# GATE-2025

## Life sciences

## Detailed Solution

## Subject wise Question Paper Solution

# GATE

## Life sciences

### GATE 2025
### General Aptitude

## Subject wise Question Paper Analysis

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

**Answer-(d) Explanation**

"Back out" means to withdraw or cancel plans at the last moment, which fits the context of the sentence.

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

**Answer-(b) Explanation**

When the subject is a singular noun ("The President"), the verb should agree in number. "Along with the Council of Ministers" is additional information and doesn't affect the verb choice.

An electricity utility company charges ₹ 7 per kWh (kilo watt-hour). 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%

**Answer-(b) Explanation**

Initial Cost:
Energy consumption: 0.04 "kW"×1800 "hours"=72 "kWh"
Cost: 72×"₹" 7="₹" 504
New Cost (2 more hours each night):
Energy consumption: 0.04×2160=86.4 "kWh"
Cost: 86.4×"₹" 7="₹" 604.8
Percentage Increase:
Increase: 604.8-504="₹" 100.8
Percentage increase: (100.8/504)×100=20%
Correct answer is (b) ₹504; 20%

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?

(a) Q, M, 12, and 8

(b) K, L, 10 and 14

(c) I, J, 10, and 8

(d) L, K, 12 and 8

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

**Answer-(c) Explanation**

- The logic is based on the alphabetical positions and a consistent numerical pattern:
- **First Row**: The numbers decrease by 7:
  - N (14) → 21
  - U (21) → 14
  - F (6) → 9
  - (i) → 6
    Since the numbers decrease by 7, the letter corresponding to (i) should be **I** (9th letter).
- **Second Row**: The letters follow alphabetical order:
  - H → L → (ii) → O
    The letters are in alphabetical sequence. After L comes **J**.
- **Third Row**: The numbers decrease consistently:
  - 12 → (iv) → 15 → (iii)
    The numbers are arranged in a pattern where (iv) is **8** and (iii) is **10**.
- Therefore, the correct answer is:
- **(c) I, J, 10, and 8**

A bag contains Violet (V), Yellow (Y), Red (R), and Green (G) balls. On counting them, the following results are obtained:
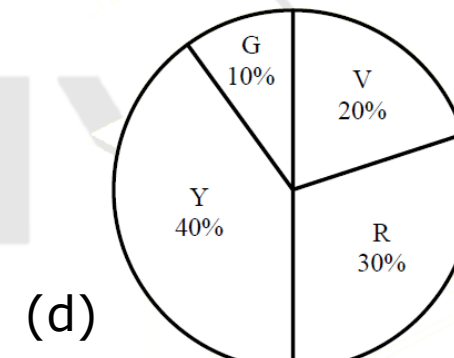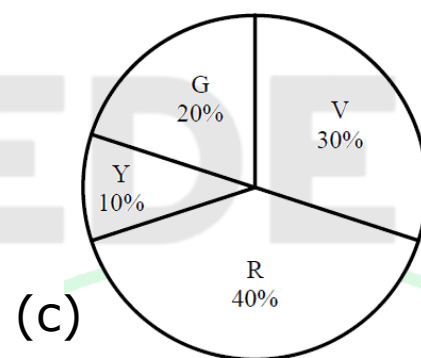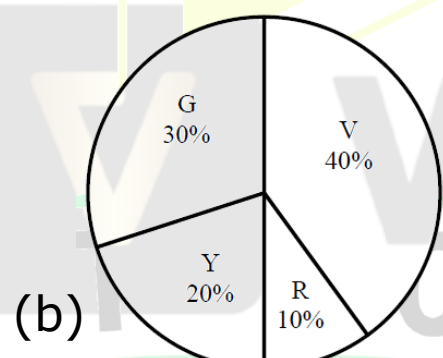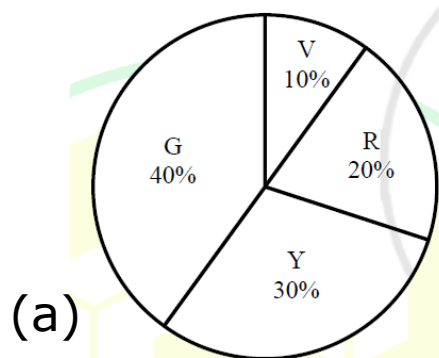(i) The sum of Yellow balls and twice the number of Violet balls is 50.
(ii) The sum of Violet and Green balls is 50.
(iii) The sum of Yellow and Red balls is 50.
(iv) The sum of Violet and twice the number of Red balls is 50.
Which one of the following Pie charts correctly represents the balls in the bag?



(a)

(b)

(c)

(d)

**Answer-(a) Explanation**

Given equations:
$Y+2V=50$, $V+G=50$, $Y+R=50$, $V+2R=50$
From (4): $V=10$
$G=50-10=40$
$R=(50-10)/2=20$
$Y=50-20=30$
$V=10\%$, $Y=30\%$, $R=20\%$, $G=40\%$

"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.

**Answer-(a) Explanation**

The passage describes a solitary man who worked tirelessly, leading to his fatal illness. Though he had little to his own name, he generously helped others, and his knowledge contributed to their reputations. The phrase "courted his fatal illness" implies he passed away, making (a) The solitary man described in the passage is dead the correct answer. The other options misinterpret the passage, as there is no mention of a court, literal fruits, or strangers building his reputation.

For the clock shown in the figure, if
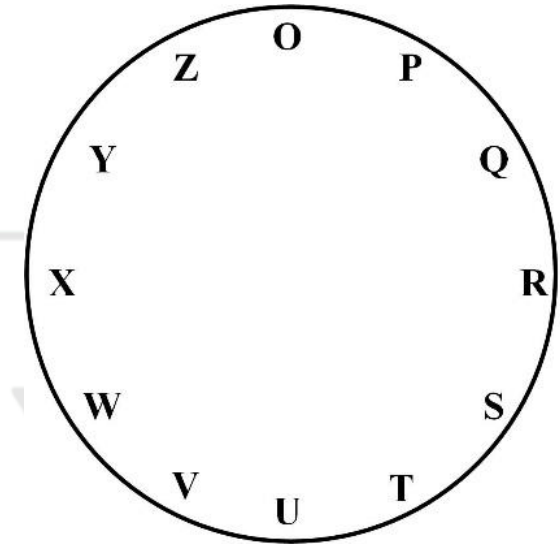
O* = O Q S Z P R T, and

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

**Answer-(b) Explanation**

To determine $P^*$, we analyze the given sequences:

$$O^* = O, Q, S, Z, P, R, T$$
$$X^* = X, Z, P, W, Y, O, Q$$

Observing the pattern, $P^*$ follows a similar structure. The correct sequence is: $P^* = P, R, T, O, Q, S, U$

Matching with the options, the correct answer is (b) P, R, T, O, Q, S, U

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

$$P<Q$$
$$S>P>T$$
$$R<T$$

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

**Answer-(c) Explanation**

To determine the value of $P$ in the five-digit number $PQRST$ using the digits 1 through 5 with the given conditions, let's analyze the constraints step by step.

Given Conditions:
1. $P < Q$
2. $S > P > T$
3. $R < T$
4. All digits $P,Q,R,S,T$ are distinct and from the set $\{1,2,3,4,5\}$.

Step-by-Step Analysis:
1. **Possible Values for** $P$: Since $P$ must be less than $Q$ and greater than $T$, and all digits are from 1 to 5, $P$ cannot be 1 (as there is no digit less than 1 for $T$) or 5 (as there is no digit greater than 5 for $Q$).
   So, $P$ can be 2, 3, or 4.
2. **Testing** $P = 2$:
   ○ $P = 2$
   ○ $T$ must be less than 2, so $T = 1$
   ○ $R$ must be less than $T$, but $T = 1$ and the smallest digit is 1, so no valid $R$. Thus, $P = 2$ is invalid.
3. **Testing** $P = 3$:
   ○ $P = 3$
   ○ $T$ must be less than 3, so $T = 1$ or 2
   ○ $R$ must be less than $T$:
     ▪ If $T = 1$, no valid $R$ (since $R < 1$ is impossible)
     ▪ If $T = 2$, $R = 1$
   ○ $S$ must be greater than $P = 3$, so $S = 4$ or 5
   ○ $Q$ must be greater than $P = 3$, so $Q = 4$ or 5
   Let's assign:
   ○ $T = 2$, $R = 1$
   ○ $S = 4$ or 5
   ○ $Q = 4$ or 5
   This is feasible, so $P = 3$ is a valid option.
4. **Testing** $P = 4$:
   ○ $P = 4$
   ○ $T$ must be less than 4, so $T = 1,2,$ or 3
   ○ $R$ must be less than $T$:
     ▪ If $T = 1$, no valid $R$
     ▪ If $T = 2$, $R = 1$
     ▪ If $T = 3$, $R = 1$ or 2
   ○ $S$ must be greater than $P = 4$, so $S = 5$
   ○ $Q$ must be greater than $P = 4$, so $Q = 5$
   However, $S = 5$ and $Q = 5$ would require $Q$ and $S$ to be the same digit, which violates the distinctness condition. Thus, $P = 4$ is invalid.

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

**Answer-(a) Explanation**

Find cost per kg:

Variety P: ₹ 800 for 5 kg → ₹ 160/kg

Variety Q: ₹ 800 for 4 kg → ₹ 200/kg

Selling price with 8% profit:

Selling price = ₹ 192/kg

Cost price per kg = 192/1.08 = 177.78

Use the alligation method to find the ratio $\frac{200-177.78}{177.78-160} = \frac{22.22}{17.78} \approx 5:4$

Thus, the correct answer is 5:4.

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
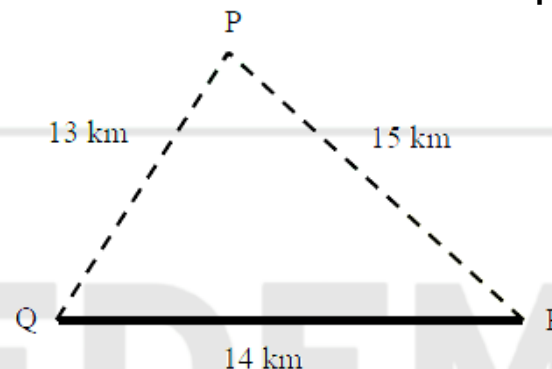
**Answer-(c) Explanation**

To minimize the connecting road from P to QR, we use the perpendicular distance from P to QR as the shortest path.

Using Heron's formula, we first find the area of triangle PQR:

Semi-perimeter, $s = \frac{13+14+15}{2} = 21$

Area, $A = \sqrt{s(s-PQ)(s-QR)(s-RP)}$

$A = \sqrt{21(21-13)(21-14)(21-15)} = \sqrt{21 \times 8 \times 7 \times 6} = \sqrt{7056} = 84$ km$^2$

Now, the altitude (shortest road) from P to QR: $h = \frac{2A}{QR} = \frac{2 \times 84}{14} = \frac{168}{14} = 12$ km

Thus, the minimum possible road length is (c) 12.0 km.

# GATE

## Life sciences

### GATE 2025
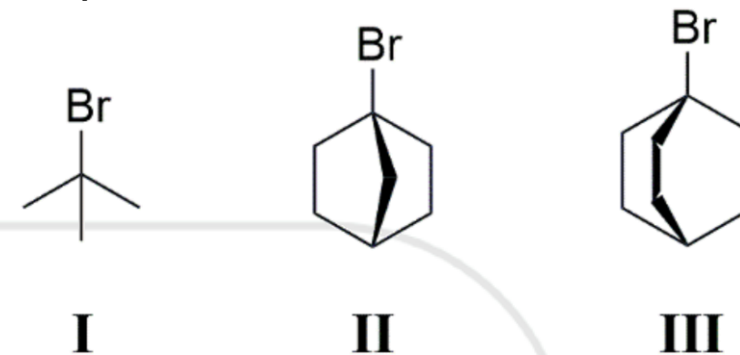### Chemistry

**Subject wise Question Paper Analysis**

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) II < I < III

I     II     III

**Answer-(b) Explanation**

- Solvolysis of tertiary halides occurs via the SN1 mechanism, which depends on the carbocation stability formed after the departure of Br⁻.
- Compound I (Tert-butyl bromide): Forms a highly stable tertiary carbocation due to +I and hyperconjugation effects.
- Compound II (Endo-bromonorbornane): Forms a bridgehead carbocation, which is highly unstable due to Bredt's rule.
- Compound III (Exo-bromonorbornane): Forms a more stable carbocation than II due to better orbital overlap but is still less stable than I.
- Thus, the order of solvolysis rate is II < III < I.

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

**Answer-(a) Explanation**

- The correct order of boiling points for hydrogen halides is (a) HF > HI > HBr > HCl. This is because:

- HF has strong hydrogen bonding.

- HI has stronger van der Waals forces than HBr and HCl due to its larger size.

- HBr and HCl follow with weaker van der Waals forces.

The bond order in $N_2{}^{2-}$ species is

(a) 2

(b) 2.5

(c) 3

(d) 3.5

**Answer-(a) Explanation**

Using Molecular Orbital Theory (MOT):

Total electrons in $N_2^{2-}$ = 16

Bond order = $\frac{(8-4)}{2} = 2$

Thus, the answer is 2.

The standard enthalpy of the reaction,
C (graphite) + $H_2O$ (g) → CO (g) + $H_2$ (g) is found to be +131.3 kJ mol$^{-1}$
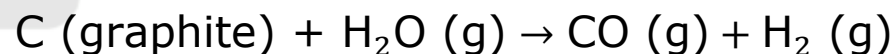and the $\Delta_f H^0$ value for CO (g) is −110.5 kJ mol$^{-1}$.
The value of $\Delta_f H^0$ (in kJ mol$^{-1}$) for $H_2O$ (g) is
(The standard enthalpies of formation of elements in their reference states are zero at all temperatures)
(a) +241.8
(b) 0.0
(c) -241.8
(d) +20.8

**Answer-(c) Explanation**

Given:

$$C \text{ (graphite)} + H_2O \text{ (g)} \to CO \text{ (g)} + H_2 \text{ (g)}$$

$$\Delta H = +131.3 \text{ kJ/mol}, \quad \Delta_f H°(\text{CO}) = -110.5 \text{ kJ/mol}$$

$$\Delta H = [\Delta_f H°(\text{CO}) + \Delta_f H°(\text{H}_2)] - [\Delta_f H°(\text{C}) + \Delta_f H°(\text{H}_2 O)]$$

Since C (graphite) and $H_2$ have zero enthalpy:

$$131.3 = (-110.5 + 0) - [x]$$

$$x = -241.8 \text{ kJ/mol}$$

Thus, the answer is (c) -241.8.

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: $\ln A$

**Answer-(a) Explanation**

The correct option regarding the plot of $\ln kr$ against $1/T$ is (a) Slope: $-EaR/$; Intercept on the y-axis: $\ln A$.

This is derived from the Arrhenius equation: $lnk_r = lnA - \dfrac{E_a}{R} \times \dfrac{1}{T}$

Slope is the coefficient of $\dfrac{1}{T}$, which is $-\dfrac{E_a}{R}$.

Intercept on the y-axis is $lnA$.

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

**Answer-(a) Explanation**

For an ideal gas undergoing isothermal expansion, the internal energy ΔU = 0 (since $U$ depends only on temperature, which remains constant).

Heat $q > 0$ (heat is absorbed to do work).

Work $w < 0$ (gas does work on the surroundings).

$\Delta U = 0$, $q > 0$, $w < 0$.
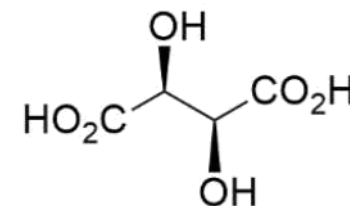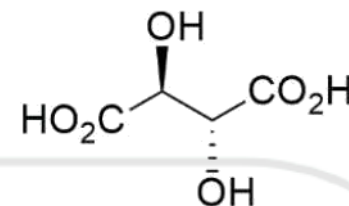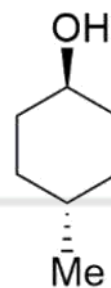
No heat exchange $q = 0$ (adiabatic expansion).

No work done $w = 0$ (expansion against zero external pressure).

$\Delta U = 0$, $q = 0$, $w = 0$.

Therefore, (a) Path I: $\Delta U = 0$, $q > 0$, $w < 0$; Path II: $\Delta U = 0$, $q = 0$, $w = 0$.

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.



I   II   III   IV

**Answer-(a, c) Explanation**

- I: The molecule is achiral because it has a plane of symmetry due to the presence of two identical groups (OH) on adjacent carbons in a cyclohexane ring.

- II: This molecule is also achiral because it has a plane of symmetry passing through the cyclohexane ring and the -OH and -Me groups are symmetrically arranged.

- III: It is chiral because it has two chiral centers without a plane of symmetry or any internal mirror image.

- IV: It is chiral because it contains two chiral centers and no plane of symmetry, resulting in a non-superimposable mirror image.

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.

**Answer-(b, d) Explanation**

$[Ni(CN)_4]^{2-}$: Strong field, square planar, diamagnetic.

$[Ni(CO)_4]$: Strong field, tetrahedral, diamagnetic.

$[Ni(Cl_4)]^{2-}$: Weak field, tetrahedral, paramagnetic.

Therefore, the correct statements are (b) and (d).

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)

**Answer-(5.96 to 5.98) Explanation**

To find the isoelectric point (pI) of valine, simply average its two pKa values:

pI = (pKa1 + pKa2) / 2 = (2.32 + 9.62) / 2 = 5.97

Hence the answer is 5.97.

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)

(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−a

| Column I | | Column II | |
|---|---|---|---|
| Species | | 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. | $sp^3d$ |

**Answer-(a) Explanation**

I3-: Linear, so central I has 2 bond pairs + 3 lone pairs = 5 regions of electron density → sp3d

PCl3: 3 bond pairs + 1 lone pair = 4 regions of electron density → sp3

BF3: 3 bond pairs + 0 lone pairs = 3 regions of electron density → sp2

CO2: Linear, so central C has 2 double bonds = 2 regions of electron density → sp

Therefore, the correct matching is: i-d, ii-c, iii-b, iv-a, which corresponds to option (a).

