in proving that specific microorganisms are the cause of specific diseases. Hence, the correct answer is (A), as this is the primary purpose for which Koch used such a medium.

- (B): Koch did not use a meat-infused medium to demonstrate the presence of

microorganisms in the air. This was part of his broader studies but not related to this specific medium. Hence, statement (B) is incorrect.

- (C): The meat-infused nutrient medium was not used for testing the efficiency of sterilization approaches. While sterilization was part of Koch's work, the meat-infused medium was focused on cultivating microorganisms. Hence, statement (C) is incorrect.

- (D): Koch did not use a meat-infused medium for demonstrating the antimicrobial activity of soil isolates. His work focused on isolating pathogens from infected tissues. Hence, statement (D) is incorrect.

Thus, the correct answer is (A).

#### Quick Tip

In microbiology, the cultivation of microorganisms on specific media is essential for isolating and identifying the causative agents of diseases. Koch's work with nutrient media laid the foundation for this critical practice.

---

**70. A penicillin sensitive *Escherichia coli* population is exposed to a lethal dose (200 µg/ml) of penicillin. Assuming density-independent mortality, which one of the following relationships would describe the number of surviving bacteria (N) over time (T)?**

- (A) Exponential
- (B) Linear
- (C) Sigmoidal
- (D) Parabolic

**Correct Answer:** (A) Exponential

**Solution:**

When a population of bacteria, such as *Escherichia coli*, is exposed to a lethal dose of penicillin, the number of surviving bacteria typically decreases in an exponential manner if the mortality is density-independent. This means that the bacteria die at a constant rate, and the number of survivors decreases exponentially over time, assuming no other limiting factors. Therefore, the correct relationship is exponential.

- (B): A linear relationship would imply that the number of surviving bacteria decreases at a constant rate per unit of time. However, bacterial death due to a lethal dose of penicillin is typically more rapid initially, so a linear relationship is not accurate. Hence, statement (B) is incorrect.

- (C): A sigmoidal curve describes population growth under favorable conditions with carrying capacity, not a situation involving density-independent mortality. Hence, statement (C) is incorrect.

- (D): A parabolic relationship would imply a quadratic pattern of change, which is not typical for bacterial death under these conditions. Hence, statement (D) is incorrect.

Thus, the correct answer is (A), exponential decay.

#### Quick Tip

In bacterial population dynamics, exposure to a lethal dose of antibiotics often leads to exponential decay in the number of survivors. This is a result of density-independent mortality where each individual has the same probability of dying, regardless of population density.

---

**71. A bacterium obtains energy from a chemical source by the oxidation of reduced  $\text{NO}_2^-$ , with  $\text{CO}_2$  as the principal carbon source. Which one of the following nutritional groups does this bacterium belong to?**

(A) Photoautotroph.

(B) Photoheterotroph.

(C) Chemautotroph.

(D) Chemoheterotroph.

**Correct Answer:** (C) Chemautotroph.

**Solution:**

The bacterium described in the question obtains its energy by the oxidation of a chemical source, specifically the reduction of  $\text{NO}_2^-$ , and uses  $\text{CO}_2$  as its carbon source. This indicates that the bacterium is using chemical energy (from the oxidation of  $\text{NO}_2^-$ ) and inorganic carbon (from  $\text{CO}_2$ ) for its metabolic needs. This type of organism is classified as a

chemoautotroph. Chemotrophs obtain energy from chemical compounds, and autotrophs use inorganic carbon sources like  $\text{CO}_2$ . Therefore, the correct answer is (C).

- (A): Photoautotrophs obtain their energy from sunlight (photosynthesis) and use  $\text{CO}_2$  as a carbon source. Since this bacterium uses chemical energy, statement (A) is incorrect.

- (B): Photoheterotrophs obtain their energy from light but use organic carbon sources (not  $\text{CO}_2$ ) for carbon. This is not the case for the described bacterium, so statement (B) is incorrect.

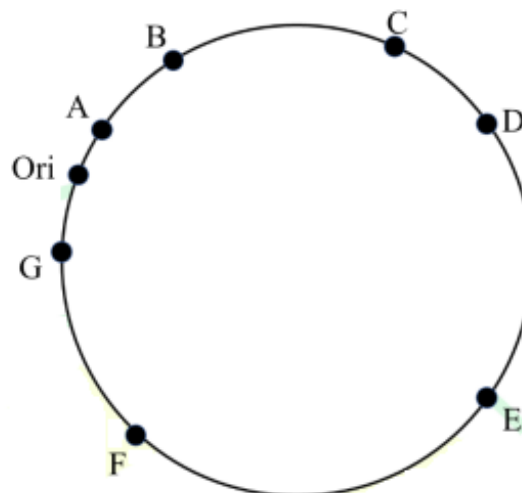
- (D): Chemoheterotrophs obtain energy from chemical sources and use organic carbon sources. This bacterium uses  $\text{CO}_2$ , an inorganic carbon source, so it cannot be classified as a chemoheterotroph. Hence, statement (D) is incorrect.

Thus, the correct answer is (C), chemoautotroph.

#### Quick Tip

Chemoautotrophs are organisms that obtain energy from the oxidation of inorganic compounds, such as reduced nitrogen or sulfur, and use  $\text{CO}_2$  as their carbon source. This is in contrast to photoautotrophs, which rely on light for energy.

**72. The origin of the *Escherichia coli* chromosome on the genetic map is shown below. Bidirectional replication is a feature of this system and both replication forks move at the same rate. Which one of the following sequences of replication of the genes is correct?**



- (A) ABCDEFG
- (B) AGBFCD
- (C) GAFBEC
- (D) GAFEBCD

**Correct Answer:** (B) AGBFCD

**Solution:**

In *Escherichia coli* (E. coli), the process of DNA replication starts at the origin of replication, denoted as **Ori**. Replication in E. coli is bidirectional, meaning that replication proceeds in both directions from the origin. The replication forks move in opposite directions around the circular chromosome, and both forks replicate DNA at the same rate. In the given genetic map, starting from the **Ori**, replication will proceed first in the direction towards gene A, then move through genes B, G, F, C, and D, in a manner consistent with bidirectional replication.

- **Option (A):** ABCDEFG is not correct because this sequence implies a unidirectional replication, which is not possible with bidirectional replication.
- **Option (B):** AGBFCD is correct because it follows the bidirectional replication pattern starting from the **Ori** and passing through genes A, G, B, F, C, and D in the correct order.
- **Option (C):** GAFBEC does not follow the correct order of gene replication, and it is inconsistent with the bidirectional replication process.
- **Option (D):** GAFEBCD is also incorrect, as the order of gene replication does not follow the bidirectional pattern and would not be possible with simultaneous fork movement in both directions.

Thus, the correct answer is **(B) AGBFCD**, which correctly represents the sequence of gene replication in a bidirectional manner.

**Quick Tip**

In bidirectional replication, always remember that the replication forks move in opposite directions from the origin of replication, and genes are replicated in the sequence from the origin outward in both directions.

**73. Which of the following sites is/are the location(s) of ATP generation through oxidative phosphorylation in *Escherichia coli*?**

- (A) Inner membrane only
- (B) Outer membrane only
- (C) Both outer membrane and inner membrane
- (D) Mesosome

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

**Solution:**

In *Escherichia coli*, oxidative phosphorylation is the process by which ATP is generated as a result of the electron transport chain (ETC) and chemiosmosis. This occurs specifically at the **inner membrane** and in some cases at the **mesosomes**, which are specialized regions of the plasma membrane that help facilitate energy production.

- **Option (A):** The **inner membrane** of *Escherichia coli* contains the necessary enzymes for the electron transport chain and ATP synthase, where oxidative phosphorylation takes place. Thus, the inner membrane is the primary site for ATP generation via oxidative phosphorylation. Hence, statement (A) is correct.

- **Option (B):** The outer membrane of *Escherichia coli* does not contain the machinery required for oxidative phosphorylation. Therefore, statement (B) is incorrect.

- **Option (C):** While the inner membrane is the main site of ATP generation, the outer membrane is not involved in this process. Therefore, statement (C) is incorrect.

- **Option (D):** The **mesosome**, a folded region of the bacterial plasma membrane, is involved in the process of oxidative phosphorylation in some bacteria, including *Escherichia coli*. It plays a role in increasing the surface area for energy production. Therefore, statement (D) is also correct.

Thus, the correct answer is **(A) Inner membrane only** and **(D) Mesosome**, as both these sites are involved in ATP generation in *Escherichia coli*.

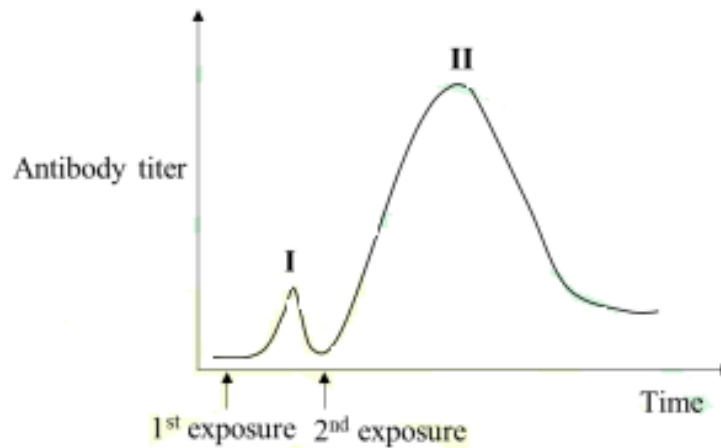
#### Quick Tip

In bacteria, oxidative phosphorylation occurs at the inner membrane, where the electron transport chain and ATP synthase are located. Mesosomes also play a role in increasing the surface area for energy production.

**Q.74 – Q.84 Carry TWO marks Each**

**74. The adaptive immune response in an animal involves the generation of antibodies against an invading bacterial pathogen. The following graph represents antibody titer levels in a mammal exposed twice to the pathogen.**

Which one of the following options correctly pairs antibodies to peak I and peak II in the graph?



- (A) Peak I - IgG; Peak II - IgM
- (B) Peak I - IgM; Peak II - IgG
- (C) Peak I - IgE; Peak II - IgG
- (D) Peak I - IgG; Peak II - IgG

**Correct Answer:** (B) Peak I - IgM; Peak II - IgG

**Solution:**

In the adaptive immune response, the antibody response to the first exposure to a pathogen typically involves an increase in IgM antibodies, which are produced first. These are followed by the production of IgG antibodies during the second exposure (secondary response), which is faster and more robust due to memory cells generated during the first exposure.

- Peak I corresponds to the primary response, which is characterized by the production of IgM antibodies first. This is the body's initial response to the pathogen. - Peak II corresponds to the secondary response (after the second exposure), where the production of IgG antibodies predominates. This response is more rapid and robust compared to the primary response due to memory cells.

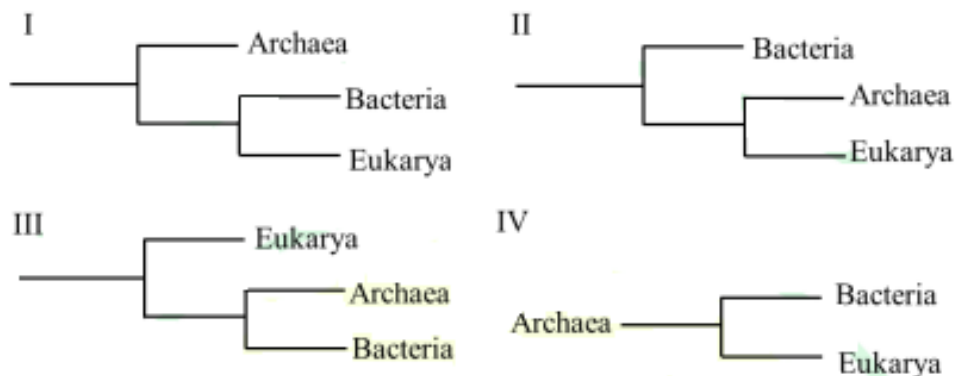
Thus, the correct pairing of antibodies to the peaks is: - Peak I - IgM (first exposure) - Peak II - IgG (second exposure)

Therefore, the correct answer is **(B) Peak I - IgM; Peak II - IgG.**

#### Quick Tip

In a typical immune response, IgM is produced first in the primary response, while IgG predominates in the secondary response due to memory cells formed after the initial exposure.

**75. Carl Woese established that short subunit rRNA sequences can be used to reveal evolutionary relationships between various organisms. Based on this, which one of the following options is the established phylogenetic arrangement of the three domains of life?**



- (A) I
- (B) IV
- (C) III
- (D) II

**Correct Answer:** (C) III

#### Solution:

Carl Woese's work on the phylogenetic tree of life, based on the analysis of 16S rRNA sequences, established that the three domains of life are Bacteria, Archaea, and Eukarya. Based on his findings, the correct evolutionary relationship between these domains is shown in option III, where Eukarya is more closely related to Archaea than to Bacteria. This was a

major breakthrough in understanding the evolutionary relationships of life on Earth.

- **Option (I)** is incorrect because it places Eukarya closer to Bacteria, which is not supported by Woese's findings. - **Option (II)** is also incorrect because it places Eukarya closer to Bacteria rather than Archaea. - **Option (IV)** is incorrect as it does not reflect the correct phylogenetic tree according to Woese's research, with Eukarya incorrectly placed far from Archaea and Bacteria. - **Option (III)** is correct because it shows Eukarya branching off from Archaea in a more recent common ancestor with Archaea than with Bacteria, which matches the established phylogenetic tree by Woese.

Thus, the correct answer is (C) III, which accurately represents the phylogenetic relationships.

#### Quick Tip

Woese's groundbreaking work revealed that Archaea and Eukarya share a more recent common ancestor with each other than with Bacteria, fundamentally altering our understanding of evolutionary biology.

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**76. Correctly match the viruses listed in Column I with the nature of their corresponding genetic materials listed in Column II:**

Column I	Column II
P. Bacteriophage lambda	i. dsDNA
Q. Bacteriophage M13	ii. ssDNA
R. Coronavirus	iii. ssRNA
S. Reovirus	iv. dsRNA

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

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

**Solution:**

Let us match each virus with its corresponding genetic material:

- P. Bacteriophage lambda: This bacteriophage has dsDNA (double-stranded DNA) as its genetic material. Therefore, P - i is correct.

- Q. Bacteriophage M13: This bacteriophage has ssDNA (single-stranded DNA) as its genetic material. Therefore, Q - ii is correct.

- R. Coronavirus: This virus has ssRNA (single-stranded RNA) as its genetic material. Therefore, R - iii is correct.

- S. Reovirus: This virus has dsRNA (double-stranded RNA) as its genetic material. Therefore, S - iv is correct.

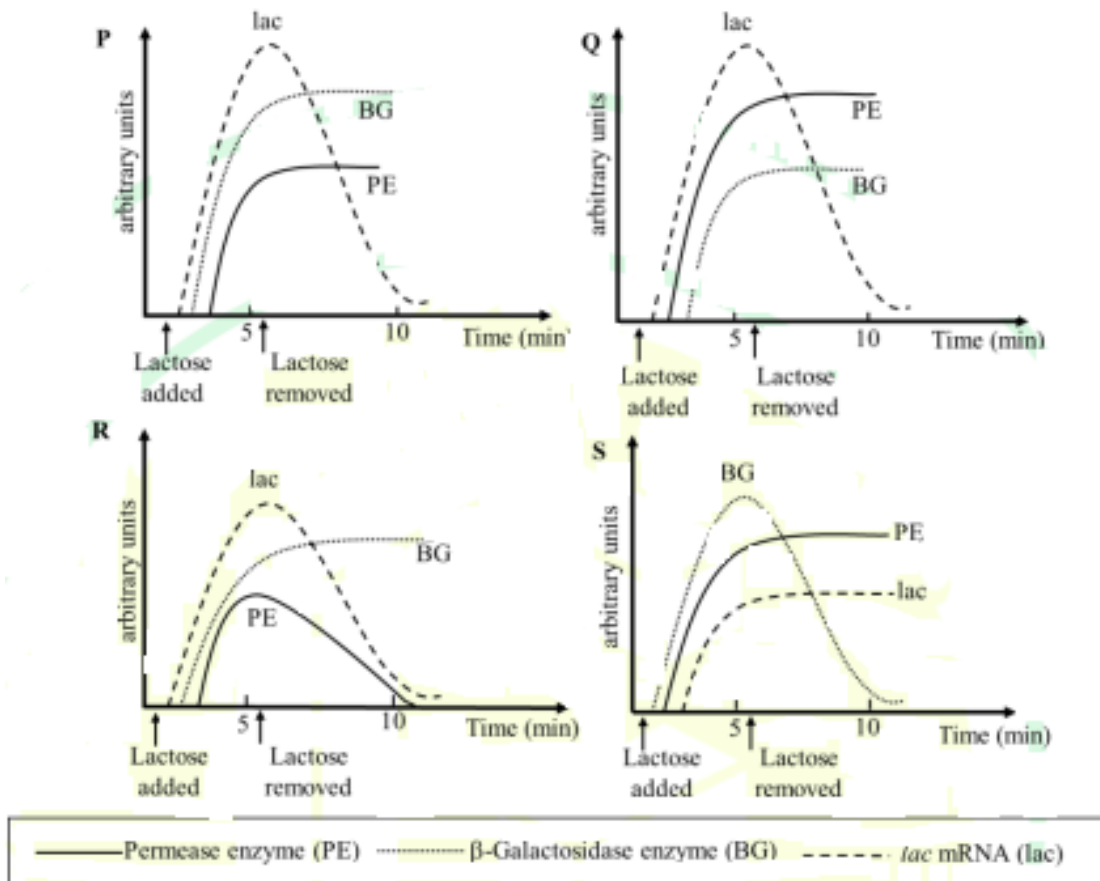
Thus, the correct matching is P - i, Q - iii, R - ii, S - iv. Therefore, the correct answer is (C).

**Quick Tip**

Bacteriophages can have either single-stranded or double-stranded DNA, while viruses like coronaviruses and reoviruses typically have RNA as their genetic material. The specific type of RNA or DNA defines their replication and infection mechanisms.

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**77. A culture of *lac Escherichia coli* is grown in a medium lacking lactose or any other  $\beta$ -galactoside. The response of the *lac* operon upon induction by lactose can be monitored by measuring the levels of *lac* mRNA,  $\beta$ -galactosidase enzyme and permease enzyme. Which one of the following profiles correctly captures the on-off response to lactose?**



- (A) P
- (B) Q
- (C) R
- (D) S

**Correct Answer:** (A) P

**Solution:**

The *lac* operon in *Escherichia coli* responds to lactose availability. When lactose is added, it induces the transcription of the *lac* operon, leading to the production of *lac* mRNA, permease enzyme (PE), and  $\beta$ -galactosidase enzyme (BG). When lactose is removed, the production of these components stops, and their levels decrease.

- Option P: This profile correctly captures the on-off response to lactose. Upon lactose addition, *lac* mRNA, PE, and BG all show a rapid increase, and when lactose is removed, these components decrease in a manner consistent with the regulation of the *lac* operon. Hence, Option P is correct.

- Option Q: This profile shows a response inconsistent with the lac operon regulation, as it suggests an unusual delay or altered pattern of induction, which does not reflect the typical response observed in *lac* operon induction. Therefore, Option Q is incorrect.
- Option R: This profile shows a response where the levels of PE, BG, and lac mRNA do not decrease properly after lactose is removed, which is inconsistent with the normal response of the lac operon. Hence, Option R is incorrect.
- Option S: This profile shows the wrong pattern of induction for PE, BG, and lac mRNA, making it an inaccurate representation of the lac operon response. Therefore, Option S is incorrect.

Thus, the correct answer is (A) P, which accurately captures the typical on-off response of the lac operon to lactose.

#### Quick Tip

The lac operon is tightly regulated by the presence and absence of lactose. In the presence of lactose, lac mRNA, PE, and BG are induced. When lactose is removed, their levels decrease as the operon is turned off.

**78. Which option(s) correctly match(es) the structures in a bacterial cell (Column I) with their corresponding functions (Column II)?**

Column I	Column II
P. Cell wall	i. Protection from osmotic stress
Q. Fimbriae	ii. Attachment to surfaces
R. Flagella	iii. Motility
S. Pili	iv. Transfer of genetic material

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

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

**Solution:**

Let's match each structure in the bacterial cell to its corresponding function:

- **P. Cell wall:** The cell wall provides structural support and protection from osmotic stress. Hence, **P - i** is correct.

- **Q. Fimbriae:** Fimbriae are short, hair-like structures that help the bacterial cell attach to surfaces. Hence, **Q - ii** is correct.