For product formation from only one type of reactant (e.g. $A \to$ 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 $kr$ is the rate constant)

(a) i−R, ii−P, iii−S
(b) i−Q, ii−P, iii−R
(c) i−S, ii−R, iii−Q
(d) i−Q, ii−P, iii−S

| Column I Order | Column II Half-life Expression |
|---|---|
| i. Zero | P. ln $2/k_r$ |
| ii. First | Q. $[A]_0/2k_r$ |
| iii. Second | P. $1/k_{r[A]0}$ |
| | S. $2k_{r/[A]_0}$ |

**Answer-(b) Explanation**

For a single-reactant reaction (A → product):

Zero order: $t_{1/2} = \dfrac{[A]_0}{2k_r} \to$ Match: Q

First order: $t_{1/2} = \dfrac{\ln 2}{k_r} \to$ Match: P

Second order: $t_{1/2} = \dfrac{1}{k_r[A]_0} \to$ Match: R

Correct Matching is i – Q, ii – P, iii – R

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

Reactions:

I) Me—CH(Me)—CHO    i) MeMgBr / ii) H₃O⁺  →  II) MeCHO   i) ⁱPrMgBr / ii) H₃O⁺ →

III) Me—CH(Me)—C(=O)—OMe (with Me)   i) MeMgBr (excess) / ii) H₃O⁺ → IV) Me—C(=O)—Me   i) ⁱPrMgBr / ii) H₃O⁺ →

**Possible products:**

P: Me—CH(Me)—CH(OH)—Me

Q: Me—CH(Me)—C(OH)(Me)—Me

R: Me—CH(Me)—C(=O)—Me
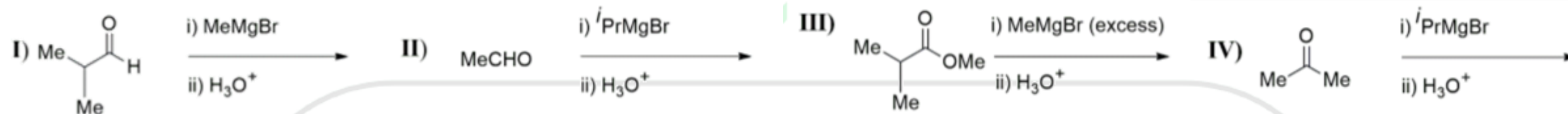
(a) P is formed as the major product in reaction I.
(b) P is formed as the major product in reaction II.
(c) Q is formed as the major product in reaction IV.
(d) R is formed as the major product in reaction III.
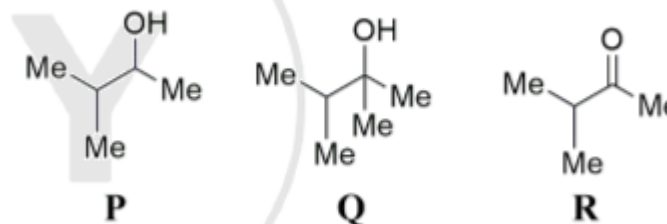
**Answer-(a, b, c) Explanation**

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**Answer-(a, b, c) Explanation**

- **Reaction I:**
  - **Reagent**: MeMgBr (Grignard reagent) with an aldehyde.
  - **Product**: Tertiary alcohol with two methyl groups and an -OH group.
  - This matches the structure of **P**.
  - **P is the major product.**
- **Reaction II:**
  - **Reagent**: i-PrMgBr with MeCHO.
  - **Product**: A secondary alcohol with isopropyl and methyl groups.
  - This also matches **P**.
  - **P is the major product.**
- **Reaction III:**
  - **Reagent**: MeMgBr (excess) with an ester.
  - **Product**: Tertiary alcohol with three methyl groups.
  - This matches **Q**.
  - **Q is the major product.**
- **Reaction IV:**
  - **Reagent**: i-PrMgBr with a ketone.
  - **Product**: Tertiary alcohol with isopropyl and two methyl groups.
  - This also matches **Q**.
  - **Q is the major product.**

Addition of a few drops of concentrated HCl to an aqueous solution of $CoCl_2$ forms a dark blue complex X.
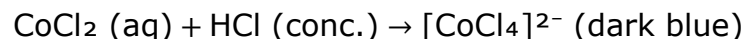
The CORRECT statement(s) for this reaction is(are)

(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 CoCl2 (aqueous solution) are the same.

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

**Answer-(b, c, d) Explanation**

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The reaction involves the formation of a complex when concentrated HCl is added to an aqueous solution of $CoCl_2$:

$$CoCl_2 \text{ (aq)} + HCl \text{ (conc.)} \rightarrow [CoCl_4]^{2-} \text{ (dark blue)}$$

## Analysis of Statements:

- **(a) X is a centrosymmetric complex.**

  - The complex formed is **$[CoCl_4]^{2-}$**, which has a tetrahedral geometry.
  - Tetrahedral complexes are not centrosymmetric.
  - **Incorrect**

- **(b) The oxidation state of cobalt does not change in this reaction.**

  - In both $CoCl_2$ (aq) and $[CoCl_4]^{2-}$, the oxidation state of Co is **+2**.
  - **Correct**

- **(c) The number of unpaired electrons on cobalt in X and in $CoCl_2$ (aqueous solution) are the same.**

  - $Co^{2+}$ has an electronic configuration of $[Ar]\,3d^7$.
  - In both octahedral ($Co(H_2O)_6^{2+}$) and tetrahedral ($[CoCl_4]^{2-}$) fields, $Co^{2+}$ has **3 unpaired electrons**.
  - **Correct**

- **(d) The spin-only magnetic moment value for X is 3.87 BM.**

...

  - Magnetic moment ($\mu$) is calculated using:
  $$\mu = \sqrt{n(n+2)} \text{ BM}$$
  Where **n = 3** (number of unpaired electrons).
  $$\mu = \sqrt{3(3+2)} = \sqrt{15} = 3.87 \text{ BM}$$
  - **Correct**

## Final Answer:

**(b), (c), and (d)**

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.

**Answer-(a, c, d) Explanation**

(a) The N-terminal amino acid of a polypeptide can be identified by Edman's reagent (phenyl isothiocyanate). TRUE. Edman degradation cleaves the N-terminal amino acid.

(b) L-Threonine has only one chiral center. FALSE. L-Threonine has two chiral centers.

(c) Cytosine is present both in RNA and DNA. TRUE. Cytosine is a common base in both.

(d) A mixture of different amino acids can be separated by ion-exchange chromatography. TRUE. Separates based on charge.

Therefore, the correct statements are (a), (c), and (d).

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

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

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

**Answer-(20.55 to 20.59) Explanation**

The energy of the transition from $n_h = 4$ to $n_l = 2$ for the hydrogen atom can be calculated using the Rydberg formula:

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

Where:
- $R_H = 1.097 \times 10^7$ m$^{-1}$ (Rydberg constant)
- $n_h = 4$ (higher energy level)
- $n_l = 2$ (lower energy level)

Substituting the values:

$\Delta E = 1.097 \times 10^7 \left( \frac{1}{2^2} - \frac{1}{4^2} \right)$ $\Delta E = 1.097 \times 10^7 \left( \frac{1}{4} - \frac{1}{16} \right)$ $\Delta E = 1.097 \times 10^7 \left( \frac{4}{16} - \frac{1}{16} \right)$ $\Delta E = 1.097 \times 10^7 \times \frac{3}{16}$ $\Delta E = 2.057 \times 10^6$ m$^{-1}$

To convert it to cm$^{-1}$, multiply by $10^{-2}$:

$$\Delta E = 2.057 \times 10^4\ \text{cm}^{-1}$$

Since $E$ is given in units of $10^3$ cm$^{-1}$, we get:

$$E = \frac{2.057 \times 10^4}{10^3} = 20.57$$

Final Answer:
**20.57**

A non-volatile solute has a molecular weight of 180 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 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)

We can calculate the amount of solute using the boiling point elevation formula:

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

Where:

- $\Delta T_b = 0.153\,K$ (boiling point elevation)
- $K_b = 0.51\,K\,kg\,mol^{-1}$ (ebullioscopic constant of water)
- $m = $ molality $= \dfrac{\text{moles of solute}}{\text{kg of solvent}}$

**1. Calculate Molality (m):**

$$m = \frac{\Delta T_b}{K_b} = \frac{0.153}{0.51} = 0.3\,mol\,kg^{-1}$$

**1. Calculate Moles of Solute:**

Since molality is moles of solute per kilogram of solvent, and the mass of water is 500 g = 0.5 kg:

Moles of solute $= m \times$ mass of solvent (kg)

**Answer-(27) Explanation**

The standard potentials ($E^0$) for the $Fe^{3+}/Fe$ and $Fe^{3+}/Fe^{2+}$ couples are $-0.04$ V and $+0.76$ V, respectively.

Given: Faraday constant = 96500 C mol$^{-1}$.

The value for $E^0(Fe^{2+}/Fe)$, in V, is _____. (rounded off to two decimal places)

**Answer-(-0.46 to -0.42) Explanation**

To determine the standard potential $E^0$ for the $Fe^{2+}/Fe$ couple, we can use the given standard potentials for the $Fe^{3+}/Fe$ and $Fe^{3+}/Fe^{2+}$ couples and apply the principles of thermodynamics.

Given:
- $E^0(Fe^{3+}/Fe) = -0.04\,V$
- $E^0(Fe^{3+}/Fe^{2+}) = +0.76\,V$
- Faraday constant $F = 96500\,C\,mol^{-1}$

Step-by-Step Calculation:
1. **Write the half-reactions and their corresponding Gibbs free energy changes**:
   - For $Fe^{3+} + 3e^- \rightarrow Fe$:
   $$\Delta G_1^0 = -n_1 F E^0(Fe^{3+}/Fe) = -3 \times 96500 \times (-0.04) = 11580\,J\,mol^{-1}$$
   - For $Fe^{3+} + e^- \rightarrow Fe^{2+}$:
   $$\Delta G_2^0 = -n_2 F E^0(Fe^{3+}/Fe^{2+}) = -1 \times 96500 \times 0.76 = -73340\,J\,mol^{-1}$$
2. **Determine the Gibbs free energy change for the $Fe^{2+} + 2e^- \rightarrow Fe$ reaction**:
   - The overall reaction can be considered as the sum of the two given half-reactions:
   $$Fe^{3+} + 3e^- \rightarrow Fe \quad (\Delta G_1^0)$$
   $$Fe^{2+} \rightarrow Fe^{3+} + e^- \quad (-\Delta G_2^0)$$
   $$Fe^{2+} + 2e^- \rightarrow Fe \quad (\Delta G_3^0)$$
   - Therefore:
   $$\Delta G_3^0 = \Delta G_1^0 - \Delta G_2^0 = 11580 - (-73340) = 84920\,J\,mol^{-1}$$
3. **Calculate the standard potential for the $Fe^{2+}/Fe$ couple**:
   - The relationship between Gibbs free energy change and standard potential is:
   $$\Delta G_3^0 = -n_3 F E^0(Fe^{2+}/Fe)$$
   $$84920 = -2 \times 96500 \times E^0(Fe^{2+}/Fe)$$
   $$E^0(Fe^{2+}/Fe) = -\frac{84920}{2 \times 96500} = -0.44\,V$$
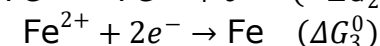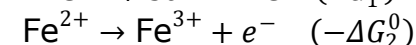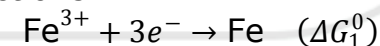
Zinc is essential for the function of

(a) carboxypeptidase A.

(b) chlorophyll a.

(c) myoglobin.

(d) vitamin B12.

**Answer-(a) Explanation**

Zinc is an essential trace element that plays a crucial role in various biological processes, including the function of certain enzymes. Let's analyze the options:

(a) **Carboxypeptidase A**: This is a digestive enzyme that requires zinc as a cofactor for its activity. Zinc is essential for the proper functioning of carboxypeptidase A, which is involved in the digestion of proteins.

(b) **Chlorophyll a**: Chlorophyll a is a pigment involved in photosynthesis in plants. It contains magnesium, not zinc, as a central atom in its structure.

(c) **Myoglobin**: Myoglobin is a protein found in muscle tissues that binds oxygen. It contains iron, not zinc, as a central atom in its heme group.

(d) **Vitamin B12**: Vitamin B12, also known as cobalamin, contains cobalt as a central atom in its structure. It does not require zinc for its function.

Which one of the following molecules captures $CO_2$ in the $C_4$ cycle?

(a) 1,3-Bisphosphoglycerate

(b) Oxaloacetate

(c) Phosphoenolpyruvate

(d) Ribulose-1,5-bisphosphate

**Answer-(c) Explanation**

In the C4 cycle, phosphoenolpyruvate (PEP) captures $CO_2$ to form oxaloacetate through the action of the enzyme PEP carboxylase. This adaptation minimizes photorespiration by concentrating $CO_2$ in the bundle sheath cells for the Calvin cycle.
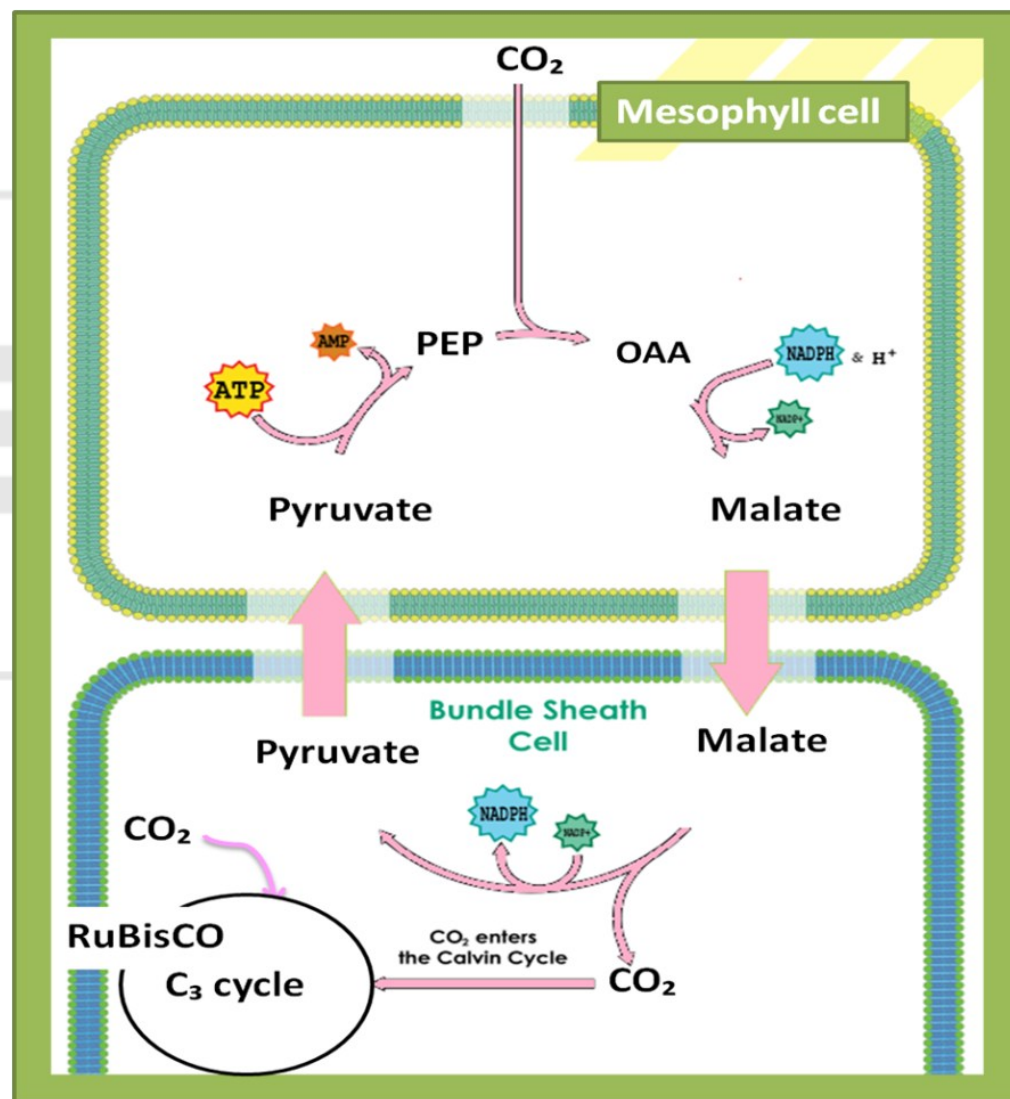
Fig: Hatch and Slack Pathway

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

**Answer-(c) Explanation**

Size-exclusion chromatography (SEC), also known as gel filtration chromatography, separates biomolecules based on their hydrodynamic volumes. In this method, a porous stationary phase is used, and molecules are separated as they pass through the column. Larger molecules, which cannot enter the pores, elute first, while smaller molecules, which can enter the pores, take longer to elute. This technique is particularly useful for separating proteins, polysaccharides, and other macromolecules based on their size. Unlike ion-exchange chromatography, which separates molecules based on charge, or thin-layer chromatography, which separates based on polarity, SEC specifically relies on the hydrodynamic volume of the molecules, making it the correct choice for this separation criterion.

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

(a) BamHI

(b) EcoRI

(c) HindIII

(d) EcoRV

**Answer-(d) Explanation**

(A). Sticky end digestion

5'G̲AATTC3'  *EcoRI* →  5'G3'        AATTC3'
3'CTTAA̲G5'  digest       3'CTTAA5'        3'G5'

(B). Blunt end digestion

5'GAT̲ATC3'  *EcoRV* →  5'GAT3'      5'ATC3'
3'CTA̲TAG5'  digest       3'CTA5'      3'TAG5'
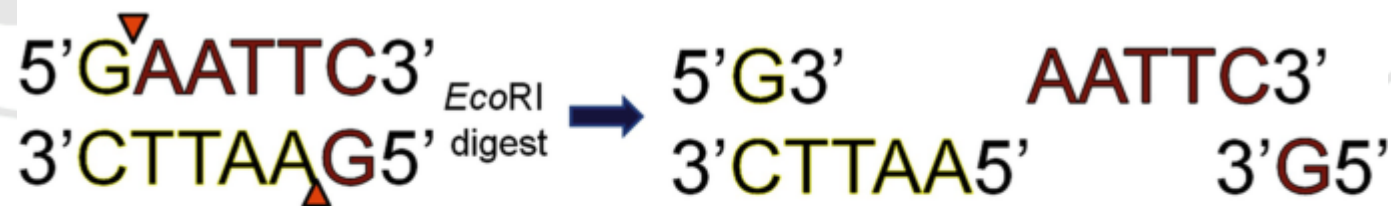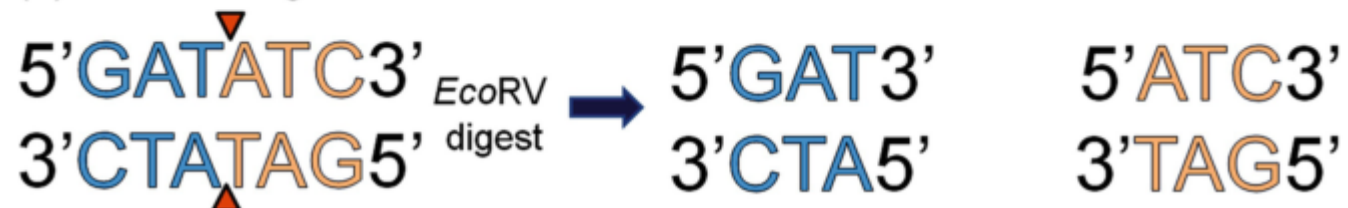
Which one of the following DNA repair systems requires DNA glycosylases?