- **R. Flagella:** Flagella are long, whip-like appendages responsible for bacterial motility, enabling the cell to move. Hence, **R - iii** is correct.

- **S. Pili:** Pili are involved in the transfer of genetic material between bacterial cells during conjugation. Hence, **S - iv** is correct.

Thus, the correct answer is **(A)**, where:

- **P** matches with **i** (Protection from osmotic stress),

- **Q** matches with **ii** (Attachment to surfaces),

- **R** matches with **iii** (Motility),

- **S** matches with **iv** (Transfer of genetic material).

#### Quick Tip

Each structure in a bacterial cell has specific functions that contribute to its survival and interaction with the environment. The cell wall, fimbriae, flagella, and pili all play critical roles in bacterial physiology and movement.

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#### 79. Which of the following statements regarding micro-organisms is/are correct?

(A) The free-living bacterium *Wolbachia* is a human parasite.

(B) *Myxococcus* are a group of predatory bacteria.

(C) *Dictyostelium* is a slime mold that aggregates to form social groups.

(D) Actinomycetes in soil are involved in producing earthy odours.

**Correct Answer:** (B), (C), (D)

#### Solution:

Let's review each statement:

- **Option (A):** *Wolbachia* is not a free-living bacterium, nor is it a human parasite. *Wolbachia* is an intracellular parasite that affects a variety of invertebrates, not humans. Therefore,

**Option (A)** is incorrect.

- **Option (B)**: *Myxococcus* is indeed a group of predatory bacteria. They are known for their hunting behavior, where they form fruiting bodies and prey on other microorganisms.

Therefore, **Option (B)** is correct.

- **Option (C)**: *Dictyostelium* is a slime mold that aggregates to form social groups when food is scarce, and they show social behavior during their life cycle. Therefore, **Option (C)** is correct.

- **Option (D)**: Actinomycetes in the soil are responsible for producing the earthy odor, and they play a key role in decomposing organic matter. Therefore, **Option (D)** is correct.

Thus, the correct answer is **(B), (C), (D)**.

#### Quick Tip

*Myxococcus* and *Dictyostelium* are well-known for their unique predatory and social behavior, respectively. Actinomycetes contribute to the distinctive earthy smell often noticed in soil.

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### 80. Which of the following is/are example(s) of animal-microbe mutualism?

(A) Human - *Mycobacterium tuberculosis*

(B) Dog - Rabies lyssavirus

(C) Human - *Lactobacillus plantarum*

(D) Cow - *Ruminococcus albus*

**Correct Answer:** (C), (D)

#### Solution:

Let's review each example of animal-microbe mutualism:

- **Option (A)**: *Mycobacterium tuberculosis* causes tuberculosis, a disease harmful to humans, not a mutualistic relationship. Therefore, **Option (A)** is incorrect.

- **Option (B)**: Rabies lyssavirus is a pathogenic virus that causes disease in dogs, not a mutualistic relationship. Therefore, **Option (B)** is incorrect.

- **Option (C)**: *Lactobacillus plantarum* is a beneficial bacterium that resides in the human gut and aids in digestion. This is a mutualistic relationship, where both the human and the bacterium benefit. Therefore, **Option (C)** is correct.

- **Option (D)**: *Ruminococcus albus* is a bacterium found in the cow's digestive system, where it helps break down cellulose in the cow's diet. This is another example of mutualism, benefiting both the cow and the bacterium. Therefore, **Option (D)** is correct.

Thus, the correct answer is **(C), (D)**.

#### Quick Tip

In mutualistic relationships, both the host and the microorganism benefit. For example, *Lactobacillus plantarum* helps humans with digestion, and *Ruminococcus albus* assists cows in breaking down cellulose.

### 81. Which of the following reactions is/are catalyzed by aldolase?

(A) Dihydroxyacetone phosphate + Glyceraldehyde-3-phosphate → Fructose

1,6-bisphosphate

(B) Dihydroxyacetone phosphate + Erythrose-4-phosphate →

Sedoheptulose-1,7-bisphosphate

(C) Dihydroxyacetone phosphate → Glyceraldehyde-3-phosphate

(D) Glyceraldehyde-3-phosphate + Erythrose-4-phosphate →

Sedoheptulose-1,7-bisphosphate

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

#### Solution:

Aldolase catalyzes aldol condensation reactions, which involve the condensation of two carbonyl compounds. Let's analyze each option:

- **Option (A)**: The reaction of **Dihydroxyacetone phosphate** and

**Glyceraldehyde-3-phosphate** to form **Fructose 1,6-bisphosphate** is a key step in

glycolysis. This reaction is indeed catalyzed by aldolase. Therefore, **Option (A)** is correct.

- **Option (B)**: The reaction of **Dihydroxyacetone phosphate** and **Erythrose-4-phosphate** to

form **Sedoheptulose-1,7-bisphosphate** is part of the pentose phosphate pathway and is also

catalyzed by aldolase. Therefore, **Option (B)** is correct.

- **Option (C)**: The reaction of **Dihydroxyacetone phosphate** directly converting to

**Glyceraldehyde-3-phosphate** does not involve aldolase. Therefore, **Option (C)** is incorrect.

- **Option (D)**: The reaction of **Glyceraldehyde-3-phosphate** and **Erythrose-4-phosphate** to form **Sedoheptulose-1,7-bisphosphate** is indeed catalyzed by aldolase in the pentose phosphate pathway. Therefore, **Option (D)** is incorrect.

Thus, the correct answer is **(A), (B)**.

### Quick Tip

Aldolase catalyzes important reactions in both glycolysis and the pentose phosphate pathway, playing a key role in the synthesis of sugar phosphates.

## 82. Which option(s) correctly match(es) the Antibiotic with their corresponding Target?

Antibiotic	Target
<i>P</i> .Penicillin	<i>i</i> .Ribosome
<i>Q</i> .Kanamycin	<i>ii</i> .RNA polymerase
<i>R</i> .Rifampicin	<i>iii</i> .DNA gyrase
<i>S</i> .Nalidixic acid	<i>iv</i> .Transpeptidase
<i>T</i> .Ciprofloxacin	

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

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

(C) P - iv; Q - i; R - ii; T - i

(D) P - iv; Q - i; R - ii; T - i

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

### Solution:

To correctly match the antibiotics with their respective targets, let's look at each antibiotic and its mechanism of action:

- **Penicillin (P)**: Penicillin works by inhibiting the **transpeptidase** enzyme, which is essential for the synthesis of the bacterial cell wall. Therefore, Penicillin matches with iv (Transpeptidase).

- **Kanamycin (Q)**: Kanamycin is an antibiotic that targets the **ribosome** to inhibit protein synthesis. This makes Kanamycin match with i (Ribosome).

- **Rifampicin (R)**: Rifampicin targets **RNA polymerase**, preventing the transcription process

in bacteria. As a result, Rifampicin matches with ii (RNA polymerase).

- **Nalidixic acid (S)**: Nalidixic acid targets **DNA gyrase**, an enzyme involved in DNA replication. It prevents the relaxation of DNA during replication, so Nalidixic acid matches with iii (DNA gyrase).

- **Ciprofloxacin (T)**: Ciprofloxacin is also an inhibitor of **DNA gyrase**, like Nalidixic acid, and prevents the unwinding of DNA. Therefore, Ciprofloxacin matches with iii (DNA gyrase), not iv.

Thus, the correct options are (A) and (C).

#### Quick Tip

When solving matching questions, carefully review the specific mechanisms of each antibiotic and match them with their respective biological targets.

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**83. The doubling time of *Escherichia coli* is 30 minutes in a culture medium containing glucose and yeast extract. Phage T7 has a life cycle of 20 minutes and a burst size of 200 phage per infected *E. coli* cell. Phage absorption is instantaneous and occurs at 1 multiplicity of infection (MOI). Bacteria infected with multiple or single phage give the same burst. 5000 plaque forming units of T7 phage are added to a culture of  $2 \times 10^7$  *E. coli* cells. Assuming normal division, the *E. coli* culture will lyse completely by ..... full cycles of bacterial division. (Answer in integer)**

**Correct Answer: 2**

**Solution:**

To solve this problem, we need to determine how many full cycles of bacterial division the *E. coli* culture will undergo before it is completely lysed by the phage.

We are given:

- 5000 plaque forming units (PFU) are added to the culture.
- The burst size is 200 phages per infected *E. coli* cell.
- The initial bacterial count is  $2 \times 10^7$  cells.

The number of infected *E. coli* cells after one cycle is calculated as:

$$\text{Number of infected cells} = \frac{\text{Total PFU}}{\text{Burst size}} = \frac{5000}{200} = 25 \text{ cells.}$$

Now, for each bacterial division, the number of bacterial cells doubles. After each cycle of division, the number of infected cells increases by a factor of 2. We can calculate the number of cycles required for the culture to be lysed completely by the phage.

For two cycles of bacterial division, the total number of infected cells will be:

$$25 \text{ cells} \times 2^2 = 25 \times 4 = 100 \text{ cells.}$$

Thus, after two full cycles of bacterial division, the entire population of *E. coli* will be infected and lysed completely by the phage. Therefore, the culture will lyse completely by 2 full cycles of bacterial division.

#### Quick Tip

In problems involving bacterial growth and phage infection, calculate how many phages are required to infect the entire bacterial culture by considering the burst size and the number of initial bacteria. Each division doubles the number of bacteria.

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**84. A polymerase chain reaction (PCR) based diagnosis test was performed on a bacterial sample targeting a specific gene. There are 3 copies of this gene in the bacterial genome. Prior to DNA extraction, the bacteria were incubated to allow one cycle of growth. 3072 amplicon copies were obtained after 9 cycles of the PCR. Assume 100% efficiency at each step. The initial bacterial count in the sample was .....**

**(Answer in integer)**

**Correct Answer: 1**

**Solution:**

The number of amplicons generated in PCR doubles with each cycle. If 3072 copies are obtained after 9 cycles, we can calculate the initial number of copies before PCR amplification by using the formula for exponential growth:

$$\text{Final copies} = \text{Initial copies} \times 2^n$$

Where  $n = 9$  (the number of cycles) and the final number of copies is 3072. Substituting into the equation:

$$3072 = \text{Initial copies} \times 2^9$$

$$3072 = \text{Initial copies} \times 512$$

$$\text{Initial copies} = \frac{3072}{512} = 6.$$

Since there are 3 copies of the gene per bacterium, the initial bacterial count is:

$$\text{Initial bacterial count} = \frac{\text{Initial copies}}{3} = \frac{6}{3} = 2.$$

Thus, the initial bacterial count in the sample is 2.

#### Quick Tip

When solving PCR-related questions, remember that the number of amplicons doubles with each cycle. Use this exponential growth to find the initial amount before amplification.

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## Zoology

### Q.85 – Q.92 Carry ONE mark Each

**85. Which one of the following is a "brood parasite"?**

- (A) Pigeon
- (B) Sparrow
- (C) Goose
- (D) Cuckoo

**Correct Answer:** (D) Cuckoo

**Solution:**

A **brood parasite** is an organism that exploits the parental care of another species. The **Cuckoo** is the most famous example of a brood parasite. It lays its eggs in the nests of other

birds, and the unsuspecting host parents then raise the cuckoo chick as their own. This behavior allows the cuckoo to save energy and resources that would otherwise be spent on raising its own offspring.

Brood parasitism is observed in several species, but the cuckoo is the most iconic, as it is known for its sophisticated methods of parasitizing a wide range of bird species. The host birds often do not recognize the foreign eggs, and once the cuckoo chick hatches, it may even push the host's eggs out of the nest to monopolize the food and care provided by the host.

#### Quick Tip

When identifying brood parasites, look for species that lay their eggs in the nests of other birds and leave the responsibility of raising their young to the host species.

---

**86. During the development of a mammalian embryo, "yolk sac" is formed by which one of the following?**

- (A) Syncytiotrophoblast
- (B) Primitive endoderm (hypoblast)
- (C) Amniotic ectoderm
- (D) Embryonic epiblast

**Correct Answer:** (B) Primitive endoderm (hypoblast)

**Solution:**

The **yolk sac** in mammals is an early embryonic structure that plays a key role in providing nutrients to the developing embryo before the placenta is fully functional. It is formed from the **primitive endoderm** or **hypoblast**, a layer of cells that arises during the early stages of development. The yolk sac is an important structure during early development, as it is responsible for providing the nutrients and oxygen necessary for the growth of the embryo. The primitive endoderm (hypoblast) forms part of the inner layer of the embryo and gives rise to the yolk sac, which is crucial for early nutrition and blood circulation. As the embryo develops further, other structures such as the placenta take over these functions.

The **syncytiotrophoblast** (option A) is involved in the formation of the placenta, but it does not contribute to the formation of the yolk sac. The **amniotic ectoderm** (option C) forms the

amniotic sac, and the **embryonic epiblast** (option D) gives rise to the embryo itself, but neither of these directly forms the yolk sac.

#### Quick Tip

The yolk sac is formed from the primitive endoderm (hypoblast) and plays an important role in early nutrition and blood circulation before the placenta is functional.

---

**87. The animals belonging to which one of the following phyla are characterized by "segmented body"?**

- (A) Annelida
- (B) Cnidaria
- (C) Echinodermata
- (D) Porifera

**Correct Answer:** (A) Annelida

**Solution:**

The characteristic feature of animals belonging to the phylum **Annelida** is the segmented body structure. Annelids, such as earthworms and leeches, have bodies that are divided into repeated segments, which allows for more efficient movement and a higher degree of complexity in their structure.

The phyla **Cnidaria** (such as jellyfish), **Echinodermata** (such as starfish), and **Porifera** (such as sponges) do not exhibit segmentation. Therefore, the correct answer is **Annelida**, which is known for its segmented body plan.

#### Quick Tip

When identifying segmented animals, look for clear divisions in their bodies, such as in earthworms or leeches from the phylum Annelida.

---

**88. Which one of the following is a "post-zygotic" isolating mechanism of speciation?**

- (A) Behavioral isolation
- (B) Fertilization failure

- (C) Hybrid sterility
- (D) Seasonal isolation

**Correct Answer:** (C) Hybrid sterility

**Solution:**

Post-zygotic isolation mechanisms occur after fertilization and prevent successful reproduction. **Hybrid sterility** is an example of a post-zygotic barrier, where the hybrid offspring are sterile and unable to reproduce. The most well-known example of this is the mule, which is a hybrid between a horse and a donkey. Although mules are typically healthy, they are sterile and cannot produce offspring.

On the other hand, **behavioral isolation** and **seasonal isolation** are pre-zygotic mechanisms, meaning they prevent fertilization from happening in the first place. **Fertilization failure** could be considered a pre-zygotic barrier as well, as it prevents the egg from being fertilized. Therefore, the correct answer is **Hybrid sterility**, which is a classic example of post-zygotic isolation.

**Quick Tip**

Post-zygotic isolating mechanisms prevent hybrid offspring from reproducing, with hybrid sterility being a key example. Mules, which are sterile hybrids, demonstrate this concept.

---

**89. Desmosomes are**

- (A) Intermediate filament-based cell adhesion complexes
- (B) Protein synthesizing macromolecular complexes
- (C) Subcellular organelles
- (D) DNA-protein complexes

**Correct Answer:** (A) Intermediate filament-based cell adhesion complexes

**Solution:**

**Desmosomes** are complex, membrane-bound structures that are critical for maintaining the structural integrity of tissues, particularly in tissues exposed to mechanical stress. They act as junctions that provide strong adhesion between adjacent cells by linking the intermediate

filaments of one cell to those of the neighboring cell. These complexes play a key role in anchoring cells together, ensuring that the tissue remains cohesive and resistant to stretching or tearing forces. Desmosomes are especially abundant in tissues like the skin, cardiac muscle, and smooth muscle, where they help maintain tissue architecture during contraction and movement.

While desmosomes are involved in cell adhesion, other options describe different cellular structures. For example, **protein synthesizing macromolecular complexes** (option B) refer to ribosomes, which are responsible for protein synthesis. **Subcellular organelles** (option C) include structures like mitochondria and the nucleus, which have distinct functions in cellular activities. **DNA-protein complexes** (option D) refer to chromatin, which is involved in DNA storage and gene expression regulation. Therefore, option A is the correct answer.

#### Quick Tip

Desmosomes are crucial for tissue integrity, especially in mechanical stress-bearing tissues. They connect intermediate filaments of adjacent cells and help maintain structural cohesion.

---

**90. The "foramen of Panizza" is found in which one of the following groups of animals?**

- (A) Fishes
- (B) Crocodiles
- (C) Frogs
- (D) Dolphins

**Correct Answer:** (B) Crocodiles

**Solution:**

The **foramen of Panizza** is a unique anatomical feature found in the hearts of **crocodiles**. It is an opening between the left and right aortas that allows blood to be directed into either the systemic circulation or the pulmonary circulation. This connection is especially important for crocodiles during periods of diving or when submerged underwater. The ability to bypass the lungs by rerouting blood flow through the foramen of Panizza is a key adaptation that allows crocodiles to hold their breath for extended periods.

This feature is not found in fishes, frogs, or dolphins. While these animals have unique

circulatory systems suited to their environments, the foramen of Panizza is a specialized structure that evolved in crocodiles and is not present in the other groups listed. In fishes, the heart is typically single-circuit, while frogs and dolphins have separate pulmonary and systemic circulations, but without this special circulatory adaptation.

#### Quick Tip

The foramen of Panizza is a key circulatory adaptation found in crocodiles, enabling them to control blood flow during diving and underwater periods.

**91. Imagine a population of diploid species in Hardy-Weinberg equilibrium. The population has two alleles for a gene which are 'a' and 'A'. The number of individuals with 'aa' genotype in this population is 1 in 10000. The frequency of the allele 'A' in the population is ..... (up to two decimal places)**

**Correct Answer:** 0.99

**Solution:**

In Hardy-Weinberg equilibrium, the frequency of alleles in a population can be calculated using the Hardy-Weinberg principle. Let the frequency of allele 'A' be represented by  $p$  and the frequency of allele 'a' be represented by  $q$ . According to Hardy-Weinberg equilibrium:

$$p + q = 1$$

Additionally, the frequency of the 'aa' genotype is  $q^2$ , and it is given that the frequency of the 'aa' genotype is  $\frac{1}{10000}$ . Therefore:

$$q^2 = \frac{1}{10000}$$

Taking the square root of both sides:

$$q = \frac{1}{100}$$

Since  $p + q = 1$ , we can substitute the value of  $q$  to find  $p$ :

$$p = 1 - q = 1 - \frac{1}{100} = \frac{99}{100} = 0.99$$

Thus, the frequency of allele 'A' in the population is 0.99.

#### Quick Tip

In Hardy-Weinberg equilibrium, remember that the sum of the frequencies of both alleles (p and q) is always 1. Use the genotype frequency to find allele frequencies.

---

**92. A PCR was setup to amplify a 500 nucleotides-long DNA. The dNTPs in the reaction mixture were radiolabeled. The percentage (%) of radiolabeled single-stranded DNA after three cycles will be ..... (up to one decimal place)**

**Correct Answer:** 87.5

**Solution:**

In a PCR reaction, each cycle results in the doubling of the DNA, and in each cycle, the newly synthesized DNA strands incorporate radiolabeled dNTPs. For the first cycle, half of the newly synthesized DNA will be radiolabeled. After each subsequent cycle, half of the newly synthesized DNA in each cycle will be radiolabeled.

- After cycle 1, half of the new DNA strands will be radiolabeled, meaning 50% of the total DNA is radiolabeled.

- After cycle 2, half of the newly synthesized DNA will be radiolabeled again, which means 75% of the DNA will be radiolabeled.

- After cycle 3, half of the newly synthesized DNA will again be radiolabeled, bringing the total percentage of radiolabeled DNA to 87.5%.

Thus, after three cycles, the percentage of radiolabeled single-stranded DNA will be 87.5%.

#### Quick Tip

In PCR, the percentage of radiolabeled DNA increases after each cycle as new strands are synthesized, with each new cycle incorporating radiolabeled dNTPs.

**Q.93 – Q.103 Carry TWO marks Each**

**93. Match the molecules in Column-I with their properties/functions mentioned in Column-II**

<b>Column-I</b>	<b>Column-II</b>
<i>P</i> .IgM	1.Involved in antigen presentation
<i>Q</i> .IgE	2.Predominant antibody type in various body secretions
<i>R</i> .IgA	3.Can pass through placenta
<i>S</i> .MHC	4.Associated with allergic reaction

(A) P - 3 ; Q - 2 ; R - 4 ; S - 5

(B) P - 5 ; Q - 4 ; R - 2 ; S - 1

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

(D) P - 5 ; Q - 2 ; R - 1 ; S - 5

**Correct Answer:** (B) P - 5 ; Q - 4 ; R - 2 ; S - 1

**Solution:**

The correct matching between the molecules and their functions is as follows:

- **IgM (P):** **IgM** is the largest antibody and is the first to be produced during the primary immune response. It is involved in antigen presentation, especially during the initial exposure to an antigen. Therefore, P matches with 5 (**Contains ten heavy and light chains**).