(A) Base-excision

(B) Direct

(C) Mismatch

(D) Nucleotide-excision

**Answer-(a) Explanation**



U          Deaminated C

G

Uracil DNA glycosylase → Removes unwanted base uracil

AP-site

G

AP-endonuclease and phosphodiesterase | Gap → Cleaves the AP-site

G

DNA polymerase and ligase → Adds new DNA and seals the gap

C

G
Damage repaired

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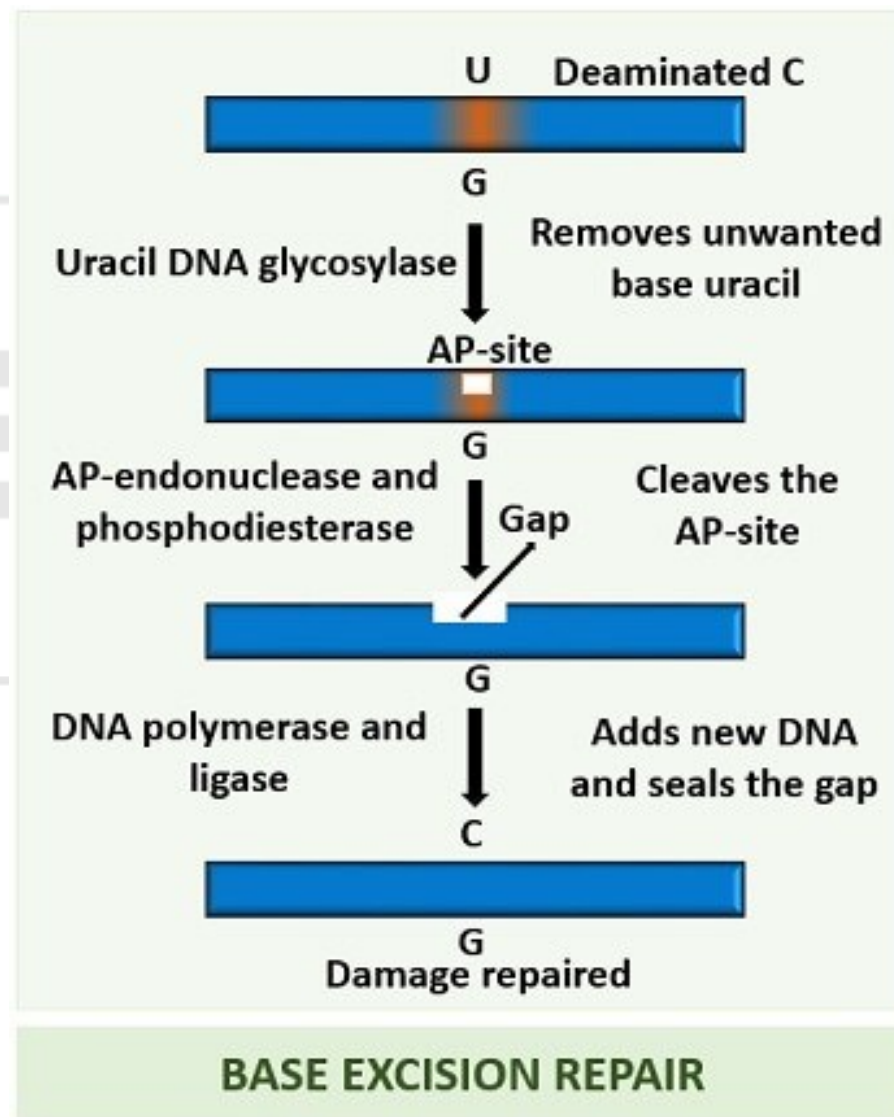
Which one of the following ion channels opens to repolarize the neuronal membrane when an action potential is generated?

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

(B) $H^+$ channel

(C) $Na^+$ channel

(D) $K^+$ channel

**Answer-(d) Explanation**



## Action potential

Repolarization (closure of $Na^+$ and opening of $K^+$, voltage gated channels)

Depolarization (opening of voltage gated $Na^+$ channels)

(local potential change; graded potential)

Hyperpolarization (Voltage gated $K^+$ channels remain open after the potential reaches resting level)

RMP

Threshold level

Time (ms)  0   3   (1 – 4 ms)
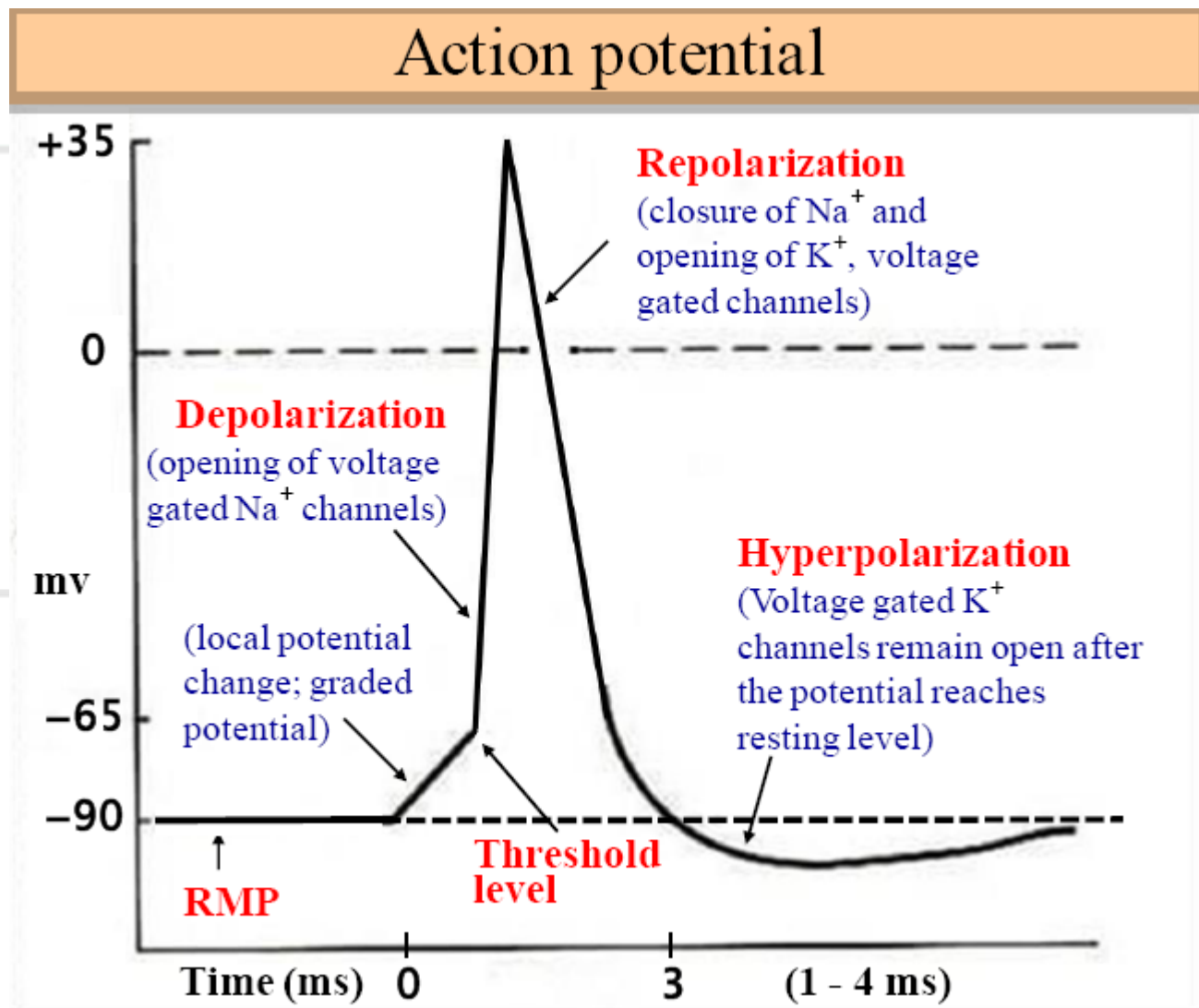
Which one of the following is the most sensitive immunoassay?

(a) Immunoelectrophoresis

(b) Immunofluorescence

(c) Radial immunodiffusion

(d) Radioimmunoassay

**Answer-() Explanation**

Radioimmunoassay (RIA) is the most sensitive immunoassay among the options given. It uses radioactively labeled antigens or antibodies to detect and quantify trace amounts of substances, even in the picogram range, due to its high sensitivity and specificity.



Radioimmunoassay (RIA)
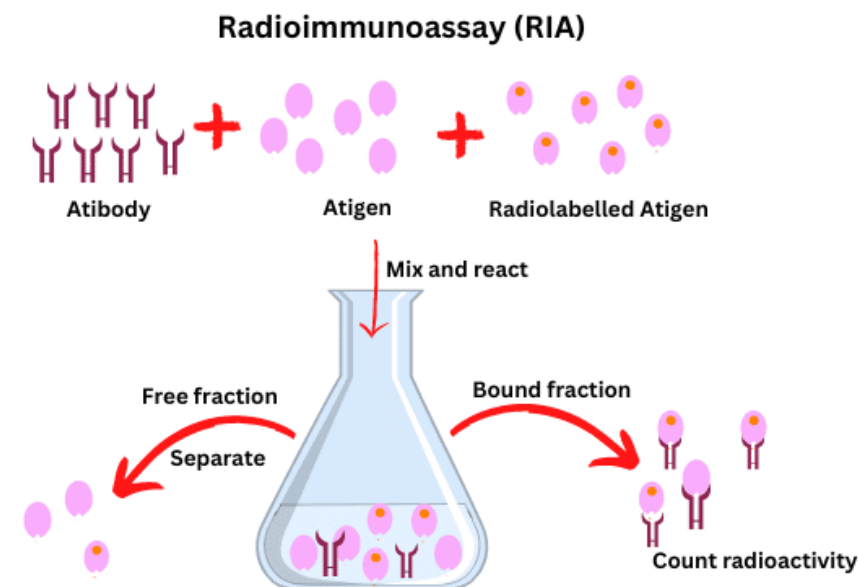
Which of the following statements about antibodies is/are correct?

(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 harbour complementarity-determining regions.

(d) All antibodies have same half-life.

**Answer-(a, c) Explanation**

**(a)Correct -** Different classes (IgG, IgA, IgM, IgE, IgD) have distinct effector functions such as opsonization, neutralization, and activation of the complement system.

**(c) Correct -** The variable domains of antibodies contain complementarity-determining regions (CDRs) responsible for antigen binding.

**(b) Incorrect** - The amino-terminal is the variable region, and the carboxy-terminal is the constant region.

**(d) Incorrect** - Different antibody classes have different half-lives (e.g., IgG has a longer half-life compared to IgE).

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

**Answer-(c) Explanation**
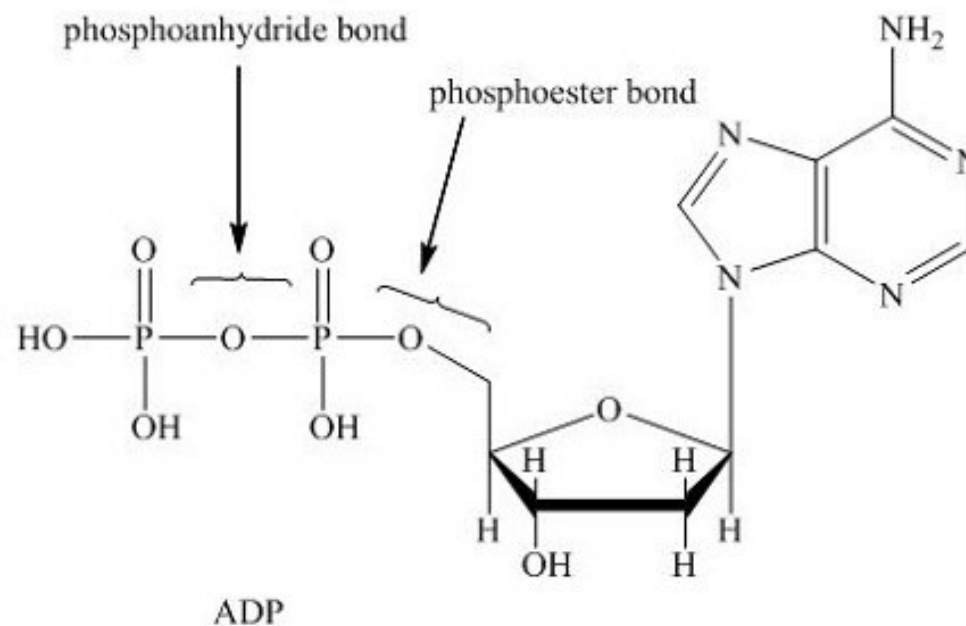
For an enzyme that follows Michaelis-Menten kinetics, a competitive inhibitor

(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 $V_{max}$.

**Answer-(c) Explanation**

| Type of Inhibition | Km | Vmax |
|---|---|---|
| **Competitive** | Increases | No change |
| **Non-competitive** | No change | Decreases |
| **Uncompetitive** | Decreases | Decreases |
| **Mixed** | Increases or Decreases | Decreases |

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.

**Answer-(b) Explanation**
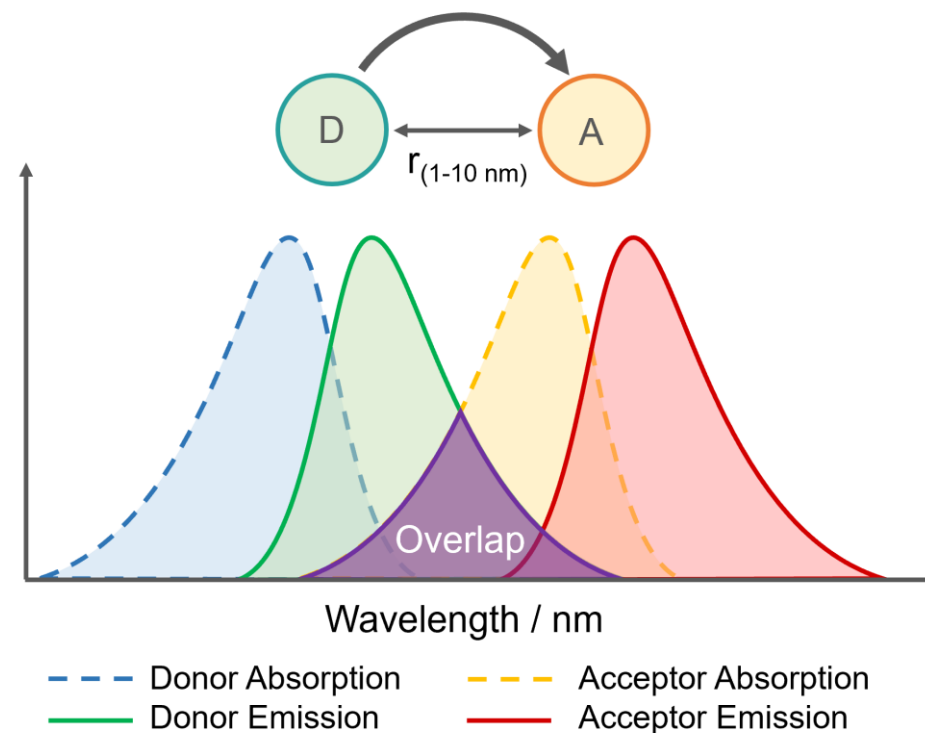


sds

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.

**Answer-(c) Explanation**

**Statement Q:** There is a K⁺ concentration difference across the vesicular membrane:

This is true. There is a significant concentration gradient of K⁺ ions across the membrane (50 mM inside vs. ~0 mM outside).

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

This is false. For a membrane potential to develop, the membrane must be selectively permeable to ions (e.g., K⁺) and allow charge separation.

**Why P is False?**

Phospholipid vesicles (liposomes) without embedded ion channels or transporters cannot allow ions to pass through their membranes. Since K⁺ ions cannot diffuse out of the vesicles, no charge separation occurs, and no membrane potential develops.

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.

**Answer-(a) Explanation**
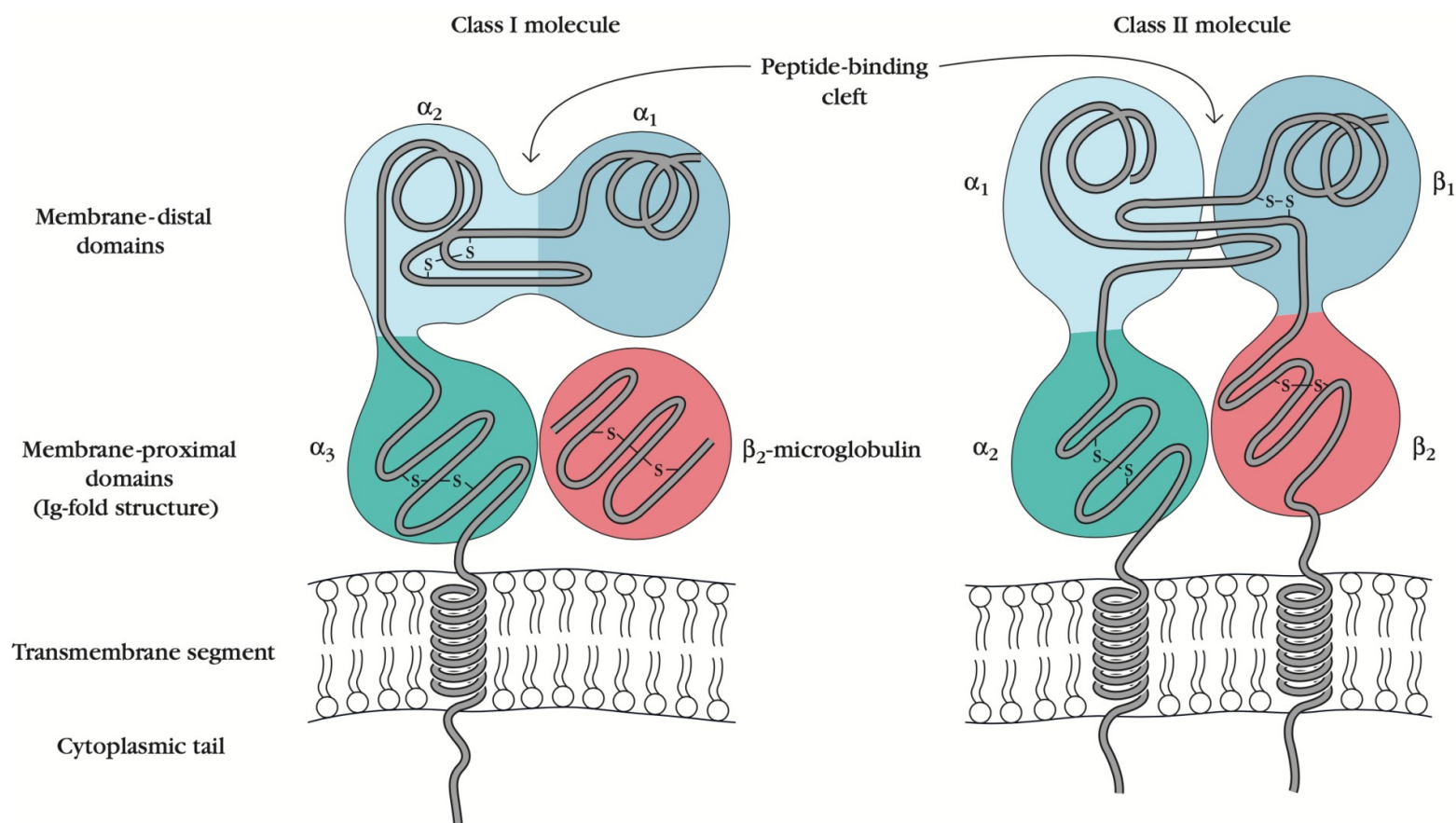
Which of the following peptides do/does NOT absorb ultraviolet light above 250 $nm$ wavelength?

(a) MQRTVWG

(b) YDEIGVL

(c) PLASNGK

(d) GSQTKRL

**Answer-(c, d) Explanation**

**Explanation:**

- UV absorption above 250 nm is mainly due to the presence of aromatic amino acids:

  **Tryptophan (W), Tyrosine (Y), and Phenylalanine (F)**.

- (a) **MQRTVWG** contains **Tryptophan (W)**, which absorbs above 250 nm.

- (b) **YDEIGVL** contains **Tyrosine (Y)**, which absorbs above 250 nm.

- (c) **PLASNGK** has no aromatic amino acids, so it **does not absorb** above 250 nm.

- (d) **GSQTKRL** also lacks aromatic amino acids and **does not absorb** above 250 nm.

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

(a) Calcitonin

(b) Glucagon

(c) Serotonin

(d) Thyroxine

**Answer-(a, b) Explanation**

**Explanation:**

- **(a) Calcitonin** is a peptide hormone produced by the thyroid gland that regulates calcium levels.
- **(b) Glucagon** is a peptide hormone secreted by the alpha cells of the pancreas that raises blood glucose levels.
- **(c) Serotonin** is a neurotransmitter derived from tryptophan, not a peptide hormone.
- **(d) Thyroxine (T4)** is an amino acid-derived hormone synthesized from tyrosine, not a peptide hormone.
- **Final Answer:**
- **(a) and (b)**

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

(a) Chondroitin-4-sulfate

(b) Chitin

(c) Cellulose

(d) Heparin

**Answer-(a, d) Explanation**



HYALURONIC ACID
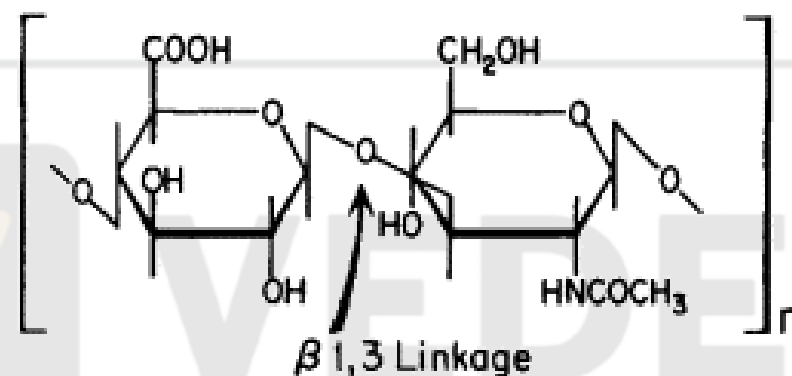
DERMATAN SULFATE (Chondroitin Sulfate B)
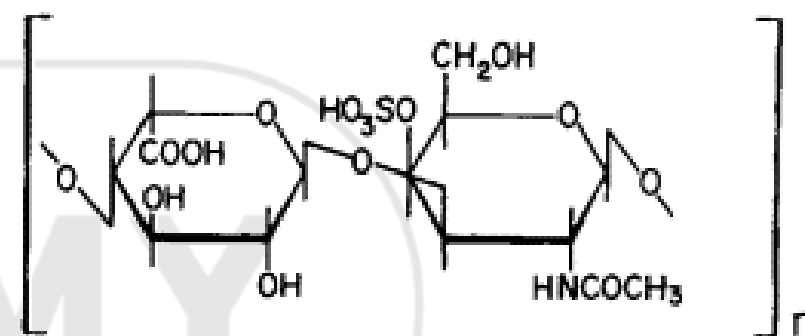
CHONDROITIN 6-SULFATE (Chondroitin Sulfate C)
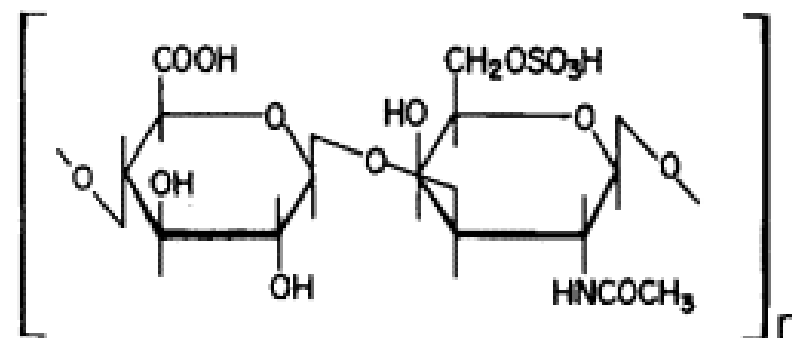
KERATAN SULFATE
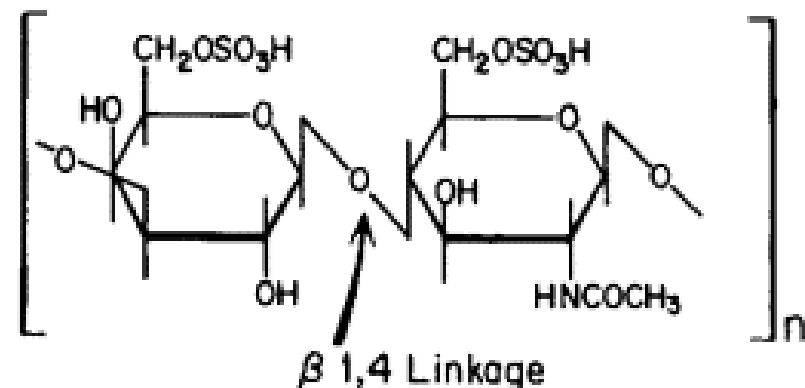
The equilibrium dissociation constant of acetic acid is $1.74 \times 10^{-5}$ $M$. The $pK_a$ of acetic acid (rounded off to one decimal place) is _____ .

**Answer-(4.7 to 4.8) Explanation**

$$pK_a = -\log(1.74 \times 10^{-5})$$
$$pK_a = -(\log 1.74 + \log 10^{-5})$$
$$pK_a = -(0.241 + (-5))$$
$$pK_a = 5 - 0.241$$
$$pK_a = 4.759$$

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 _____ $bp$.

**Answer-(146) Explanation**

- Diameter of nucleosome core particle (D) = 11 nm
- Ratio of wrapped DNA length to nucleosome diameter = 4.51
- Distance per base pair in DNA helix = 0.34 nm/bp

1. Calculate the wrapped DNA length:

$$\text{Wrapped DNA Length} = \text{Ratio} \times \text{Nucleosome Diameter}$$

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

2. Calculate the length of DNA in base pairs:

$$\text{Length in bp} = \frac{\text{Wrapped DNA Length}}{\text{Distance per bp}}$$

$$\text{Length in bp} = \frac{49.61}{0.34} = 145.91$$

E. coli is grown exclusively in a medium containing $^{15}NH_4Cl$ as the sole nitrogen source. Subsequently, the cells were shifted to a medium containing $^{14}NH_4Cl$. The molar ratio of hybrid DNA ($^{15}N$-$^{14}N$) to light DNA ($^{14}N$-$^{14}N$) after four generations (rounded off to two decimal places) will be _____ .

**Answer-(0.14) Explanation**

- **E. coli** is initially grown in **15NH₄Cl**, so all DNA is **heavy (15N-15N)**.

- After shifting to **14NH₄Cl**, each replication produces:

  - **Hybrid DNA (15N-14N)** from one old heavy strand and one new light strand.

  - **Light DNA (14N-14N)** from two new light strands.

## Calculations:

1. **Generation 0:** 100% **15N-15N**

2. **Generation 1:** 100% **15N-14N** (hybrid)

3. **Generation 2:** 50% **15N-14N** and 50% **14N-14N**

4. **Generation 3:** 25% **15N-14N** and 75% **14N-14N**

5. **Generation 4:** 12.5% **15N-14N** and 87.5% **14N-14N**

- Hybrid DNA = **12.5%** or **0.125**

- Light DNA = **87.5%** or **0.875**

Molar ratio of Hybrid to Light DNA:

$$\text{Molar Ratio} = \frac{\text{Hybrid}}{\text{Light}} = \frac{0.125}{0.875} = 0.142857$$

# GATE

## Life sciences

**GATE 2025**
**Botany**

**Subject wise Question Paper Analysis**

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

**Answer-() Explanation**

- **John Hutchinson** developed a classification system for flowering plants, leading to his book **"Classification of Flowering Plants."**

- **Adolf Engler and Karl Prantl** are known for their influential work **"Die Natürlichen Pflanzenfamilien,"** a comprehensive classification of plant families.

- **Arthur Cronquist** proposed an evolutionary approach to plant classification, which he detailed in **"Evolution and Classification of Flowering Plants."**

- **Alfred Barton Rendle** wrote **"The Families of Flowering Plants,"** focusing on the description and classification of plant families.

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

**Answer-(c) Explanation**

Phloem sieve elements are living cells responsible for transporting sugars and other nutrients in plants. They lack a nucleus at maturity to allow efficient flow of nutrients but remain alive with the help of companion cells that provide metabolic support. The other options have a nucleus when mature.

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

| | Group I | | Group II |
|---|---|---|---|
| (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

**Answer-(b) Explanation**

All the listed carnivorous plants use modified leaves to trap their prey. Pitcher plant (Nepenthes) forms a pitcher-shaped leaf, Bladderwort (Utricularia) modifies its leaves into bladder-like underwater traps, Sundew (Drosera) uses sticky glandular leaves, and Venus flytrap (Dionaea) has snap-trap leaves. These adaptations maximize prey capture for nutrient acquisition, making option (b) P-1; Q-1; R-1; S-1 correct.

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

**Answer-(b) Explanation**

Pectin is a complex carbohydrate naturally produced only by plants, primarily in the cell walls of fruits where it acts as a gelling agent. Cellulose and starch are also plant-based but have some occurrence in other organisms, while chitin is found in fungi and arthropods, not in plants.

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

(a) Fungi

(b) Bacteria

(c) Virus

(d) Nematodes

**Answer-(c) Explanation**

Necrotic ring spot disease in stone fruits is caused by the Prunus necrotic ringspot virus (PNRSV). This virus affects species like cherries, peaches, and plums, leading to ring-like necrotic lesions on leaves and fruits.

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

**Answer-(b, d) Explanation**

- **(a)** Incorrect: **Hairy root disease** in tobacco is caused by **Agrobacterium rhizogenes**, not **Agrobacterium tumefaciens**.

- **(b)** Correct: **Loose smut of barley** is caused by **Ustilago nuda**, a fungal pathogen.

- **(c)** Incorrect: **Stem rust of grape** is not caused by **Plasmopara viticola**. **Plasmopara viticola** causes **downy mildew** in grapes.

- **(d)** Correct: **Fire blight** in pear is caused by **Erwinia amylovora**, a bacterial pathogen.

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

**Answer-(a, b) Explanation**

- **(a) Homologous recombination** enables precise gene replacement or knock-out by recombining a designed DNA construct with the target gene sequence.

- **(b) CRISPR-Cas9** introduces targeted double-strand breaks, leading to mutations or complete knock-out through non-homologous end joining.

- **(c) Antisense RNA technique** reduces gene expression but does not result in a complete knock-out.

- **(d) Activation tagging** enhances gene expression rather than knocking out the gene.

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).

**Answer-(22) Explanation**

1. **Determine the diploid chromosome number (2n):**

   - An egg cell is haploid and has **10 chromosomes**, so the diploid number is:

$$2n = 2 \times 10 = 20$$

2. **Understanding double trisomic:**

   - A **double trisomic** has **two extra chromosomes**, one on each of two different chromosome pairs.

   - Therefore, the total number of chromosomes is:

$$2n + 2 = 20 + 2 = 22$$

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)

$$CO_2 + H_2O \xrightarrow{\text{light}} (CH_2O) + O_2 \qquad \text{(equation 1)}$$

$$CO_2 + 2H_2S \xrightarrow{\text{light}} (CH_2O) + H_2O + 2S \qquad \text{(equation 2)}$$

$$CO_2 + 2H_2A \xrightarrow{\text{light}} (CH_2O) + H_2O + 2A \qquad \text{(equation 3)}$$
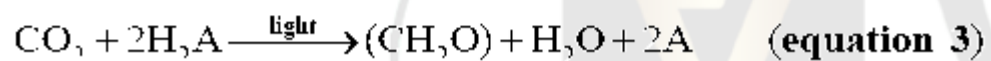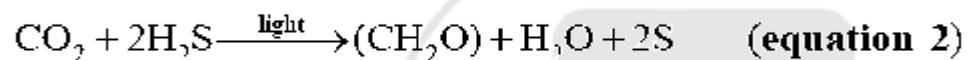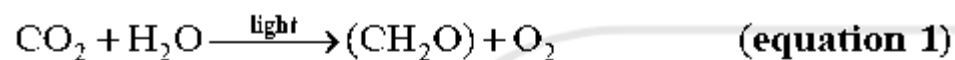
where H2A in equation 3 is a generalized electron donor.
Which one of the following statements is DISPROVEN by equation 3?
(a) The source of oxygen produced in photosynthesis in green plants is CO2
(b) The source of oxygen produced in photosynthesis in green plants is H2O
(c) Light is essential in every form of photosynthesis
(d) Glucose is the end product in all forms of photosynthesis

**Answer-(a) Explanation**

Equation 2 shows that purple sulfur bacteria produce ($CH_2O$) (a generalized carbohydrate), not glucose, as the end product, along with $H_2O$ and S (sulfur). This disproves the statement that glucose is the universal end product. In different photosynthetic organisms, the end product can vary depending on the electron donor used.

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

**Answer-(b) Explanation**

In the shoot apical meristem (SAM), anticlinal division means that cells divide perpendicular to the surface, maintaining the epidermal layer without mixing with underlying layers. If a single epidermal cell becomes tetraploid, it will continue to divide anticlinally, producing daughter cells that remain in the same layer. Therefore, the tetraploidy would be restricted to that single lineage without spreading to other cells in the epidermis or deeper layers of the SAM.

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

**Answer-(a) Explanation**

- In the **C3 cycle (Calvin cycle)**, the first stable product is **3-Phosphoglycerate**, commonly found in **C3 plants** like **wheat**.

- In the **C4 cycle**, the first stable product is **Oxaloacetate**, found in **C4 plants** like **sugarcane**.

- In **CAM (Crassulacean Acid Metabolism)**, **Oxaloacetate** is also the first product, commonly found in **CAM plants** like **pineapple**.

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.

**Answer-(b) Explanation**

- **Wild type:** Both genes are normal, flowering occurs at 30 days.
- **a mutant:** Gene A is absent, leading to increased B transcripts and early flowering (15 days). This indicates **A normally suppresses B**, and **B promotes flowering**.
- **b mutant:** Absence of B results in delayed flowering (60 days), confirming that **B promotes flowering**.
- **ab double mutant:** Both A and B are absent, flowering is delayed (60 days), consistent with the absence of B's promotion.
- This pattern supports the pathway:
- **A suppresses B**
- **B promotes flowering**

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

(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-3; R-4; S-2; T-1

(d) P-3; Q-5; R-4; S-2; T-1

| 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 |

**Answer-(c) Explanation**

sds

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

(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

| 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 |

**Answer-(c) Explanation**

The matching is based on the chemical nature and biosynthetic origin of each metabolite. **Azadirachtin** is a complex **triterpene** derived from neem with insecticidal properties. **Saponin** is a **triterpene glycoside** known for its surfactant and medicinal properties. **Gallocatechin** is a **polyphenol** found in tea, acting as an antioxidant. **Cocaine** is an **alkaloid** with stimulant effects, synthesized from nitrogen-containing precursors. **Menthol** is a **monoterpene** with cooling effects, biosynthesized through the isoprenoid pathway. The structural features and biosynthetic origins justify the correct matching as **(c) P-5; Q-3; R-4; S-2; T-1**.

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

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

(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

| 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 |

**Answer-(a) Explanation**

- **Neomycin phosphotransferase (NPT II)** inactivates **Kanamycin** by phosphorylation, conferring antibiotic resistance.

- **Phosphinothricin acetyltransferase (PAT)** detoxifies **Bialaphos** (and glufosinate), which inhibits glutamine synthetase.

- **Dihydrofolate reductase** provides resistance to **Methotrexate** by reducing its inhibitory effect on nucleotide synthesis.

- **5-Enolpyruvyl shikimate 3-phosphate synthase (EPSPS)** is insensitive to **Glyphosate**, which inhibits the shikimate pathway in plants.

Which of the following sequential reactions correctly represent(s) the flow of electrons from NADH to $O_2$ 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

(d) NADH dehydrogenase → Alternative oxidase → Ubiquinone

**Answer-(a, c) Explanation**

- In the plant mitochondrial electron transport chain:
  - Electrons from **NADH** are first transferred to **NADH dehydrogenase (Complex I)**.
  - From **NADH dehydrogenase**, electrons are passed to **Ubiquinone (Coenzyme Q)**.
  - In the presence of **Alternative oxidase (AOX)**, electrons can bypass the usual cytochrome pathway and go directly from **Ubiquinone** to **Alternative oxidase**, which transfers electrons to **O₂**, forming water.
  - This pathway is unique to plants and helps in maintaining redox balance under stress conditions.