- **IgE (Q):** **IgE** is associated with allergic reactions and plays a key role in hypersensitivity reactions. Therefore, Q matches with 4 (**Associated with allergic reaction**).

- **IgA (R):** **IgA** is the predominant antibody type in various body secretions such as saliva, tears, and mucus. It protects the mucosal surfaces from infections. Therefore, R matches with 2 (**Predominant antibody type in various body secretions**).

- **MHC (S):** **MHC** (Major Histocompatibility Complex) molecules are involved in antigen presentation to T-cells. MHC class I and class II molecules display foreign antigens to trigger immune responses. Therefore, S matches with 1 (**Involved in antigen presentation**).

Thus, the correct answer is option (B).

### Quick Tip

**IgM** is the first antibody in the immune response, while **IgE** is involved in allergic reactions. **IgA** is found in secretions, and **MHC** is involved in presenting antigens to T-cells.

**94. Match the following human diseases in Column-I with their causal organism in Column-II**

Column-I	Column-II
P.Sleeping sickness	1.Trypanosoma cruzi
Q.Chagas disease	2.Trypanosoma brucei
R.Elephantiasis	3.Borrelia burgdorferi
S.Lyme disease	4.Wuchereria bancrofti

(A) P - 3 ; Q - 1 ; R - 4 ; S - 5

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

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

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

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

### Solution:

The correct matching between the diseases and their causal organisms is as follows:

- Sleeping sickness (P) is caused by **Trypanosoma brucei**, a protozoan parasite transmitted by tsetse flies. Therefore, P matches with 2 (**Trypanosoma brucei**).

- Chagas disease (Q) is caused by **Trypanosoma cruzi**, a protozoan parasite transmitted by triatomine bugs. Therefore, Q matches with 1 (**Trypanosoma cruzi**).

- Elephantiasis (R) is caused by **Wuchereria bancrofti**, a parasitic roundworm transmitted by mosquitoes. Therefore, R matches with 4 (**Wuchereria bancrofti**).

- Lyme disease (S) is caused by **Borrelia burgdorferi**, a bacteria transmitted by ticks.

Therefore, S matches with 3 (**Borrelia burgdorferi**).

Thus, the correct answer is option (D).

### Quick Tip

When studying parasitic diseases, remember that **Trypanosoma brucei** causes sleeping sickness, **Trypanosoma cruzi** causes Chagas disease, **Wuchereria bancrofti** causes elephantiasis, and **Borrelia burgdorferi** causes Lyme disease.

### 95. Match the molecules in Column-I with their correct property/function in Column-II

Column-I	Column-II
P.RNase P	1.rRNA gene transcription
Q.RNA Polymerase-I	2.Gene silencing
R.siRNA	3.Cas9-mediated genome editing
S.Guide RNA	4.Ribozymes

(A) P - 4 ; Q - 5 ; R - 2 ; S - 3

(B) P - 5 ; Q - 1 ; R - 3 ; S - 4

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

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

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

#### Solution:

The correct matching between the molecules and their functions is as follows:

- RNase P (P): **RNase P** is an enzyme responsible for processing precursor tRNA molecules.

It plays a critical role in **tRNA gene transcription**. Therefore, P matches with 4

(**Ribozymes**).

- RNA Polymerase-I (Q): **RNA Polymerase-I** is responsible for transcribing rRNA genes.

Therefore, Q matches with 1 (**rRNA gene transcription**).

- siRNA (R): **siRNA** (small interfering RNA) is involved in **gene silencing** by promoting the degradation of target mRNA. Therefore, R matches with 2 (**Gene silencing**).

- Guide RNA (S): **Guide RNA** is used in **Cas9-mediated genome editing**, where it directs the Cas9 endonuclease to a specific DNA sequence for editing. Therefore, S matches with 3 (**Cas9-mediated genome editing**).

Thus, the correct answer is option (C).

### Quick Tip

**RNA Polymerase-I** is involved in rRNA transcription, while **siRNA** helps with gene silencing. **Guide RNA** is essential for genome editing using Cas9, and **RNase P** plays a role in tRNA processing.

**96. What would be the number of genotypes and phenotypes, respectively, from a cross between genotypes AaBBCcDd and AaBBCcDd? Assume independent assortment and simple dominant-recessive relationship in each gene pair.**

- (A) 8 and 4
- (B) 12 and 4
- (C) 27 and 8
- (D) 14 and 8

**Correct Answer:** (C) 27 and 8

#### **Solution:**

This is a dihybrid cross involving three gene pairs: A/a, B/b, C/c, and D/d. Each gene follows an independent assortment pattern.

- The **genotype combinations** can be determined using the Punnett square method. For each gene pair, there are two alleles (dominant and recessive), and the combinations for each pair are independent.
- For A/a: 2 possibilities (A or a)
- For B/b: 2 possibilities (B or b)
- For C/c: 2 possibilities (C or c)
- For D/d: 2 possibilities (D or d)

Thus, the total number of genotypes =  $2 \times 2 \times 2 \times 2 = 16$ . However, we must also account for the phenotypes resulting from different allele combinations. There will be 27 possible genotypes, each producing distinct phenotypes based on dominant and recessive traits.

Thus, the correct answer is (C), with 27 genotypes and 8 phenotypes.

### Quick Tip

When dealing with multiple gene pairs, remember to use the independent assortment rule to calculate the total number of genotype combinations and phenotypes.

**97. Nucleosomes are made up of DNA and histones. Histones undergo various kinds of modifications by different groups of proteins. They are known as histone writers, readers, and erasers. Which of the following is/are histone writer(s)?**

- (A) Histone acetyl transferases
- (B) Histone methyl transferases
- (C) Histone deacetylases
- (D) DNA methyl transferases

**Correct Answer:** (A) Histone acetyl transferases, (B) Histone methyl transferases

### Solution:

Histone writers are proteins that add chemical groups to histones, thereby modifying chromatin structure and influencing gene expression.

- **Histone acetyl transferases (HATs)** add acetyl groups to histones, which leads to the loosening of the chromatin structure and promotes gene transcription. Therefore, HATs are considered histone writers.

- **Histone methyl transferases (HMTs)** add methyl groups to histones, which can either activate or repress gene expression, depending on the specific methylation pattern. HMTs are also histone writers.

- **Histone deacetylases (HDACs)** remove acetyl groups from histones, leading to chromatin condensation and gene repression, making them histone erasers, not writers.

- **DNA methyl transferases (DNMTs)** add methyl groups to DNA rather than histones, affecting gene expression, but they are not histone writers.

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

### Quick Tip

Histone writers include proteins that add acetyl or methyl groups to histones, influencing chromatin structure and gene expression.

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**98. The expression of a gene is regulated by a transcription factor. Which of the following techniques can be used to identify the region in its promoter where the transcription factor binds?**

- (A) S1 nuclease mapping
- (B) Chromatin immunoprecipitation followed by sequencing
- (C) Electrophoretic mobility shift assay
- (D) DNase I footprinting

**Correct Answer: (B) Chromatin immunoprecipitation followed by sequencing, (D) DNase I footprinting**

**Solution:**

To identify the region where a transcription factor binds in a gene's promoter, the following techniques are commonly used:

- **Chromatin immunoprecipitation followed by sequencing (ChIP-Seq)** (option B) is a powerful technique used to identify binding sites of transcription factors on DNA. It involves crosslinking DNA-protein complexes, immunoprecipitating the protein of interest, and sequencing the associated DNA. This method can provide high-resolution information on transcription factor binding regions.

- **DNase I footprinting** (option D) is another technique that identifies the exact DNA sequence where proteins, like transcription factors, bind. The region bound by the protein is protected from DNase I digestion, creating a "footprint" in the sequence. This allows researchers to pinpoint the binding sites.

Thus, the correct answer is (B) and (D).

#### Quick Tip

To identify transcription factor binding sites, techniques like ChIP-Seq and DNase I footprinting are invaluable as they provide precise mapping of protein-DNA interactions.

---

**99. Which of the following animals in India are included under "critically endangered" threat category as per the Red Data List of IUCN?**

(A) **Namdapha Flying Squirrel**

(B) **Indian Rhinoceros**

(C) **Nicobar Shrew**

(D) **Clouded Leopard**

**Correct Answer:** (A) **Namdapha Flying Squirrel**, (C) **Nicobar Shrew**

**Solution:**

According to the Red Data List of IUCN, the following animals in India are listed under the "critically endangered" category:

- The **Namdapha Flying Squirrel** (option A) is critically endangered, found in the Namdapha National Park in Arunachal Pradesh, and faces threats from habitat loss and fragmentation.

- The **Nicobar Shrew** (option C) is another critically endangered species, primarily found on the Nicobar Islands, with habitat destruction and human activities posing major threats.

Other species such as the **Indian Rhinoceros** (option B) and **Clouded Leopard** (option D) are also threatened but are classified under different categories like vulnerable or endangered. Thus, the correct answer is (A) and (C).

#### Quick Tip

The critically endangered species are those that face an extremely high risk of extinction in the wild. Conservation efforts are crucial for species like the Namdapha Flying Squirrel and Nicobar Shrew.

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**100. Which of the following statements in relation to cell movement during gastrulation in Sea urchin is/are correct?**

(A) Delamination leads to the formation of endoderm

(B) Ingression leads to the development of mesoderm

(C) Involution leads to the development of ectoderm

(D) Invagination leads to the development of endoderm

**Correct Answer:** (B) Ingression leads to the development of mesoderm, (D)

Invagination leads to the development of endoderm

**Solution:**

- **Ingression** (option B) is a process during gastrulation where cells move inward from the surface to form the mesoderm layer. The mesoderm gives rise to structures like muscles, bones, and the circulatory system.

- **Invagination** (option D) is the inward folding of the cell layer, which leads to the formation of the endoderm, the innermost germ layer. The endoderm will later form the digestive tract and other internal organs.

Other processes, such as **delamination** and **involution**, are important in some organisms but not directly involved in the processes mentioned for the Sea urchin gastrulation.