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?
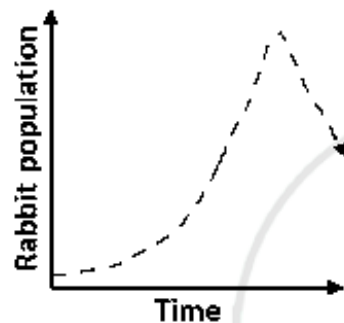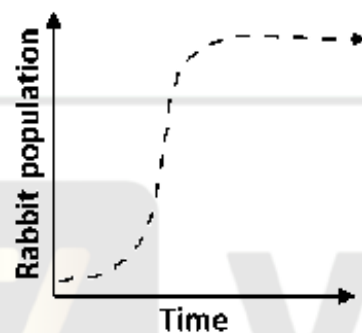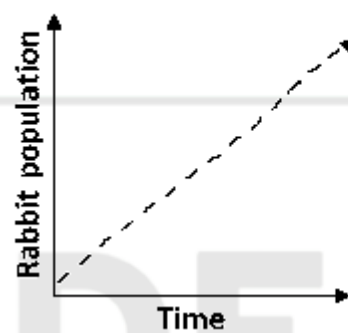


(P) | (Q) | (R) | (S)
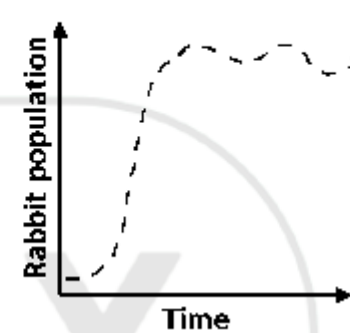
(a) P
(b) Q
(c) R
(d) S

**Answer-(a, b, d) Explanation**

(P) shows an initial exponential growth followed by a decline, which can happen due to resource depletion or increased predation.(Q) represents logistic growth where the population grows rapidly and then stabilizes at the carrying capacity of the environment.(S) depicts a fluctuating population, which can occur due to environmental variability, predation, or competition.(R) shows continuous exponential growth, which is not sustainable in a real ecosystem due to resource limitations and carrying capacity constraints.

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

(a) Malate + $NAD^+$ → Pyruvate + $CO_2$ + NADH

(b) Malate + $NAD^+$ ⇌ Oxaloacetate + NADH

(c) Malate ⇌ Fumarate

(d) Malate + $NADP^+$ → Pyruvate + $CO_2$ + NADPH

**Answer-(a, d) Explanation**

Malic enzymes catalyze the oxidative decarboxylation of malate to produce pyruvate, CO₂, and reduced cofactors (NADH or NADPH).
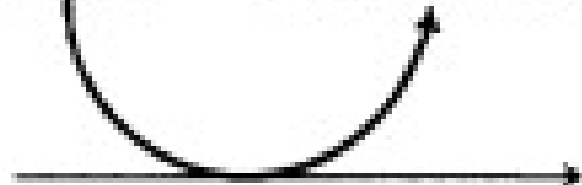
In a genetic cross between a true-breeding tall parent bearing red flowers and a true-breeding dwarf parent bearing white flowers, only tall plants with red flowers are obtained in the F1 population. Considering these two traits segregate independently, if one tall individual is selected from the F2 population, the probability that it would be genotypically homozygous for plant height and make red flowers is _____ (Round off to two decimal places).

**Answer-(0.24 to 0.26) Explanation**

1. **Determine the genotypes of the parents**:
   o Tall parent with red flowers: **TTRR**
   o Dwarf parent with white flowers: **ttrr**
2. **F1 generation**:
   o All F1 offspring are **TtRr** (tall and red).
3. **F2 generation**:
   o The F2 generation results from the cross **TtRr × TtRr**.
   o Since the traits segregate independently, we analyze them separately.

**Step 1: Analyze Plant Height (T/t)**
- The cross **Tt × Tt** yields:
   o 1 **TT** (homozygous tall)
   o 2 **Tt** (heterozygous tall)
   o 1 **tt** (dwarf)
- The probability of selecting a **tall plant (TT or Tt)** is:

$$P(\text{Tall}) = \frac{3}{4}$$

- Among tall plants, the probability of being **homozygous (TT)** is:

$$P(\text{TT} \mid \text{Tall}) = \frac{1}{3}$$

**Step 2: Analyze Flower Color (R/r)**
- The cross **Rr × Rr** yields:
   o 1 **RR** (homozygous red)
   o 2 **Rr** (heterozygous red)
   o 1 **rr** (white)
- The probability of producing **red flowers (RR or Rr)** is:

$$P(\text{Red}) = \frac{3}{4}$$

**Step 3: Combine the Probabilities**
- We are asked for the probability that a tall plant is **homozygous for plant height (TT)** and **produces red flowers**.
- Since the traits segregate independently, we multiply the probabilities:

$$P(\text{TT and Red}) = P(\text{TT} \mid \text{Tall}) \times P(\text{Red})$$

$$P(\text{TT and Red}) = \frac{1}{3} \times \frac{3}{4}$$

$$P(\text{TT and Red}) = \frac{1}{4}$$

# GATE

## Life Science

**GATE 2025**

**Microbiology**

**SUBJECT Question Paper Analysis**

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)

**Answer-(b ) Explanation**

The bacterial stringent response is a survival mechanism triggered by nutrient deprivation or stress conditions. It is mediated by the alarmone ppGpp, which is synthesized by RelA and SpoT proteins. ppGpp binds to RNA polymerase, leading to a global shift in gene expression—downregulating rRNA and tRNA synthesis while upregulating stress survival and amino acid biosynthesis pathways. Other options, such as cAMP, cGMP, and cyclic di-GMP, are involved in different regulatory pathways and are not linked to the stringent response.

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 short-course

**Answer-(a ) Explanation**

DOTS (Directly Observed Therapy Short-course) is the WHO-recommended strategy for tuberculosis control. It ensures that patients take their medication under direct supervision, improving adherence and reducing the risk of drug resistance.

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

(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 - iv; S - i

| 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 |

**Answer-(a ) Explanation**

Psychrophile (P): Thrives in cold environments, temperature below 15°C.Barophile (Q): Grows in high-pressure conditions, pressure greater than 380 atm.Mesophile (R): Prefers moderate temperatures, between 15°C and 45°C.Halophile (S): Lives in high salt environments, salt concentration greater than 2M.

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.

**Answer-(a ) Explanation**

Robert Koch used meat-infused nutrient medium to culture and isolate disease-causing microorganisms like Bacillus anthracis and Mycobacterium tuberculosis. This helped him establish the connection between microbes and specific diseases, leading to the development of Koch's postulates.

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

**Answer-(a ) Explanation**

With density-independent mortality, each bacterium has the same constant probability of dying over time, regardless of population size. This leads to an exponential decrease in the number of surviving bacteria, following the relationship:

$N(t) = N_{0\,e}^{-kt}$

where N(t) is the number of survivors at time T, $N_0$ is the initial population, and k is the death rate constant.

A bacterium obtains energy from a chemical source by the oxidation of reduced $NO_2-$, with $CO_2$ as the principal carbon source. Which one of the following nutritional groups does this bacterium belong to?

(a) Photoautotroph.

(b) Photoheterotroph.

(c) Chemoautotroph.

(d) Chemoheterotroph.

**Answer-( c) Explanation**

A chemoautotroph obtains energy from chemical sources (in this case, the oxidation of reduced $NO_2^-$) and uses $CO_2$ as its carbon source for biosynthesis. Unlike photoautotrophs, it does not require light for energy.

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) AGBFCDE

(c) GAFBECD

(d) GAFEBCD
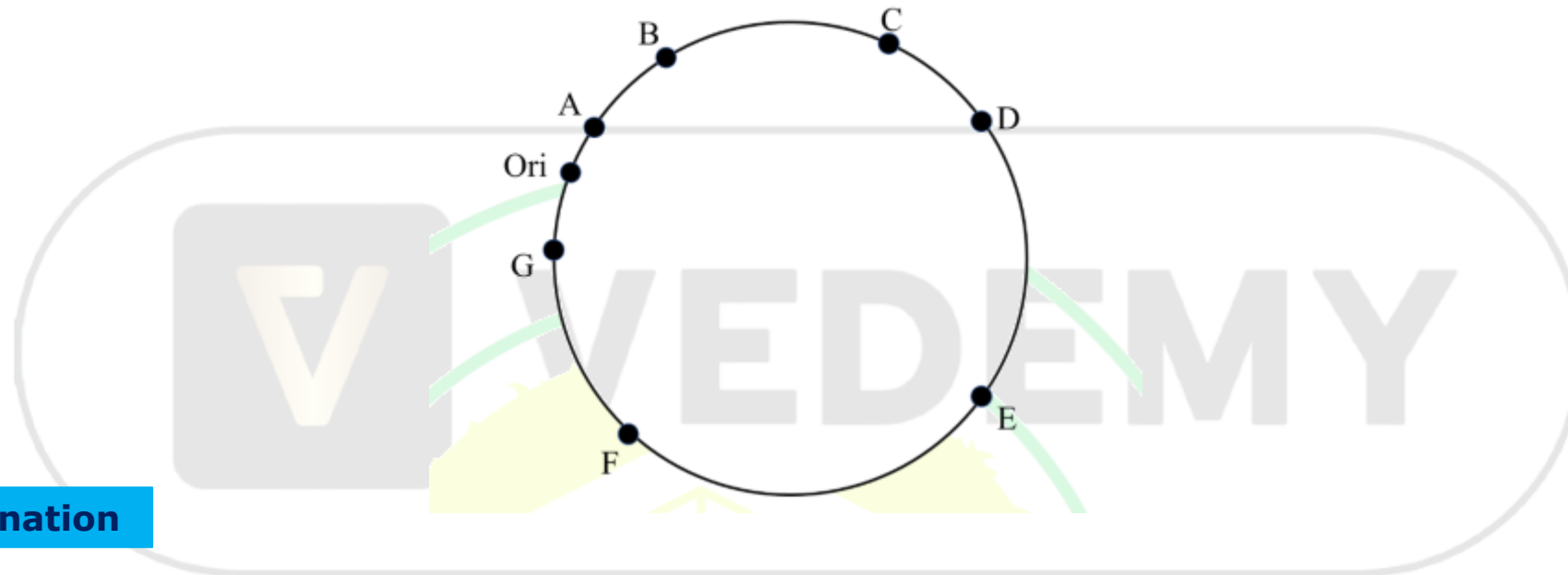


**Answer-( b) Explanation**

In E. coli, bidirectional replication starts at the oriC (origin of replication) and proceeds in both directions at equal speeds. The sequence of genes is replicated in the order they are arranged on the circular chromosome. Starting from oriC, the correct order is: thr → leu → azi → lac → gal → bio and then back to oriC.

Which of the following sites is/are the location(s) of ATP generation throughoxidative phosphorylation in Escherichia coli?

(a) Inner membrane only

(b) Outer membrane only

(c) Both outer membrane and inner membrane

(d) Mesosome

**Answer-(a, d) Explanation**

In Escherichia coli, ATP generation through oxidative phosphorylation occurs at the inner membrane where the electron transport chain and ATP synthase are located. Although mesosomes are now considered artifacts of cell preparation, they were historically thought to be invaginations of the inner membrane associated with respiration and ATP synthesis. Therefore, in historical context or older literature, mesosomes are also mentioned as sites of oxidative phosphorylation.

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
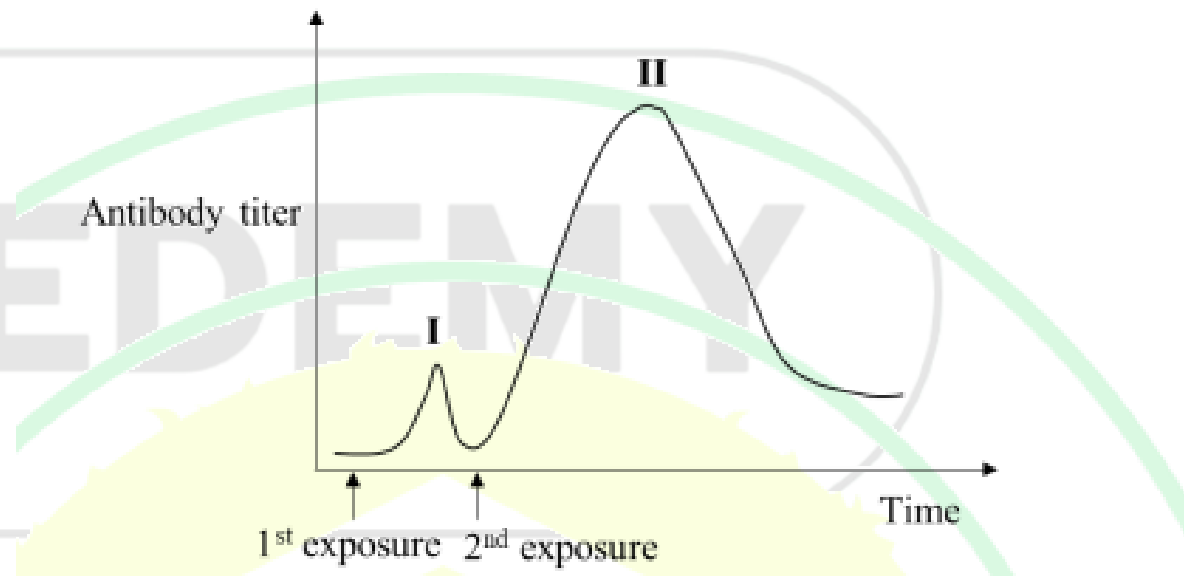


**Answer-(b ) Explanation**

During the primary immune response (first exposure), IgM is produced first as it is the initial antibody made by B cells. During the secondary immune response (second exposure), IgG is produced in higher amounts and more rapidly due to memory B cells, providing long-lasting immunity.

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) II

(D) III

I — Archaea, Bacteria, Eukarya

II — Bacteria, Archaea, Eukarya

III — Eukarya, Archaea, Bacteria

IV — Archaea, Bacteria, Eukarya
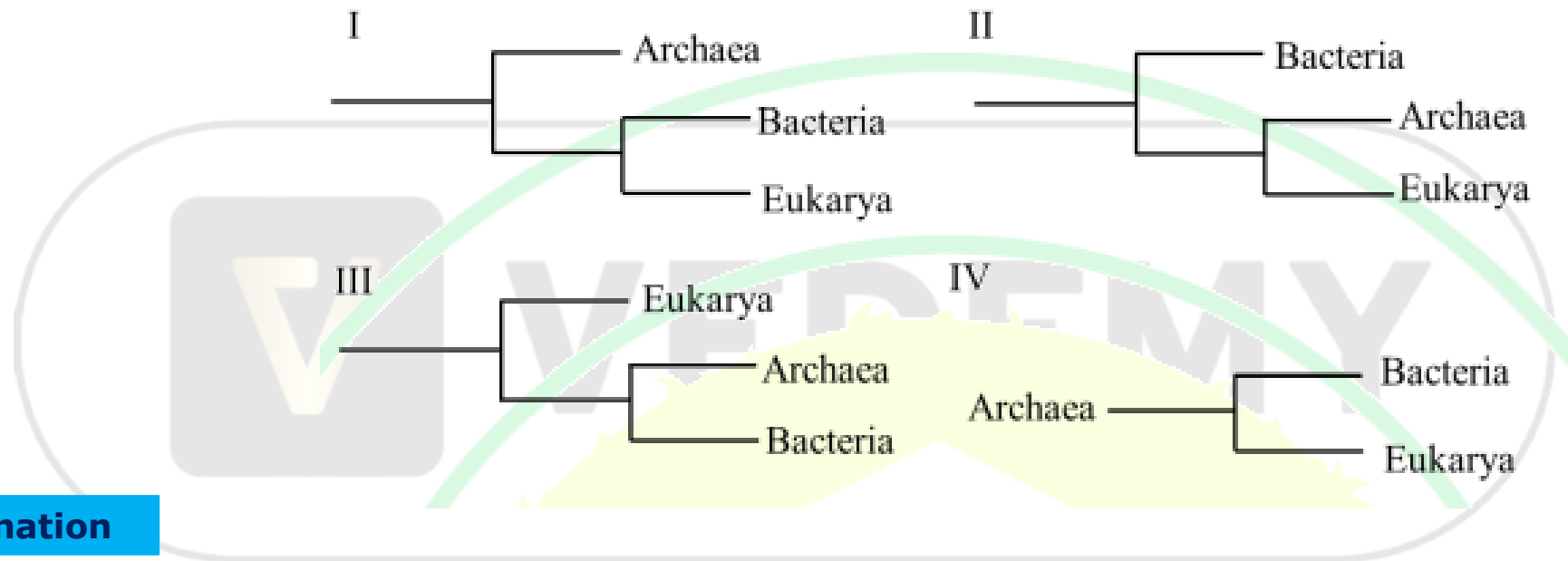
**Answer-(c) Explanation**

Carl Woese used small subunit rRNA sequences to classify life into three domains: Bacteria, Archaea, and Eukarya. He showed that Archaea are more closely related to Eukarya than to Bacteria, establishing the modern three-domain system of phylogeny.

Correctly match the viruses listed in Column I with the nature of theircorresponding genetic materials listed in Column II.

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

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

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

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

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

**Answer-( c) Explanation**

Bacteriophage lambda (P): dsDNA (double-stranded DNA).Bacteriophage M13 (Q): ssDNA (single-stranded DNA).Coronavirus (R): ssRNA (single-stranded RNA).Reovirus (S): dsRNA (double-stranded RNA).These genetic materials are characteristic of the respective viruses' replication strategies.