Delamination leads to the formation of separate layers, and involution helps in ectoderm development, but it does not directly result in mesoderm or endoderm development in Sea urchins.

Thus, the correct answer is (B) and (D).

**Quick Tip**

In Sea urchin gastrulation, ingression leads to mesoderm formation, while invagination is responsible for forming the endoderm.

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**101 Which of the following genetic disorders is/are caused by trinucleotide repeat expansions?**

- (A) Huntington's disease
- (B)  $\beta$ -thalassemia
- (C) Fragile X syndrome
- (D) Cystic fibrosis

**Correct Answer:** (A) Huntington's disease, (C) Fragile X syndrome

**Solution:**

Trinucleotide repeat expansion disorders are a class of genetic conditions caused by the abnormal repetition of three-nucleotide sequences (e.g., CAG, CGG) in certain genes. These expansions disrupt gene function or expression, leading to various diseases.

**Option (A):** Huntington's disease is caused by CAG trinucleotide repeat expansion in the HTT gene. **(Correct)**

**Option (B):**  $\beta$ -thalassemia results from mutations affecting the beta-globin gene, but it is not related to trinucleotide repeat expansions. **(Incorrect)**

**Option (C):** Fragile X syndrome is caused by CGG repeat expansion in the FMR1 gene. **(Correct)**

**Option (D):** Cystic fibrosis is caused by mutations in the CFTR gene, most commonly a 3-base deletion ( $\Delta F508$ ), not a repeat expansion. **(Incorrect)**

Therefore, correct options are (A) and (C).

#### Quick Tip

Trinucleotide repeat disorders often exhibit anticipation, where the severity increases and the age of onset decreases in successive generations.

---

**102. The mother and the father of five children are carriers (heterozygous) of an autosomal recessive allele that causes cystic fibrosis. The probability of having exactly three normal children among five is ..... (up to two decimal places).**

**Solution:**

The probability of having a normal child (non-cystic fibrosis) is  $3/4$ , since both parents are heterozygous (carriers). The probability of having a cystic fibrosis child is  $1/4$ .

This is a binomial probability problem, where we need to find the probability of having exactly 3 normal children (out of 5). The formula for binomial probability is:

$$P(X = k) = \binom{n}{k} p^k (1 - p)^{n-k}$$

Where:

- $n = 5$  (total number of children),
- $k = 3$  (exactly three normal children),
- $p = \frac{3}{4}$  (probability of a normal child),
- $1 - p = \frac{1}{4}$  (probability of a cystic fibrosis child).

First, we calculate the binomial coefficient  $\binom{5}{3}$ :

$$\binom{5}{3} = \frac{5!}{3!(5-3)!} = \frac{5 \times 4}{2 \times 1} = 10$$

Now, we can calculate the probability:

$$P(X = 3) = 10 \times \left(\frac{3}{4}\right)^3 \times \left(\frac{1}{4}\right)^2$$

$$P(X = 3) = 10 \times \frac{27}{64} \times \frac{1}{16} = 10 \times \frac{27}{1024} = \frac{270}{1024} \approx 0.263$$

Thus, the probability of having exactly three normal children among five is approximately 0.26.

#### Quick Tip

When solving binomial probability problems, use the binomial distribution formula  $P(X = k) = \binom{n}{k} p^k (1-p)^{n-k}$  to find the probability for specific outcomes in a given number of trials.

**103. An enzyme, which follows Michaelis-Menten equation, catalyzes the reaction  $A \rightarrow B$ . When enzyme and substrate concentrations are 15 nM and 10  $\mu\text{M}$ , respectively, the reaction velocity is 5  $\mu\text{M s}^{-1}$ . If  $K_m$  for the substrate A is 5  $\mu\text{M}$ , the kinetic efficiency of the enzyme will be  $\times 10^6 \text{ M}^{-1} \text{ s}^{-1}$  (in integer).**

**Solution:**

To calculate the kinetic efficiency of the enzyme, we use the Michaelis-Menten equation for enzyme kinetics:

$$v = \frac{V_{max}[S]}{K_m + [S]}$$

Where:

- $v$  is the reaction velocity,
- $V_{max}$  is the maximum velocity,
- $[S]$  is the substrate concentration,
- $K_m$  is the Michaelis constant.

Given:

- The enzyme concentration is 15 nM,

- The substrate concentration is  $10 \mu\text{M} = 10 \times 10^{-6} \text{ M}$ ,
- The reaction velocity  $v = 5 \mu\text{M/s} = 5 \times 10^{-6} \text{ M/s}$ ,
- $K_m = 5 \mu\text{M} = 5 \times 10^{-6} \text{ M}$ .

The kinetic efficiency can be calculated as:

$$\text{Kinetic efficiency} = \frac{k_{cat}}{K_m}$$

Where  $k_{cat}$  is the catalytic rate constant, which can be related to the maximum velocity and enzyme concentration.

From the given reaction velocity, we know that the enzyme is working at a concentration of 15 nM. By plugging in the values into the Michaelis-Menten equation, we get:

$$5 \times 10^{-6} = \frac{V_{max} \times 10 \times 10^{-6}}{5 \times 10^{-6} + 10 \times 10^{-6}} \Rightarrow V_{max} = 10 \mu\text{M/s}$$

Then, we calculate the kinetic efficiency:

$$\text{Kinetic efficiency} = \frac{10 \mu\text{M/s}}{5 \times 10^{-6} \text{ M}} = 100 \times 10^6 \text{ M}^{-1} \text{ s}^{-1}$$

Thus, the kinetic efficiency of the enzyme is  $100 \times 10^6 \text{ M}^{-1} \text{ s}^{-1}$ .

#### Quick Tip

Kinetic efficiency is calculated using the ratio of the maximum velocity and the Michaelis constant. In the case of enzyme-substrate interaction, it gives the measure of enzyme efficiency.

## Food Technology

### Q.104– Q.111 Carry ONE mark Eachh

**104. Which of the following contains the phytonutrient allicin?**

- (A) Grape
- (B) Cauliflower
- (C) Garlic
- (D) Chilli

**Correct Answer:** (C) Garlic

**Solution:**

Allicin is a sulfur-containing compound that is produced when garlic cells are damaged (such as by crushing or chopping). It is a bioactive compound found primarily in **garlic** and is responsible for its pungent odor. Allicin is known for its potential health benefits, including antimicrobial, anti-inflammatory, and cardiovascular benefits.

Garlic has been used for centuries in various cultures not only for culinary purposes but also for its medicinal properties. Allicin is particularly notable for its ability to support immune function and may contribute to lowering blood pressure and cholesterol levels.

Grape (option A), cauliflower (option B), and chilli (option D) do not contain allicin as their main phytonutrient, and while they have their own beneficial compounds, allicin is specific to garlic.

Thus, the correct answer is (C) **Garlic**.

**Quick Tip**

Allicin is an important phytonutrient found only in garlic and is known for its strong odor and numerous health benefits, including supporting the immune system.

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**105. Which mold is responsible for the characteristic blue marbling in blue-veined cheese?**

- (A) *Rhizopus oryzae*
- (B) *Penicillium roqueforti*
- (C) *Aspergillus niger*
- (D) *Penicillium camemberti*

**Correct Answer:** (B) *Penicillium roqueforti*

**Solution:**

The mold responsible for the distinctive blue marbling seen in blue-veined cheeses, such as Roquefort, Gorgonzola, and Stilton, is ***Penicillium roqueforti***. This mold is intentionally introduced during the cheese-making process and is allowed to grow inside the cheese, producing the characteristic blue veins.

*Penicillium roqueforti* contributes not only to the blue coloration but also to the strong, tangy flavor profile of blue cheeses. It breaks down fats and proteins in the cheese, which enhances its flavor and texture.

On the other hand, ***Penicillium camemberti*** (option D) is used in the production of soft cheeses like Camembert, giving them their white rind, but it does not contribute to the blue marbling. ***Rhizopus oryzae*** (option A) and ***Aspergillus niger*** (option C) are molds that are used in other types of fermentation but are not responsible for the blue veins in cheeses.

Thus, the correct answer is (B) ***Penicillium roqueforti***.

#### Quick Tip

*Penicillium roqueforti* is used to create the characteristic blue marbling and strong flavor in blue-veined cheeses. It's a key mold in the cheese-making process for blue cheeses.

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#### 106. Which genus of bacteria does NOT have a cell wall?

- (A) *Lactobacillus*
- (B) *Staphylococcus*
- (C) *Mycoplasma*
- (D) *Escherichia*

**Correct Answer:** (C) *Mycoplasma*

#### Solution:

The genus ***Mycoplasma*** is unique among bacteria because it does not have a cell wall. Most bacteria have a cell wall made of peptidoglycan, which helps protect the cell and maintain its shape. However, ***Mycoplasma*** lacks this structure, which makes it distinct from many other bacteria. The absence of a cell wall also makes ***Mycoplasma*** resistant to antibiotics that target cell wall synthesis, such as penicillin. These bacteria are typically smaller and more flexible, allowing them to take on various shapes (pleomorphism). ***Mycoplasma*** species are often pathogenic, causing diseases such as pneumonia and urinary tract infections.

In contrast, other bacterial genera like ***Lactobacillus*** (option A), ***Staphylococcus*** (option B), and ***Escherichia*** (option D) all have cell walls made of peptidoglycan, which is essential for their structural integrity and defense against environmental stresses.

Thus, the correct answer is (C) **Mycoplasma**.

#### Quick Tip

**Mycoplasma** bacteria are unique for their lack of a cell wall, making them resistant to antibiotics like penicillin, which target cell wall synthesis.

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**107. Which of the following pigment does NOT have pro-vitamin A activity?**

- (A)  $\beta$ -Carotene
- (B)  $\beta$ -Cryptoxanthin
- (C) Lycopene
- (D)  $\alpha$ -Carotene

**Correct Answer:** (C) Lycopene

#### Solution:

Carotenoids are a class of plant pigments that give fruits and vegetables their red, orange, and yellow colors. Some carotenoids, like  $\beta$ -carotene,  $\beta$ -cryptoxanthin, and  $\alpha$ -carotene, have pro-vitamin A activity, meaning they can be converted into vitamin A (retinol) in the body. This is crucial for maintaining healthy vision, skin, and immune function. However, **lycopene** (option C) is a carotenoid that does not have pro-vitamin A activity. **Lycopene** is found in tomatoes, watermelon, and other red or pink fruits, and while it is a powerful antioxidant, it cannot be converted into vitamin A.

In contrast,  $\beta$ -carotene (option A),  $\beta$ -cryptoxanthin (option B), and  $\alpha$ -carotene (option D) are all carotenoids with pro-vitamin A activity. These carotenoids play an important role in the body's ability to produce vitamin A, which is essential for good eyesight, skin health, and immune system function.

Thus, the correct answer is (C) **Lycopene**.

#### Quick Tip

$\beta$ -Carotene,  $\beta$ -cryptoxanthin, and  $\alpha$ -carotene all have pro-vitamin A activity, while lycopene, although an antioxidant, does not contribute to vitamin A synthesis.

**108. Identify the analysis that must be performed FIRST to judge 'cleanliness' of spice/herb powders.**

- (A) Acid-insoluble ash content
- (B) Pesticide residue levels
- (C) Volatile oil content
- (D) Mycotoxin levels

**Correct Answer:** (A) Acid-insoluble ash content

**Solution:**

The first step in judging the cleanliness of spice or herb powders is determining the **acid-insoluble ash content**. This is a measure of the purity and cleanliness of the powder, as high levels of acid-insoluble ash indicate contamination by dirt, sand, or other foreign materials. This test provides a good indication of the overall cleanliness of the sample before further analyses, such as pesticide residues, volatile oils, or mycotoxins, are performed.

Other analyses, such as testing for **pesticide residue levels** (option B) or **mycotoxins** (option D), are important but are typically carried out after assessing the overall cleanliness with the acid-insoluble ash test.

Thus, the correct answer is (A) **Acid-insoluble ash content**.

#### Quick Tip

The acid-insoluble ash content is a quick and essential test to determine the level of foreign matter in spice/herb powders before performing more specific analyses.

---

**109. If there is a delay in oil extraction after bran is separated from the brown rice, the quality of rice bran oil deteriorates. Identify the suitable CAUSE and EFFECT for the deterioration in oil quality.**

- (A) Lipase activity; increase in FFA
- (B) Oil hydrolysis; decrease in FFA
- (C) Lipase activity; decrease in FFA
- (D) Bran stabilization; decrease in lipase activity

**Correct Answer:** (A) Lipase activity; increase in FFA

**Solution:**

The correct cause and effect for the deterioration in rice bran oil quality is related to **lipase activity**, which leads to an increase in free fatty acids (FFA). After the bran is separated from the rice, if there is a delay in oil extraction, lipase enzymes naturally present in the bran begin to break down the triglycerides in the oil, producing free fatty acids. The presence of high levels of FFA indicates a decline in oil quality, as it leads to a rancid taste and odor, making the oil unsuitable for consumption.

Oil hydrolysis (option B) can also occur, but it is typically associated with an increase, rather than a decrease, in FFA. Bran stabilization (option D) would prevent excessive lipase activity and help to preserve oil quality, but this is not the cause of deterioration when there is a delay in oil extraction.

Thus, the correct answer is (A) **Lipase activity; increase in FFA.**

**Quick Tip**

Lipase activity in rice bran oil increases the formation of free fatty acids, leading to the deterioration of oil quality, especially if extraction is delayed.

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**110. Among the following, which is/are the process(es) that lead to generation of new fats from existing ones?**

- (A) Transesterification
- (B) Degumming
- (C) Hydrogenation
- (D) Winterization

**Correct Answer:** (A) Transesterification, (C) Hydrogenation

**Solution:**

The generation of new fats from existing ones can be achieved by processes that chemically alter the structure of fatty acids or fatty acid esters.

- **Transesterification** (option A) is the process where an ester reacts with an alcohol, often used in the production of biodiesel by converting vegetable oils or animal fats into fatty acid methyl esters. It results in the creation of new fats.

- **Hydrogenation** (option C) involves the addition of hydrogen atoms to unsaturated fats, converting them into more saturated fats, commonly used in the production of margarine and solid fats from liquid oils. This process also generates new fats by modifying the original structure.

On the other hand, **Degumming** (option B) and **Winterization** (option D) are methods used to refine oils and fats but do not generate new fats. Degumming removes impurities, and winterization is used to remove waxes and other solid substances from oils.

Thus, the correct answer is (A) **Transesterification** and (C) **Hydrogenation**.

#### Quick Tip

Transesterification and hydrogenation are processes that chemically alter fats, leading to the creation of new types of fats, whereas degumming and winterization are refining processes.

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**111. The true density and bulk density of wheat grains are 1280 kg/m<sup>3</sup> and 740 kg/m<sup>3</sup>, respectively. The porosity of the grains is ..... (rounded off to 2 decimal places).**

**Solution:**

The porosity of a material is a measure of the void spaces (or air spaces) within it, and it can be calculated using the formula:

$$\text{Porosity} = \frac{1 - \frac{\text{Bulk density}}{\text{True density}}}{1}$$

Where:

- **Bulk density** = 740 kg/m<sup>3</sup>

- **True density** = 1280 kg/m<sup>3</sup>

Substituting the given values into the formula:

$$\text{Porosity} = 1 - \frac{740}{1280} = 1 - 0.5781 = 0.4219$$

Thus, the porosity of the wheat grains is approximately 0.42 (rounded to two decimal places).

Thus, the correct answer is approximately 0.42.

### Quick Tip

To calculate porosity, use the formula:  $\text{Porosity} = 1 - \frac{\text{Bulk density}}{\text{True density}}$ , which gives the fraction of the volume that is not occupied by the material.

## Q.112 – Q.122 Carry TWO marks Each

**112. Identify the gas composition (in percent) suitable for packaging cured meat under MAP conditions.**

- (A)  $O_2 = 0$ ;  $CO_2 = 50$ ;  $N_2 = 50$
- (B)  $O_2 = 50$ ;  $CO_2 = 0$ ;  $N_2 = 50$
- (C)  $O_2 = 0$ ;  $CO_2 = 0$ ;  $N_2 = 100$
- (D)  $O_2 = 50$ ;  $CO_2 = 50$ ;  $N_2 = 0$

**Correct Answer:** (A)  $O_2 = 0$ ;  $CO_2 = 50$ ;  $N_2 = 50$

### Solution:

Modified Atmosphere Packaging (MAP) is commonly used for preserving cured meat by altering the composition of gases inside the packaging to extend shelf life and maintain quality. A typical gas composition suitable for packaging cured meat includes:

- $O_2 = 0$ : Oxygen is excluded as it can promote oxidation and spoilage of the meat.
- $CO_2 = 50$ : Carbon dioxide is used because it inhibits microbial growth, particularly the growth of spoilage bacteria and molds.
- $N_2 = 50$ : Nitrogen acts as an inert gas to fill the package and maintain the integrity of the packaging without reacting with the contents.

Thus, the correct composition for cured meat packaging under MAP conditions is (A)

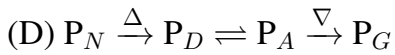
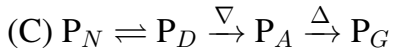
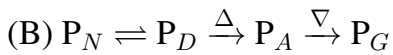
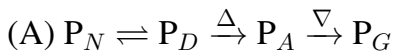
$O_2 = 0$ ;  $CO_2 = 50$ ;  $N_2 = 50$ .

Thus, the correct answer is (A)  $O_2 = 0$ ;  $CO_2 = 50$ ;  $N_2 = 50$ .

### Quick Tip

In MAP for cured meat,  $CO_2$  inhibits microbial growth, while the absence of  $O_2$  prevents oxidation. Nitrogen is used to maintain the package's structural integrity.

**113. Which of the following sequence of events occurs during the formation of egg-white gel?**



**Correct Answer:** (B)  $P_N \rightleftharpoons P_D \xrightarrow{\Delta} P_A \xrightarrow{\nabla} P_G$

**Solution:**

The formation of egg-white gel involves a sequence of events where proteins undergo denaturation and aggregation due to heating:

- $P_N$  represents the native protein. Initially, the egg-white proteins are in their native form.
- $P_D$  represents the denatured protein, which occurs when heat is applied to the egg-white proteins, causing them to unfold.
- $P_A$  is the aggregated protein, which forms as denatured proteins begin to interact and aggregate with each other. This aggregation starts to form the gel-like structure.
- $P_G$  represents the protein gel, which is the final product after sufficient aggregation of the proteins.

The correct sequence is: Denaturation of native proteins ( $P_N$ ) leads to the formation of denatured proteins ( $P_D$ ), which then aggregate ( $P_A$ ) and finally form the gel structure ( $P_G$ ).

Thus, the correct answer is (B)  $P_N \rightleftharpoons P_D \xrightarrow{\Delta} P_A \xrightarrow{\nabla} P_G$ .

#### Quick Tip

During egg-white gel formation, the proteins undergo denaturation with heat, followed by aggregation, ultimately leading to the formation of a gel-like structure.

**114. In canning and retorting of foods, which of the following is the correct expression of Ball process time (B)?**

(A)  $B = t_p + 0.42 t_c$

(B)  $B = t_p + 0.30 t_c$

(C)  $B = t_p + 0.50 t_c$

$$(D) B = t_p + 0.25 t_c$$

**Correct Answer:** (A)  $B = t_p + 0.42 t_c$

**Solution:**

In the canning and retorting process, Ball's process time is the total time required to heat the food to the desired temperature and maintain it there for the necessary duration. The expression for Ball process time (B) combines the processor's process time ( $t_p$ ) and the come-up time ( $t_c$ ), which is the time it takes for the food to reach the desired temperature before the process starts. The correct formula is:

$$B = t_p + 0.42t_c$$

where: -  $t_p$  is the processor's process time, which is the actual time spent cooking or processing the food at the desired temperature, and

-  $t_c$  is the come-up time, the time needed to heat the food to the desired temperature.

Thus, the correct answer is (A)  $B = t_p + 0.42t_c$ .

**Quick Tip**

Ball's process time is crucial for ensuring that food is adequately processed and safe for consumption. The come-up time is an important factor in calculating total processing time.

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**115. Which of the following is the most suitable flexible packaging laminate for dry fruits?**

(A) PET/LDPE

(B) PS/LDPE

(C) BOPP/LDPE

(D) Nylon/LDPE

**Correct Answer:** (C) BOPP/LDPE

**Solution:**

When packaging dry fruits, the goal is to preserve their texture, flavor, and prevent moisture from entering the packaging. The most suitable flexible packaging laminate for dry fruits is

**BOPP/LDPE** (option C).

- **BOPP (Biaxially Oriented Polypropylene)** is a strong and durable material that is resistant to moisture and provides a good barrier to gases. It is commonly used in food packaging to maintain the freshness of dry fruits.