A culture of lac+ Escherichia coli is grown in a medium lacking lactose or any other β -galactoside. The response of the lac operon upon induction by lactose can be monitored by measuring the levels of lac mRNA, β-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

**Answer-( a) Explanation**
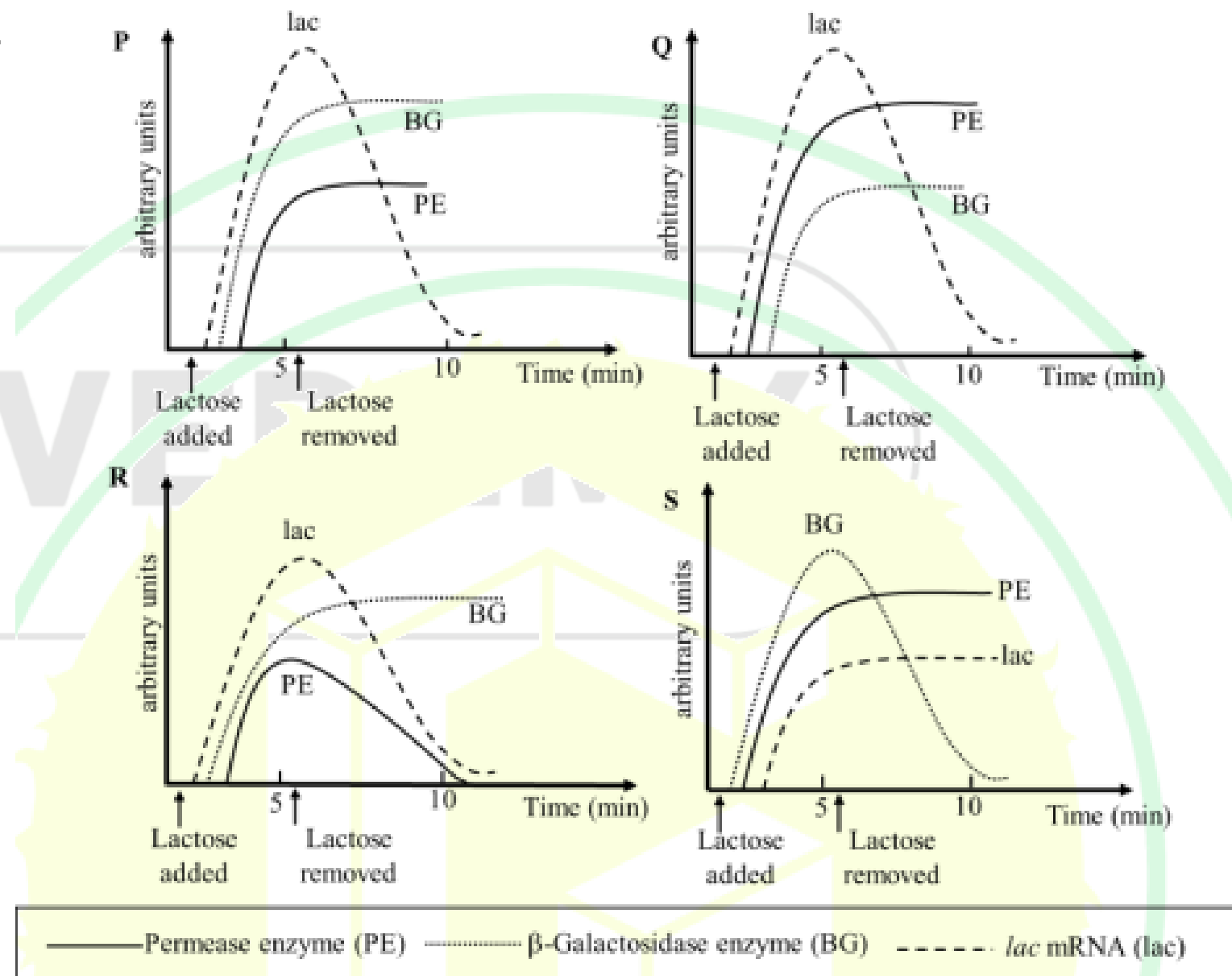
**Answer-( a) Explanation**

- The correct profile for the on-off response of the **lac operon** to lactose induction in **lac⁺ Escherichia coli** is as follows:
- **lac mRNA**: Rapid increase upon lactose induction, followed by a decrease when lactose is depleted.
- **β-galactosidase**: Gradual increase as it is synthesized from lac mRNA, plateauing once mRNA levels decline.
- **Permease**: Similar pattern to β-galactosidase, as it is also translated from lac mRNA.

- **Explanation:**
- In the absence of lactose, the **lac repressor** binds to the **operator**, preventing transcription.
- Upon addition of lactose, **allolactose** (inducer) binds to the repressor, causing it to dissociate from the operator.
- **RNA polymerase** then transcribes the **lac operon**, leading to a rapid increase in **lac mRNA**.
- **β-galactosidase** and **permease** are translated from the mRNA, increasing more gradually due to the time required for translation and protein accumulation.
- Once lactose is depleted, the repressor rebinds the operator, stopping transcription. mRNA degrades quickly, but the enzymes remain for a short period before they too decrease.

- **Final Answer:**
- The correct profile shows a rapid increase and decrease for **lac mRNA**, with a more gradual rise and plateau for **β-galactosidase** and **permease**.

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

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

(b) P - i; Q - iii; R - iii; S - iv

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

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

| 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 |

**Answer-(a ) Explanation**

Cell wall (P): Provides protection from osmotic stress by maintaining cell shape and preventing lysis. Fimbriae (Q): Facilitate attachment to surfaces, aiding in colonization and biofilm formation.Flagella (R): Responsible for motility, enabling the bacterium to move towards favorable environments.Pili (S): Involved in transfer of genetic material during conjugation (sex pili).

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

**Answer-( b, c, d) Explanation**

(b) Myxococcus: Predatory bacteria that hunt other microbes by secreting lytic enzymes.

(c) Dictyostelium: A slime mold that aggregates into a multicellular structure for reproduction.

(d) Actinomycetes: Soil bacteria producing geosmin, causing earthy odors.

(a) Incorrect: Wolbachia is an intracellular parasite of insects and nematodes, not humans.

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

**Answer-(c , d ) Explanation**

(c) Human - Lactobacillus plantarum: Mutualistic relationship where Lactobacillus aids in digestion and immunity in the human gut.(d) Cow - Ruminococcus albus: Mutualism in the rumen where Ruminococcus helps digest cellulose, providing energy to cows.(a) Incorrect: Mycobacterium tuberculosis is a pathogen, causing tuberculosis in humans.(b) Incorrect: Rabies lyssavirus is a virus causing rabies in dogs, not mutualistic.

# GATE

## Life Science

**GATE 2025**

**Zoology**

**SUBJECT Question Paper Analysis**

Which of the following reactions is/are catalyzed by aldolase?

(a) Dihydroxyacetone phosphate + Glyceraldehye-3-phosphate → Fructose 1,6- biphosphate

(b) Dihydroxyacetone phosphate + Erythrose-4-phosphate → Sedoheptulose-1,7- biphosphate

(c) Dihydroxyacetone phosphate → Glyceraldehyde-3-phosphate

(d) Glyceraldehye-3-phosphate + Erythrose-4-phosphate → Sedoheptulose-1,7- biphosphate

**Answer-(a ,b ) Explanation**

(a) Dihydroxyacetone phosphate + Glyceraldehyde-3-phosphate → Fructose 1,6-bisphosphate: Aldolase catalyzes this in glycolysis.(b) Dihydroxyacetone phosphate + Erythrose-4-phosphate → Sedoheptulose-1,7-bisphosphate: Occurs in the pentose phosphate pathway, also catalyzed by aldolase.(c) Incorrect: This is an isomerization reaction catalyzed by triose phosphate isomerase.(d) Incorrect: This is a transketolase reaction in the pentose phosphate pathway, not catalyzed by aldolase.

Which option(s) correctly match(es) the Antibiotic with their corresponding Target?

(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 - iii

(d) P - iv; Q - iii; R - ii; T - i

| Antibiotic | Target |
|---|---|
| P. Penicillin | i. Ribosome |
| Q. Kanamycin | ii. RNA polymerase |
| R. Rifampicin | iii. DNA gyrase |
| S. Nalidixic acid | iv. Transpeptidase |
| T. Ciprofloxacin | |

**Answer-(a , c ) Explanation**

The correct matching is based on the specific molecular targets of each antibiotic. **Penicillin** inhibits **transpeptidase**, an enzyme crucial for bacterial cell wall synthesis, leading to cell lysis. **Kanamycin** binds to the **ribosome**, blocking protein synthesis by interfering with mRNA translation. **Rifampicin** targets **RNA polymerase**, preventing transcription initiation. Both **Nalidixic acid** and **Ciprofloxacin** inhibit **DNA gyrase**, an essential enzyme for bacterial DNA replication and supercoiling. These mechanisms explain why the correct options are **(a) P-iv; Q-i; R-ii; S-iii** and **(c) P-iv; Q-i; R-ii; T-iii**.

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)

**Answer-( 2 to 2 ) Explanation**

### Step 1: Understand the Parameters

1. **E. coli doubling time**: 30 minutes.
2. **T7 phage life cycle**: 20 minutes.
3. **Burst size**: 200 phage per infected E. coli cell.
4. **Initial conditions**:
   - E. coli cells: $2 \times 10^7$.
   - T7 phage: 5000 plaque-forming units (PFU).

### Step 2: Phage Infection and Lysis

- The T7 phage infects E. coli cells at a **multiplicity of infection (MOI) of 1**, meaning each E. coli cell is infected by **1 phage**.
- The phage has a **life cycle of 20 minutes**, after which the infected E. coli cell lyses and releases **200 new phage particles**.

### Step 3: Bacterial Growth and Phage Spread

- The E. coli culture doubles every **30 minutes**.
- The phage life cycle is **20 minutes**, which is shorter than the bacterial doubling time. This means the phage can infect and lyse cells faster than the bacteria can divide.

### Step 4: Calculate the Number of Bacterial Divisions

- Let $n$ be the number of full cycles of bacterial division required for the culture to lyse completely.
- Each bacterial division takes **30 minutes**, and the phage life cycle is **20 minutes**. Thus, during each bacterial division cycle, the phage can complete **1.5 life cycles** (since $30/20 = 1.5$).

### Step 5: Phage Amplification

- Initially, **5000 phage** infect **5000 E. coli cells**.
- After the first phage life cycle (20 minutes), the infected cells lyse and release $5000 \times 200 = 1 \times 10^6$ new phage particles.
- These new phage particles infect $1 \times 10^6$ E. coli cells.
- This process continues exponentially.

### Step 6: Determine When the Culture Lyses Completely

- The total number of E. coli cells is $2 \times 10^7$.
- The phage infection spreads exponentially, and the culture will lyse completely when the number of infected cells equals the total number of E. coli cells.

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)

**Answer-(1 to 1 ) Explanation**

To determine the initial bacterial count, we analyze the amplification steps:

1. **Bacterial Growth**:

   o The bacteria undergo **1 cycle of growth**, doubling the number of bacteria.
   o If the initial bacterial count is $N$, after growth it becomes $2N$.

2. **Gene Copies**:

   o Each bacterium has **3 copies of the target gene**.
   o After growth, the total gene copies are $2N \times 3 = 6N$.

3. **PCR Amplification**:

   o PCR amplifies the gene copies exponentially. After **9 cycles**, the number of amplicons is:
   $$6N \times 2^9 = 6N \times 512$$
   o Given that the final amplicon count is **3072**, we solve for $N$:
   $$6N \times 512 = 3072$$
   $$N = \frac{3072}{6 \times 512} = \frac{3072}{3072} = 1$$

Which one of the following is a "brood parasite" ?

(a) Pigeon

(b) Sparrow

(c) Goose

(d) Cuckoo

**Answer(d ) Explanation**

Cuckoos are brood parasites. They lay their eggs in the nests of other bird species, leaving the host bird to incubate and raise their chicks, often at the expense of the host's own offspring.

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

**Answer-( ) Explanation**

In mammalian embryos, the yolk sac is formed from the primitive endoderm (hypoblast), which lines the inner surface of the blastocoel. It provides nutrients and supports early blood cell formation.
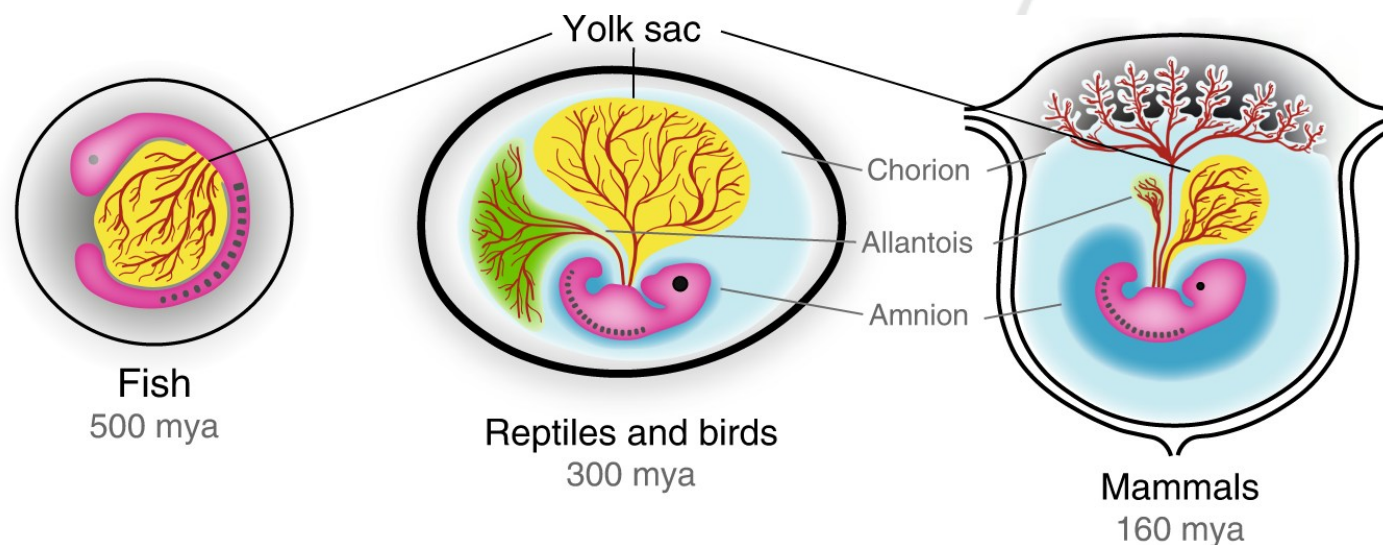
The animals belonging to which one of the following phyla are characterized by "segmented body"?

(a) Annelida

(b) Cnidaria

(c) Echinodermata

(d) Porifera

**Answer-(a ) Explanation**

Annelida is the only phylum among the options that exhibits a segmented body structure, with repeated units called metameres or segments. Examples include earthworms and leeches.



Flatworm: *Pseudobiceros bedfordi*

Annelid: *Glycera*

Nematode: *Heterodera glycines*

Ectoderm
Mesoderm
Endoderm

Coelom

Pseudocoelom
Digestive cavity

Digestive cavity

Mesoderm
Endoderm
Ectoderm

(a) **Acoelomate** (flatworms)

(b) **Eucoelomate** (annelids, mollusks, arthropods, echinoderms, chordates)

(c) **Pseudocoelomate** (roundworms)
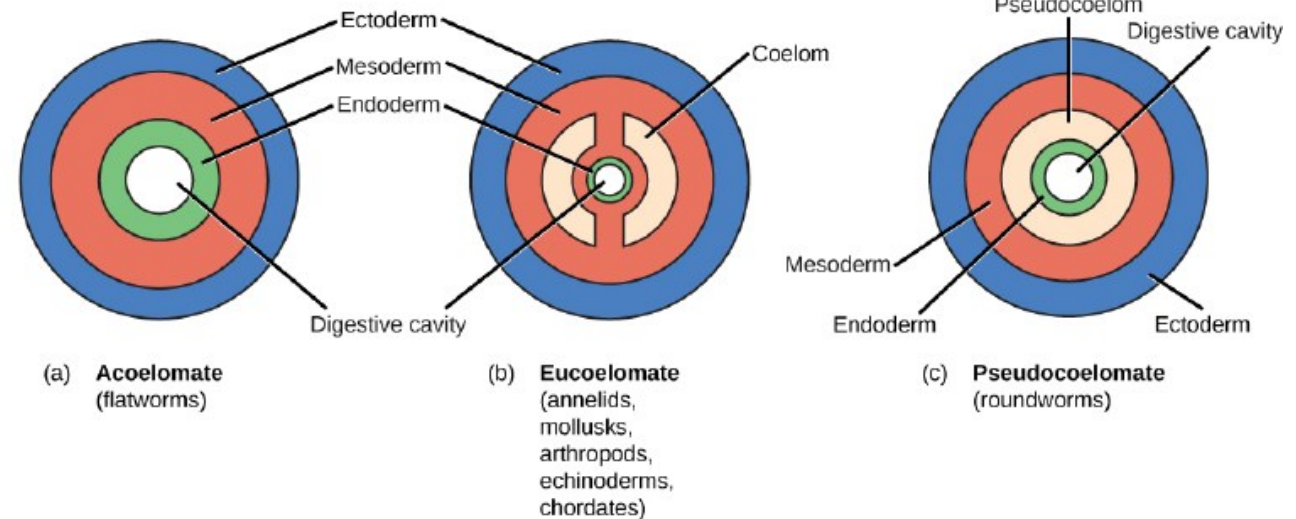
Which one of the following is a "post-zygotic" isolating mechanism of speciation?

(a) Behavioral isolation

(b) Fertilization failure

(c) Hybrid sterility

(d) Seasonal isolation

**Answer-(c) Explanation**

Hybrid sterility is a post-zygotic isolating mechanism because it occurs after fertilization. The hybrid offspring are sterile (e.g., mule), preventing gene flow between species, leading to reproductive isolation.

Desmosomes are

(a) intermediate filament-based cell adhesion complexes.

(b) protein synthesizing macromolecular complexes.

(c) subcellular organelles.

(d) DNA-protein complexes.