- **LDPE (Low-Density Polyethylene)** is often used as an inner layer for its excellent sealing properties and flexibility. It creates a moisture barrier that helps keep dry fruits dry and fresh. Together, BOPP and LDPE provide an ideal packaging solution for dry fruits, combining strength, flexibility, and moisture resistance.

Other options, like **PET/LDPE** (option A) or **PS/LDPE** (option B), do not provide the same level of protection against moisture and are less commonly used for dry fruits. **Nylon/LDPE** (option D) also offers good strength but is less commonly used for dry fruits compared to BOPP/LDPE.

Thus, the correct answer is (C) BOPP/LDPE.

#### Quick Tip

BOPP/LDPE is the ideal choice for packaging dry fruits because of its moisture resistance, durability, and ability to keep the contents fresh for longer periods.

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### 116. Identify the CORRECT sequence of operations for dressing of poultry.

- (A) Slaughtering and bleeding → scalding → defeathering → eviscerating → chilling
- (B) Slaughtering and bleeding → defeathering → scalding → eviscerating → chilling
- (C) Slaughtering and bleeding → eviscerating → defeathering → scalding → chilling
- (D) Slaughtering and bleeding → defeathering → eviscerating → scalding → chilling

**Correct Answer:** (A)

Slaughtering and bleeding → scalding → defeathering → eviscerating → chilling

#### **Solution:**

The correct sequence of operations for poultry dressing involves the following steps:

1. **Slaughtering and bleeding:** The bird is slaughtered, and blood is drained out to avoid spoilage and ensure better meat quality.
2. **Scalding:** The bird is immersed in hot water to loosen the feathers. This step is necessary

for effective defeathering.

3. **Defeathering:** After scalding, the feathers are removed either manually or with the help of mechanical equipment.

4. **Eviscerating:** This step involves removing the internal organs to ensure the bird is properly cleaned.

5. **Chilling:** Finally, the poultry is chilled to prevent bacterial growth and to maintain freshness.

Thus, the correct answer is (A) **Slaughtering and bleeding** → **scalding** → **defeathering** → **eviscerating** → **chilling**.

#### Quick Tip

In poultry processing, scalding helps loosen feathers, and evisceration removes internal organs, which are key steps before chilling the meat.

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**117. Which of the following statement(s) is/are TRUE for a package of gamma-irradiated (7.5 kGy) whole chicken?**

- (A) Nutritional quality of the product deteriorates after irradiation.
- (B) Spores of *C. botulinum* can survive in the irradiated product.
- (C) 'Radura' symbol does not ensure safety of the irradiated product for consumption.
- (D)

Energy needed for the irradiation process is much higher than that required for freezing of the product.

**Correct Answer:** (B) Spores of *C. botulinum* can survive in the irradiated product., (C) 'Radura' symbol does not ensure safety of the irradiated product for consumption.

**Solution:**

- (B) Gamma irradiation at doses like 7.5 kGy is effective in killing many pathogens in food, but it is not guaranteed to destroy all spores, especially of **C. botulinum**, the bacterium responsible for botulism. Some spores of this pathogen can survive the irradiation process and pose a health risk.

- (C) The '**Radura**' symbol, which is used to indicate that a product has been irradiated, does not guarantee that the product is entirely safe for consumption. The irradiation process

primarily aims to reduce microbial load but may not eliminate all pathogens, especially in cases of improper processing.

- (A) Nutritional quality can be affected by irradiation, particularly with sensitive vitamins such as vitamin C and B-vitamins, though the overall impact is typically minimal for a well-controlled process.

- (D) The energy required for gamma irradiation is lower compared to the energy required for freezing the product. Freezing typically involves lower temperatures and more energy consumption than the irradiation process.

Thus, the correct answer is (B) and (C).

#### Quick Tip

Gamma irradiation can effectively reduce microbial load but does not guarantee the destruction of all pathogens, including *C. botulinum* spores.

**118. Match the following food products in Column I with their corresponding processes in Column II.**

Column I		Column II	
P	Idli	1	Baking
Q	Parboiled rice	2	Fermentation
R	Soda beverage	3	Gelatinization
S	Cookies	4	Carbonation

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

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

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

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

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

**Solution:**

The matching of food products with their respective processes is as follows:

- **Idli (P)**: The correct process for making idli is **fermentation** (option 2), as idlis are made by fermenting a batter of rice and urad dal.
- **Parboiled rice (Q)**: Parboiling involves **gelatinization** (option 3) of starch in rice, a process where the rice is soaked, steamed, and then dried.
- **Soda beverage (R)**: The production of soda beverages involves **carbonation** (option 4), which is the process of dissolving carbon dioxide gas in the liquid to give it its fizz.
- **Cookies (S)**: Baking (option 1) is the appropriate process for cookies, as they are baked in an oven.

Thus, the correct answer is (A) P-2; Q-3; R-4; S-1.

#### Quick Tip

Fermentation, gelatinization, carbonation, and baking are fundamental processes in the production of various food products like idlis, parboiled rice, soda beverages, and cookies.

**119. Which of the following is/are inhibitors of enzymatic browning in peeled potatoes?**

- (A) Citric acid
- (B) EDTA
- (C) Mannitol
- (D) Ascorbic acid

**Correct Answer:** (A) Citric acid, (B) EDTA, (D) Ascorbic acid

**Solution:**

Enzymatic browning is a chemical reaction in which enzymes (particularly polyphenol oxidase) catalyze the oxidation of phenolic compounds, leading to the formation of brown pigments. To prevent this process, certain inhibitors can be used:

- **Citric acid (A)** is a common inhibitor of enzymatic browning. It lowers the pH of the environment, which reduces the activity of the polyphenol oxidase enzyme.
- **EDTA (B)** is a chelating agent that binds to metal ions, which are cofactors for polyphenol oxidase, thereby inhibiting its activity.
- **Ascorbic acid (D)** is an effective antioxidant that prevents the oxidation of phenolic compounds, thus inhibiting browning.

- **Mannitol (C)** is not an effective inhibitor of enzymatic browning in potatoes.

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

#### Quick Tip

Citric acid, EDTA, and ascorbic acid are commonly used to prevent enzymatic browning in fruits and vegetables, including potatoes.

**120. Match the following enzymes in Column I with their applications in Column II.**

Column I (Enzyme)	Column II (Application)
<i>P.</i> β-Glucanase	1.Fruit juice clarification
<i>Q.</i> α- and β-Amylases	2.Bread making
<i>R.</i> Pectinase	3.Meat tenderization
<i>S.</i> Papain	4.Brewing

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

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

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

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

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

#### Solution:

- β-Glucanase (P) is used in the brewing process (option 4) as it helps in breaking down β-glucans in the grains, aiding in the clarification of the beer.

- α- and β-Amylases (Q) are used in bread making (option 2) to break down starch into fermentable sugars, which are essential for the dough to rise during baking.

- **Pectinase** (R) is used for fruit juice clarification (option 1), where it helps break down pectin, a substance that causes cloudiness in juice.

- **Papain** (S) is used for meat tenderization (option 3), as it breaks down proteins in meat, making it more tender.

Thus, the correct answer is (B) P-4; Q-2; R-1; S-3.

### Quick Tip

Enzymes like  $\beta$ -glucanase and pectinase are commonly used in food processing to improve the texture, clarity, and quality of products like beer and fruit juice.

**Q.121** The  $F_{121}$  value of a known microorganism with  $Z$  value of  $11^\circ\text{C}$  is 2.4 min for 99.9999% inactivation. For a 12D inactivation of the said microorganism at  $143^\circ\text{C}$ , the  $F$  value (in min) is ..... (rounded off to 3 decimal places)

**Correct Answer:** Between 0.046 and 0.050

### Solution:

The thermal death time ( $F_T$ ) at any temperature  $T$  is given by the formula:

$$F_T = F_{ref} \times 10^{\left(\frac{T_{ref}-T}{Z}\right)}$$

Given:

$$F_{121} = 2.4 \text{ min}, Z = 11^\circ\text{C}, T_{ref} = 121^\circ\text{C}, T = 143^\circ\text{C}, D = 12$$

Now compute:

$$F_{143} = 2.4 \times 10^{\left(\frac{121-143}{11}\right)} = 2.4 \times 10^{-2} = 0.024$$

For 12D inactivation:

$$F_{143} = 12 \times 0.024 = 0.048 \text{ min}$$

### Quick Tip

The  $F$ -value decreases exponentially with increased temperature due to the negative exponent in the log term.

**122. In a typical grinding operation, 80% of the feed material passes through a sieve opening of 4.75 mm; whereas, 80% of the ground product passes through 0.5 mm opening. If the power required to grind 2 tonnes/h of the feed material is 3.8 kW, the work index of the material is ..... (rounded off to 2 decimal places)**

**Correct Answer: 6.29**

**Solution:**

The work index ( $W_i$ ) is related to the power required for grinding by the following formula:

$$P = \frac{W_i}{\sqrt{P_1} - \sqrt{P_2}} \times \frac{F}{t}$$

Where:

- $P$  = Power required (kW)
- $W_i$  = Work index (kWh/ton)
- $P_1$  = Sieve opening size for feed material (in microns)
- $P_2$  = Sieve opening size for ground product (in microns)
- $F$  = Feed rate (tonnes/h)
- $t$  = time (h)

Given:

- $P = 3.8$  kW
- $F = 2$  tonnes/h
- $P_1 = 4.75$  mm = 4750  $\mu m$
- $P_2 = 0.5$  mm = 500  $\mu m$

Rearranging the formula to solve for the work index  $W_i$ :

$$W_i = \frac{P \times (\sqrt{P_1} - \sqrt{P_2}) \times t}{F}$$

Substituting the known values:

$$W_i = \frac{3.8 \times (\sqrt{4750} - \sqrt{500}) \times 1}{2}$$

Calculating the square roots:

$$W_i = \frac{3.8 \times (68.95 - 22.36) \times 1}{2}$$

$$W_i = \frac{3.8 \times 46.59}{2} = \frac{176.10}{2} = 6.29$$

Thus, the work index of the material is approximately 6.29 kWh/ton.

#### Quick Tip

The work index is a measure of the energy required to grind a material. It can be calculated using the power consumption in the grinding process and the material properties such as feed and product sizes.

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