**Answer-(a ) Explanation**

Desmosomes are cell adhesion complexes that connect intermediate filaments of adjacent cells, providing mechanical strength in tissues like the skin and heart.
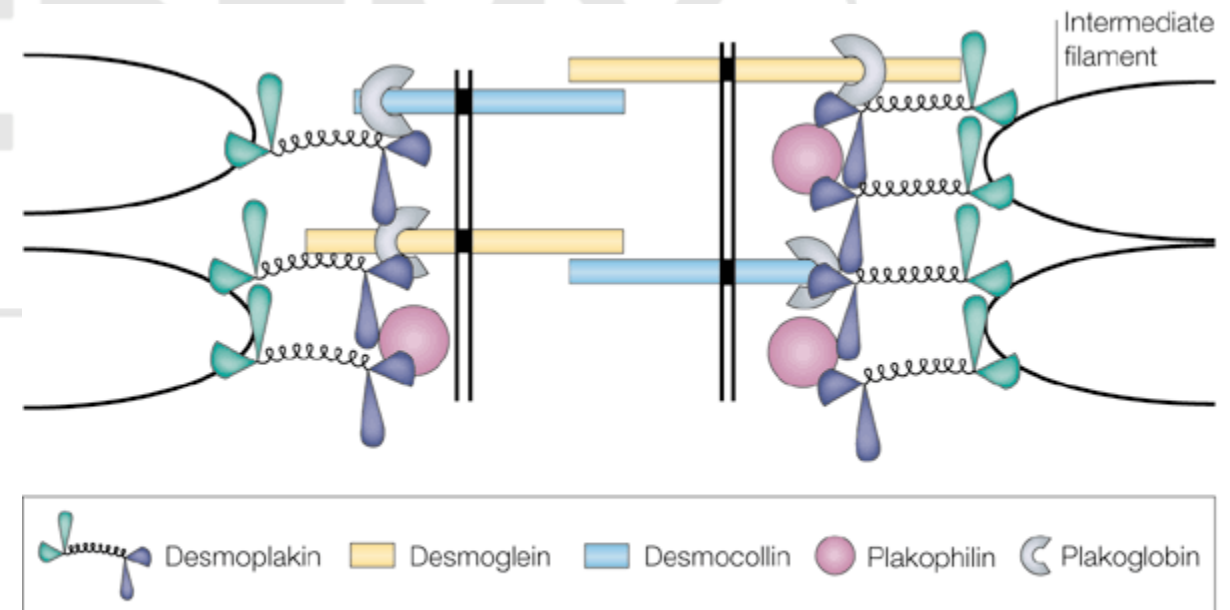


Nature Reviews | Molecular Cell Biology

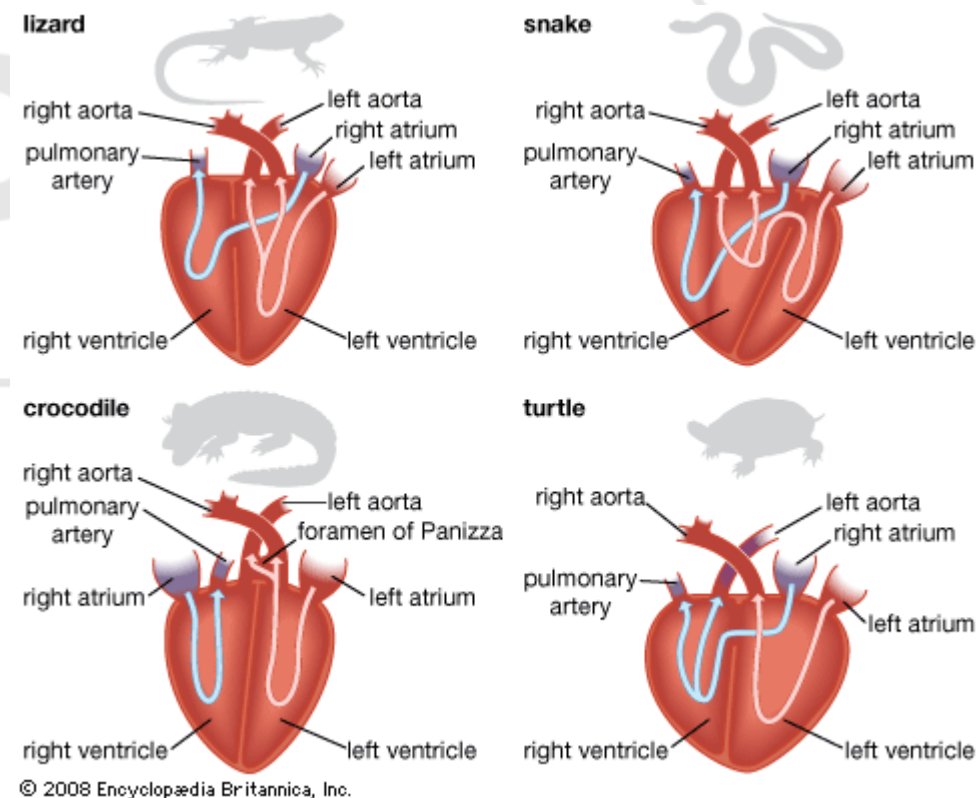The "foramen of Panizza" is found in which one of the following groups of animals?

(a) Fishes

(b) Crocodiles

(Cc) Frogs

(d) Dolphins

**Answer-(b ) Explanation**

The foramen of Panizza is a small opening connecting the left and right aorta in crocodiles, allowing them to shunt blood between the lungs and body, aiding in diving and conserving oxygen.



lizard

right aorta
pulmonary artery
left aorta
right atrium
left atrium
right ventricle
left ventricle

snake

right aorta
pulmonary artery
left aorta
right atrium
left atrium
right ventricle
left ventricle

crocodile

right aorta
pulmonary artery
right atrium
left aorta
foramen of Panizza
left atrium
right ventricle
left ventricle

turtle

right aorta
left aorta
right atrium
pulmonary artery
left atrium
right ventricle
left ventricle

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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)

**Answer-(0.99 to 0.99 ) Explanation**

**Step 2: Given Information**

- The frequency of genotype **aa** ($q^2$) is $\frac{1}{10000}$.

**Step 3: Calculate $q$**

$$q^2 = \frac{1}{10000}$$

$$q = \sqrt{\frac{1}{10000}} = \frac{1}{100} = 0.01$$

**Step 4: Calculate $p$**

Since $p + q = 1$:

$$p = 1 - q = 1 - 0.01 = 0.99$$

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)

**Answer-( 87.5 to 87.5) Explanation**

In PCR, after each cycle, the number of single-stranded DNA (ssDNA) increases.

After 3 cycles, the DNA distribution is:

1 original dsDNA (not radiolabeled)

7 newly synthesized dsDNA (radiolabeled)

8 ssDNA strands (radiolabeled)

Total DNA strands = 2(original)+14(from7dsDNA)+8(ssDNA)=24

Radiolabeled ssDNA = 8/24×100=87.5%

Therefore, the percentage of radiolabeled ssDNA is 87.5%.

Match the molecules in Column-I with their properties/functions mentioned in Column-II

(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−4 ; R−2 ; S−5

| Column-I | Column-II |
|----------|-----------|
| P. IgM | 1. Involved in antigen presentation |
| Q. IgE | 2. Predominant antibody type in various body secretions |
| R. IgA | 3. Can pass through placenta |
| S. MHC | 4. Associated with allergic reaction |
| | 5. Contains ten heavy and light chains |

**Answer-( b) Explanation**

IgM: Contains ten heavy and light chains as it is a pentamer (option 5).

IgE: Associated with allergic reactions by binding to mast cells (option 4).

IgA: Predominant in body secretions (saliva, tears, mucus) (option 2).

MHC: Involved in antigen presentation to T cells (option 1).

Match the following human diseases in Column-I with their causal organism in Column-II

(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

| 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* |
| | 5. *Rickettsia rickettsii* |

**Answer-( d) Explanation**

Sleeping sickness: Caused by Trypanosoma brucei, transmitted by the tsetse fly (option 2).Chagas disease: Caused by Trypanosoma cruzi, transmitted by Triatomine bugs (option 1).Elephantiasis: Caused by Wuchereria bancrofti, a parasitic nematode transmitted by mosquitoes (option 4).Lyme disease: Caused by Borrelia burgdorferi, transmitted by Ixodes ticks (option 3).

Match the molecules in Column-I with their correct property/function in Column-II

(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

| 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 |
| | 5. tRNA gene transcription |

**Answer-( c) Explanation**

RNase P: Functions as a ribozyme involved in tRNA processing (option 4).RNA Polymerase-I: Responsible for rRNA gene transcription (option 1).siRNA: Involved in gene silencing through RNA interference (option 2).Guide RNA: Directs Cas9 for genome editing in CRISPR systems (option 3).

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

**Answer-(c ) Explanation**

Genotypes: The cross is between AaBBCcDd x AaBBCcDd.For each gene:A/a: 3 genotypes (AA, Aa, aa)B: 1 genotype (BB)C/c: 3 genotypes (CC, Cc, cc)D/d: 3 genotypes (DD, Dd, dd)Total genotypes = 3 (A) x 1 (B) x 3 (C) x 3 (D) = 27Phenotypes:Dominant-recessive relationship for each gene pair:A: 2 phenotypes (Dominant, Recessive)B: 1 phenotype (Dominant)C: 2 phenotypes (Dominant, Recessive)D: 2 phenotypes (Dominant, Recessive)Total phenotypes = 2 (A) x 1 (B) x 2 (C) x 2 (D) = 8Therefore, 27 genotypes and 8 phenotypes are possible.

Nucleosomes are made up of DNA and histones. Histones undergo various kind 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

**Answer-(a.b ) Explanation**

Histone Writers are enzymes that add chemical groups to histones, modifying chromatin structure and gene expression.(a) Histone acetyl transferases (HATs) add acetyl groups to lysine residues, leading to gene activation by loosening chromatin structure.(b) Histone methyl transferases (HMTs) add methyl groups to histones, which can either activate or repress gene expression depending on the site of methylation.(c) Histone deacetylases (HDACs) are Erasers as they remove acetyl groups, leading to chromatin condensation and gene repression.(d) DNA methyl transferases modify DNA, not histones, and are involved in DNA methylation leading to gene silencing

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

**Answer-(b,d ) Explanation**

- **Logical Explanation:**

- **(b) ChIP-seq**: This technique uses an antibody specific to the transcription factor to pull down the DNA regions where the transcription factor is bound. By sequencing these regions, the exact binding sites within the promoter can be identified. This method provides in vivo evidence of transcription factor binding.

- **(d) DNase I footprinting**: This technique maps the precise binding site by treating the DNA-protein complex with DNase I, which cuts DNA at accessible regions. The bound transcription factor protects its binding site, creating a "footprint" that reveals the exact binding location.

- **Why Others Are Incorrect:**

- **(a) S1 nuclease mapping** is used to identify transcription start sites, not protein-DNA interactions.

- **(c) Electrophoretic mobility shift assay (EMSA)** detects DNA-protein interactions and can indicate binding but **does not pinpoint the exact binding site** within the promoter region.

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

**Answer-(a,c ) Explanation**

(A) Namdapha Flying Squirrel: Listed as Critically Endangered by IUCN due to habitat loss and restricted distribution.(C) Nicobar Shrew: Also Critically Endangered due to its limited range in Nicobar Islands and habitat destruction.(B) Indian Rhinoceros is listed as Vulnerable, not critically endangered.(D) Clouded Leopard is listed as Vulnerable by IUCN

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

**Answer-(b.d ) Explanation**

(b) Ingression: Mesodermal cells detach and move into the blastocoel, forming the primary mesenchyme, which later develops into mesoderm.(d) Invagination: The vegetal plate bends inward to form the archenteron, leading to the development of the endoderm.(a) Delamination and (c) Involution are not associated with these specific germ layers in sea urchin gastrulation.

Which of the following genetic disorders is/are caused by trinucleotide repeat expansions?

(a) Huntington's disease

(b) β-thalassemia

(c) Fragile X syndrome

(d) Cystic fibrosis

**Answer-(a,c ) Explanation**

(a) Huntington's disease: Caused by CAG trinucleotide repeat expansion in the HTT gene.(c) Fragile X syndrome: Caused by CGG trinucleotide repeat expansion in the FMR1 gene.(b) β-thalassemia and (d) Cystic fibrosis are caused by point mutations or deletions, not by trinucleotide repeat expansions.

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)

**Answer-(0.25 to 0.27 ) Explanation**

### Step 1: Determine Probabilities

For **cystic fibrosis**, the inheritance is **autosomal recessive**, so:
- **Probability of a normal child (NN or Nn)** = **3/4**
- **Probability of an affected child (nn)** = **1/4**

### Step 2: Apply Binomial Probability Formula

The probability of having exactly **k** normal children out of **n** total children is given by the binomial formula:

$$P(X = k) = \binom{n}{k} p^k (1-p)^{n-k}$$

Where:
- $n = 5$ (total children)
- $k = 3$ (exactly 3 normal children)
- $p = 3/4$ (probability of normal child)

$$P(X = 3) = \binom{5}{3}\left(\frac{3}{4}\right)^3 \left(\frac{1}{4}\right)^2$$

### Step 3: Calculate the Probability

1. Calculate the binomial coefficient:
$$\binom{5}{3} = \frac{5!}{3!\,(5-3)!} = \frac{5 \times 4}{2 \times 1} = 10$$

2. Calculate the probabilities:
$$\left(\frac{3}{4}\right)^3 = \frac{27}{64}$$
$$\left(\frac{1}{4}\right)^2 = \frac{1}{16}$$

3. Combine the terms:
$$P(X = 3) = 10 \times \frac{27}{64} \times \frac{1}{16} = 10 \times \frac{27}{1024} = 10 \times 0.026367 = 0.26367$$

4. Round to two decimal places:
$$P(X = 3) \approx 0.26$$

### Final Answer:
**0.26**

Q. An enzyme, which follows Michaelis-Menten equation, catalyzes the reaction

A→B. When enzyme and substrate concentrations are 15 nM and 10 μM, respectively, the reaction velocity is 5 μMs$^{-1}$. If Km for the substrate A is 5 μM, the kinetic efficiency of the enzyme will be _____×10$^6$ M$^{-1}$s$^{-1}$ (in integer)

**Answer-(100 to 100 ) Explanation**

Step 1: Use the Michaelis-Menten Equation

$$V_0 = V_{max}\frac{[S]}{K_m + [S]}$$

Where:
- $V_0 = 5\,\mu M\,s^{-1}$ (initial velocity)
- $[S] = 10\,\mu M$ (substrate concentration)
- $K_m = 5\,\mu M$ (Michaelis constant)

Step 2: Calculate $V_{max}$

Rearrange the Michaelis-Menten equation to solve for $V_{max}$:

$$V_{max} = V_0 \left(\frac{K_m+[S]}{[S]}\right)\ V_{max} = 5\left(\frac{5+10}{10}\right) = 5\left(\frac{15}{10}\right) = 5 \times 1.5 = 7.5\,\mu M\,s^{-1}$$

Step 3: Calculate Catalytic Efficiency

Catalytic efficiency is given by:

$$\text{Catalytic Efficiency} = \frac{K_{cat}}{K_m}$$

1. Calculate $K_{cat}$ using:

$$K_{cat} = \frac{V_{max}}{[E]}$$

Where:
- $[E] = 15\,nM = 0.015\,\mu M$

$$K_{cat} = \frac{7.5}{0.015} = 500\,s^{-1}$$

1. Calculate **Catalytic Efficiency**:

Catalytic Efficiency $= \frac{K_{cat}}{K_m} = \frac{500}{5\times10^{-6}}$ Catalytic Efficiency $= 10^8\,M^{-1}s^{-1}$

Expressing as $\times 10^6$:

$$\text{Catalytic Efficiency} = 100 \times 10^6\,M^{-1}s^{-1}$$

Which of the following contains the phytonutrient allicin?

(a) Grape

(b) Cauliflower

(c) Garlic

(d) Chilli

**Answer-(c ) Explanation**

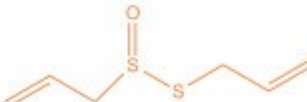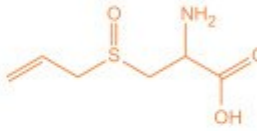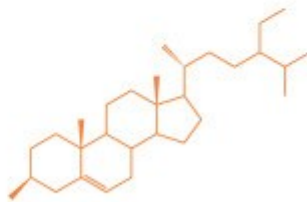Allicin is a sulfur-containing phytonutrient known for its antibacterial, antiviral, and anti-inflammatory properties.It is exclusively found in Garlic and is produced when garlic is crushed or chopped, activating the enzyme alliinase.Other options do not contain allicin:
Grape: Contains resveratrol.
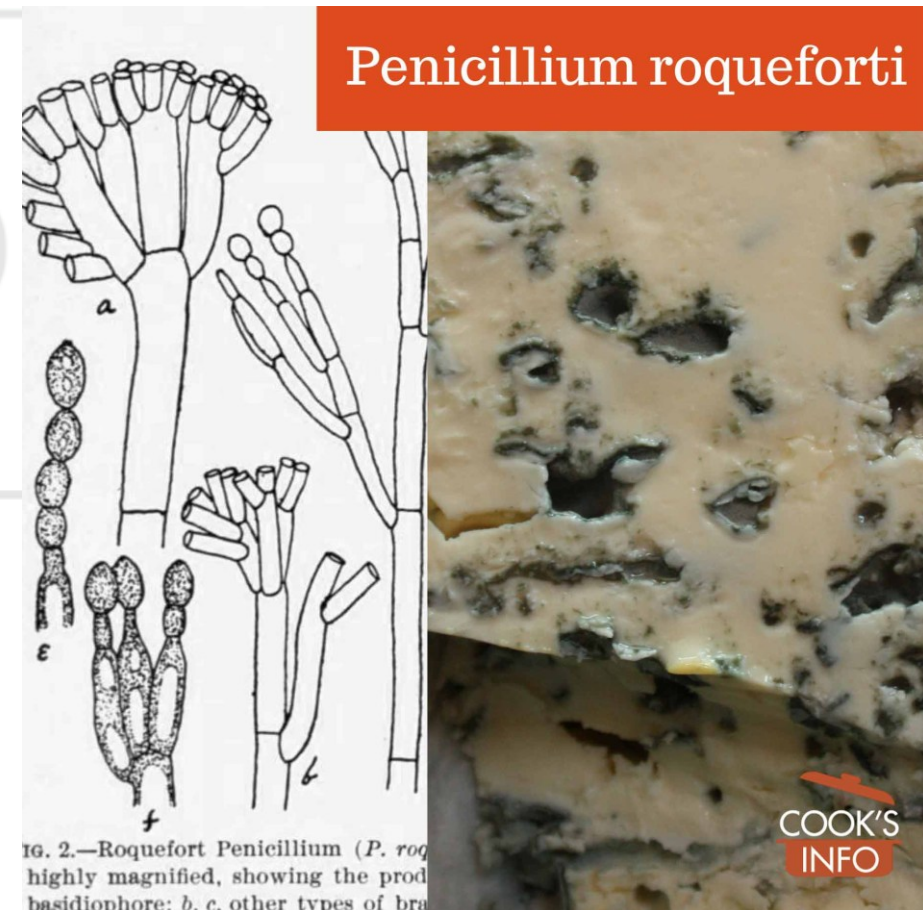Cauliflower: Contains glucosinolates.
Chilli: Contains capsaicin.

| Spice | Bioactive compounds | Chemical structure |
| --- | --- | --- |
| Garlic | Alliin | |
| | Allicin | |
| | Sitosterol | |
| | Ajoene | |

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

**Answer-( b) Explanation**

Penicillium roqueforti is a mold species responsible for the blue marbling in blue-veined cheeses such as Roquefort, Gorgonzola, and Stilton. It produces blue-green veins by growing in the air pockets of the cheese, giving it a distinct flavor and aroma. Other options are incorrect:Rhizopus oryzae: Involved in tempeh fermentation, not blue cheese. *Aspergillus niger*: Used for citric acid production. *Penicillium camemberti*: Used in Camembert and Brie, producing a white rind, not blue veins
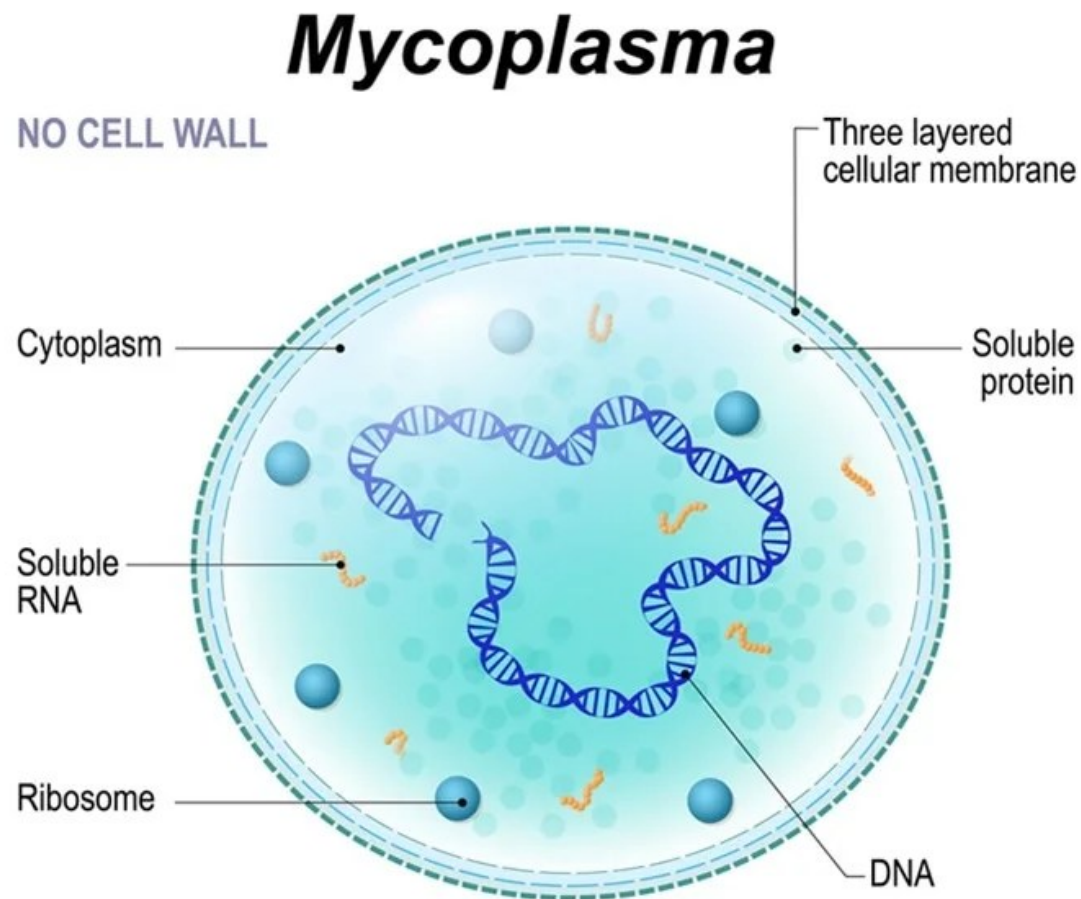
**Penicillium roqueforti**

IG. 2.—Roquefort Penicillium (*P. roq* highly magnified, showing the prod basidiophore: *b, c,* other types of bra

Which genus of bacteria does NOT have cell wall?

(a) Lactobacillus

(b) Staphylococcus

(c Mycoplasma

(d) Escherichia

**Answer-(c ) Explanation**
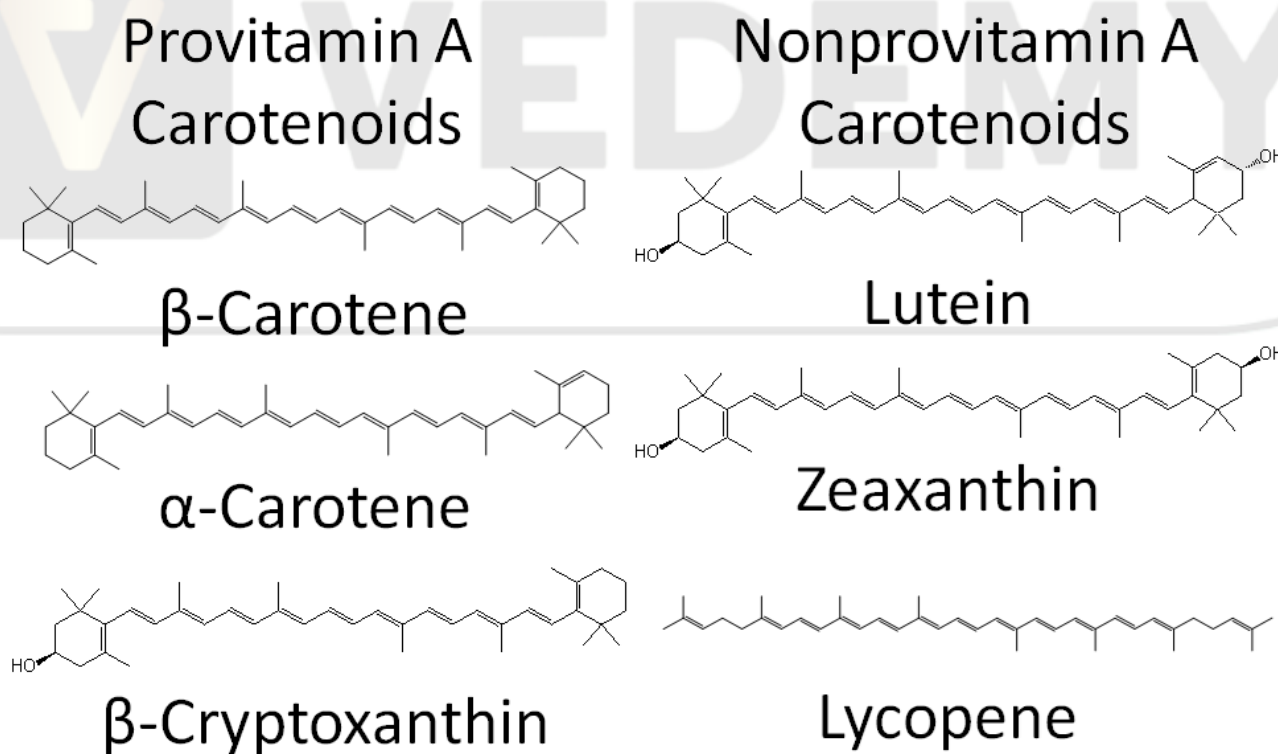
Mycoplasma is the only bacterial genus that lacks a cell wall, making it resistant to antibiotics like penicillin that target cell wall synthesis. Lactobacillus, Staphylococcus, and Escherichia all have peptidoglycan cell walls characteristic of typical bacteria.



**Mycoplasma**

NO CELL WALL

- Cytoplasm
- Soluble RNA
- Ribosome
- Three layered cellular membrane
- Soluble protein
- DNA

Which of the following pigment does NOT have pro-vitamin A activity?

(A) $\alpha$ Carotene

(B) $\beta$ -Cryptoxanthin

(C) Lycopene

(D) $\alpha$ Carotene

**Answer-( c) Explanation**



Provitamin A Carotenoids: β-Carotene, α-Carotene, β-Cryptoxanthin

Nonprovitamin A Carotenoids: Lutein, Zeaxanthin, Lycopene

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

**Answer-( a) Explanation**

Acid-insoluble ash content is measured first to judge cleanliness because it indicates the presence of dirt, sand, and other inorganic contaminants in spice/herb powders.It helps assess physical contamination, whereas other options assess chemical or biological impurities.

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

**Answer-(a ) Explanation**

Lipase activity in rice bran hydrolyzes triglycerides into free fatty acids (FFA).Delay in oil extraction allows lipase to act, leading to an increase in FFA, which deteriorates oil quality by causing rancidity. Other options are incorrect as they do not correctly link the cause (lipase activity) with the effect (increase in FFA).

Among the following, which is/are the process(es) that lead to generation of new fats from existing ones?

(Aa Transesterification

(b) Degumming

(c) Hydrogenation

(d) Winterization

**Answer-(a,c ) Explanation**

Transesterification: Converts existing fats into new forms by exchanging the fatty acid chains with alcohols, altering their physical and chemical properties.Hydrogenation: Adds hydrogen to unsaturated fats, converting them into saturated fats or trans fats, effectively creating new fat structures. Degumming and Winterization do not create new fats but are purification and stabilization processes.

The true density and bulk density of wheat grains are 1280 kg/m3 and 740 kg/m3, respectively. The porosity of the grains is _____. (rounded off to 2 decimal places)

To calculate the porosity (ε) of wheat grains, use the formula: $\varepsilon = 1 - \dfrac{\text{Bulk density}}{\text{True density}}$

Given:

True density = $1280\,\text{kg/m}^3$
Bulk density = $740\,\text{kg/m}^3$

Substitute the values: $\varepsilon = 1 - \dfrac{740}{1280} = 1 - 0.5781 = 0.4219$

Porosity (ε) = 0.42 (rounded to 2 decimal places).

Identify the gas composition (in percent) suitable for packaging cured meat under MAP conditions.

(a) O2 = 0; CO2 = 50; N2 = 50

(b) O2 = 50; CO2 = 0; N2 = 50

(c) O2 = 0; CO2 = 0; N2 = 100

(d) O2 = 50; CO2 = 50; N2 = 0

**Answer-(a) Explanation**

$O_2$ = 0%: To prevent oxidation and microbial growth.

$CO_2$ = 50%: To inhibit bacterial growth.

$N_2$ = 50%: To maintain package integrity and prevent collapse.

Thus, the answer is $O_2$ = 0; $CO_2$ = 50; $N_2$ = 50.

Which of the following sequence of events occurs during formation of egg-white gel?

Assume: PN: Native protein; PD: Denatured protein; PA: Aggregated protein; PG: Protein gel →: forward reaction; ↔ : reversible reaction; Δ: heating; ∇: cooling

(a) $P_N$ Δ ↔ PD ∇ ↔ PA ∇ ↔ PG

(b) $P_N$ Δ ↔ PD Δ → PA Δ → PG

(c) $P_N$Δ ↔ PD ∇ → PG

(d) $P_N$ Δ ↔ PA Δ → PG

**Answer-(b) Explanation**

PN Δ ↔ PD: Heating (Δ) causes native protein (PN) to unfold/denature (PD). This step is reversible (↔).

PD Δ → PA: Further heating denatured protein (PD) causes it to aggregate (PA). This step is generally considered irreversible (→).

PA Δ → PG: The aggregated proteins (PA) form a 3D network, resulting in a protein gel (PG). This is typically considered a forward reaction (→), not reversible by cooling.

Therefore, the correct answer is (b) PN Δ ↔ PD Δ → PA Δ → PG

In canning and retorting of foods, which of the following is the correct expression of Ball process time (B)?

Assume: tp = processor's process time; tc = come-up time

(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) $B = t_p + 0.25\ t_c$

**Answer-(a) Explanation**

0.42 is an experimentally determined factor that accounts for the lethality achieved during the come-up time.

In short, Total process time = Process time at temperature + 42% of come-up time.

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

**Answer-(c) Explanation**

BOPP (Biaxially Oriented Polypropylene): Provides excellent moisture barrier, clarity, and stiffness.

LDPE (Low-Density Polyethylene): Offers good sealing properties and flexibility.

This combination ensures protection from moisture and maintains the quality of dry fruits.

Thus, BOPP/LDPE is correct.

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

**Answer-(a) Explanation**

Slaughtering and bleeding: The bird is killed and bled.

Scalding: The bird is immersed in hot water to loosen feathers.

Defeathering: Feathers are removed.

Eviscerating: Internal organs are removed.

Chilling: The carcass is cooled to preserve quality.

Thus, (a) Slaughtering and bleeding → scalding → defeathering → eviscerating → chilling.

Which of the following statement(s) is/are TRUE for a package of gammairradiated (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.

**Answer-(b, c) Explanation**

(b) Spores of C. botulinum can survive in the irradiated product: Irradiation at 7.5 kGy does not destroy highly resistant spores like those of C. botulinum.
(c) 'Radura' symbol does not ensure safety of the irradiated product for consumption: The Radura symbol indicates irradiation but does not guarantee safety, which depends on proper handling and storage.
(a) is false because irradiation at 7.5 kGy does not significantly affect nutritional quality.
(d) is false because the energy required for irradiation is much lower than that needed for freezing.

Match the following food products in Column I with their corresponding processes in Column II

(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

| | Column I | | Column II |
|---|---|---|---|
| P | Idli | 1 | Baking |
| Q | Parboiled rice | 2 | Fermentation |
| R | Soda beverage | 3 | Gelatinization |
| S | Cookies | 4 | Carbonation |

**Answer-(a) Explanation**

Idli (P): Relies on Fermentation (2) for leavening and characteristic flavor.

Parboiled rice (Q): Involves Gelatinization (3) of starch during the parboiling process.

Soda beverage (R): Achieves its fizz through Carbonation (4).

Cookies (S): Prepared through Baking (1)

Therefore, the correct match is P-2, Q-3, R-4, S-1. This corresponds to option (a).

Which of the following is/are inhibitor(s) of enzymatic browning in peeled potatoes?

(a) Citric acid

(b) EDTA

(c) Mannitol

(d) Ascorbic acid

**Answer-(a, b, d) Explanation**

Enzymatic Browning: Enzymatic browning is an oxidation reaction. It requires the enzyme polyphenol oxidase (PPO), oxygen, and phenolic compounds (naturally present in potatoes). PPO catalyzes the oxidation of phenols to quinones, which then polymerize to form melanins, the brown pigments.

(a) Citric acid: Inhibits browning by lowering the pH, which reduces the activity of PPO. It also chelates copper, a cofactor for PPO.

(b) EDTA: Inhibits browning by chelating metal ions (like copper) required for PPO activity.

(c) Mannitol: Does not directly inhibit PPO. However, it can act as a protectant for proteins during drying or storage.

(d) Ascorbic acid: Inhibits browning by acting as a reducing agent. It reduces quinones back to their original phenolic form, preventing melanin formation.

Therefore, the correct answers are (a), (b), and (d).

Match the following enzymes in Column I with their applications in Column II

(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

|   | Column I | | Column II |
|---|---|---|---|
| P | β-Glucanase | 1 | Fruit juice clarification |
| Q | α- and β-Amylases | 2 | Bread making |
| R | Pectinase | 3 | Meat tenderization |
| S | Papain | 4 | Brewing |

**Answer-(b) Explanation**

β-Glucanase (P): Used in Brewing (4) to break down beta-glucans, reducing viscosity and improving filtration.

α- and β-Amylases (Q): Crucial for Bread making (2) to break down starch into sugars for yeast fermentation.

Pectinase (R): Used in Fruit juice clarification (1) to degrade pectin, reducing cloudiness.

Papain (S): Functions in Meat tenderization (3) by breaking down tough muscle fibers.

Therefore, the correct answer is P-4; Q-2; R-1; S-3.

The $F_{121}$ value of a known microorganism with Z value of 11 °C is 2.4 min for 99.9999% inactivation. For a 12D inactivation of the said microorganism at 143 °C, the F value (in min) is _____. (rounded off to 3 decimal places)

**Answer-(0.046 to 0.050 ) Explanation**

## Step 1: Understand the Given Data
- **$F_{121}$ value**: 2.4 minutes (time required for 99.9999% inactivation at 121°C).
- **Z value**: 11°C (change in temperature required to change the D value by a factor of 10).
- **Target inactivation**: 12D (12-log reduction).
- **Target temperature**: 143°C.

## Step 2: Calculate the D Value at 121°C
The **D value** is the time required for a 1-log reduction at a specific temperature. For 99.9999% inactivation (6-log reduction), the F value is related to the D value by:

$$F = n \cdot D$$

where $n$ is the number of log reductions. For 99.9999% inactivation, $n = 6$:

$$2.4 = 6 \cdot D_{121}$$
$$D_{121} = \frac{2.4}{6} = 0.4 \text{ minutes}$$

## Step 3: Calculate the D Value at 143°C
Using the **Z value**, we can calculate the D value at 143°C. The relationship between D values at two temperatures is:

$$\frac{D_{T1}}{D_{T2}} = 10^{\frac{T2-T1}{Z}}$$

Substitute $T1 = 121°C$, $T2 = 143°C$, and $Z = 11°C$:

$$\frac{D_{121}}{D_{143}} = 10^{\frac{143-121}{11}} = 10^2 = 100$$
$$D_{143} = \frac{D_{121}}{100} = \frac{0.4}{100} = 0.004 \text{ minutes}$$

## Step 4: Calculate the F Value for 12D Inactivation at 143°C
The F value for 12D inactivation is:

$$F = 12 \cdot D_{143}$$
$$F = 12 \cdot 0.004 = 0.048 \text{ minutes}$$

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)

**Answer-(6.25 to 6.32) Explanation**

To calculate the **work index** of the material, we use **Bond's Law**, which relates the energy required for grinding to the size reduction of the material. The formula for Bond's Law is:

$$W = 10 \cdot W_i \cdot \left(\frac{1}{\sqrt{P_{80}}} - \frac{1}{\sqrt{F_{80}}}\right)$$

where:
- $W$ is the specific energy consumption (kWh/tonne),
- $W_i$ is the work index (kWh/tonne),
- $F_{80}$ is the 80% passing size of the feed (μm),
- $P_{80}$ is the 80% passing size of the product (μm).

### Step 1: Convert Sizes to Microns
- $F_{80} = 4.75\,\text{mm} = 4750\,\text{μm}$,
- $P_{80} = 0.5\,\text{mm} = 500\,\text{μm}$.

### Step 2: Calculate Specific Energy Consumption ($W$)
The power required to grind 2 tonnes/h of the feed material is 3.8 kW. The specific energy consumption is:

$$W = \frac{\text{Power}}{\text{Feed Rate}} = \frac{3.8\,\text{kW}}{2\,\text{tonnes/h}} = 1.9\,\text{kWh/tonne}$$

### Step 3: Solve for Work Index ($W_i$)
Substitute the values into Bond's Law:

$$1.9 = 10 \cdot W_i \cdot \left(\frac{1}{\sqrt{500}} - \frac{1}{\sqrt{4750}}\right)$$

Calculate the terms in the parentheses:

$$\frac{1}{\sqrt{500}} = \frac{1}{22.36} = 0.0447$$

$$\frac{1}{\sqrt{4750}} = \frac{1}{68.92} = 0.0145$$

$$\frac{1}{\sqrt{500}} - \frac{1}{\sqrt{4750}} = 0.0447 - 0.0145 = 0.0302$$

Now solve for $W_i$:

$$1.9 = 10 \cdot W_i \cdot 0.0302$$

$$W_i = \frac{1.9}{10 \cdot 0.0302} = \frac{1.9}{0.302} = 6.29\,\text{kWh/tonne}$$