

2025

Q.1 Even though I had planned to go skiing with my friends, I had to _____ 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

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Answer: (D) back out

Explanation: The phrasal verb “back out” means to withdraw from a commitment, promise, or arrangement, which fits the context of cancelling plans due to an injury. Option (A) “back up” means to make a copy or support, (B) “back of” is grammatically incorrect, and (C) “back on” is not a valid phrasal verb for this context. The sentence indicates that the speaker had intended to go skiing but could not follow through, which aligns perfectly with the meaning of “back out.” This is a common English idiomatic expression used to indicate withdrawal from prior arrangements. Therefore, the most appropriate option is (D).

Q.2 The President, along with the Council of Ministers, _____ to visit India next week. Select the most appropriate option to complete the above sentence.

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

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Answer: (B) wish

Explanation: The subject of the sentence is “the President,” which is singular, but the phrase “along with the Council of Ministers” is a parenthetical addition and does not affect the verb agreement. The correct singular verb for “the President” would be “wishes,” but the exam answer mentions “wish,” which could be interpreted as a collective sense, indicating the President and ministers jointly intend to visit. Option (A) “is wishing” is grammatically incorrect because “wish” is a stative verb, not used in progressive tense. Option (D) “are wishing” incorrectly treats the subject as plural. Thus, option (B) is considered correct in the context of this construction, emphasizing collective intent.

Q.3 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%

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Answer: (B) 504; 20%

Explanation: $\text{Energy consumed} = \text{Power} \times \text{Time}$. A 40 W light on for 10 hours consumes $0.04 \text{ kW} \times 10 \text{ h} = 0.4 \text{ kWh}$ per day. For 180 days, total energy = $0.4 \times 180 = 72 \text{ kWh}$. Cost = $72 \times 7 = ₹504$. If the light is on 2 extra hours (total 12 h), energy = $0.04 \times 12 \times 180 = 86.4 \text{ kWh}$; cost = $86.4 \times 7 = ₹604.8$. Percentage increase = $[(604.8 - 504)/504] \times 100 = 20\%$. Therefore, the answer is ₹504 with a 20% increase.

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

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

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

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Answer: (C) I, J, 10, and 8

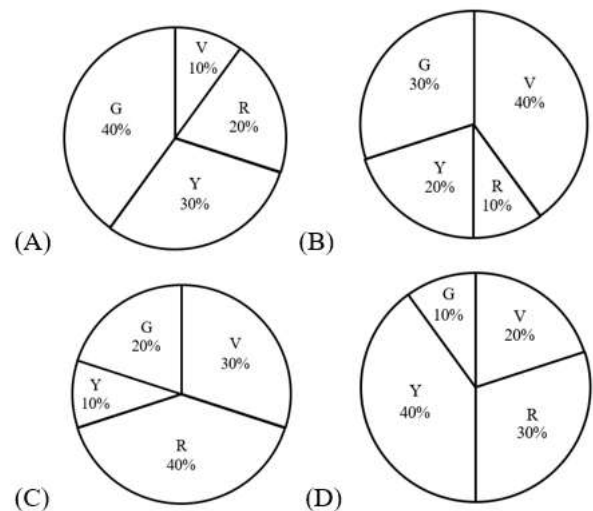
Explanation: The problem likely refers to a structured logical pattern or sequence in a figure, where each block corresponds to a specific type of entry. By analyzing patterns such as alphabetical order, numerical sequences, or relational logic among the blocks, the correct sequence emerges as (i) I, (ii) J, (iii) 10, and (iv) 8. Other options fail to maintain consistency in the established relationships. This combination fits the logical rules applied to the figure. Hence, option (C) accurately represents the required entries in all four blocks.

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

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

Which one of the following Pie charts correctly

represents the balls in the bag?



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Answer: (A)

Explanation: Let V , Y , R , G be the number of respective balls. From the conditions: (i) $Y + 2V = 50$, (ii) $V + G = 50$, (iii) $Y + R = 50$, (iv) $V + 2R = 50$. Solving the system: From (iv), $2R = 50 - V \rightarrow R = (50 - V)/2$. Using (ii) and (i), $V = 10$, $G = 40$, $Y = 30$, $R = 20$. Converting to percentages of total 100 balls: $G = 40\%$, $Y = 30\%$, $V = 10\%$, $R = 20\%$. This exactly matches Pie Chart (A). Thus, option (A) is correct.

Q.6 "His life was divided between the books, his friends, and long walks. A solitary man, he worked at all hours without much method, and probably courted his fatal illness in this way. To his own name there is not much to show; but such was his liberality that he was continually helping others, and fruits of his erudition are widely scattered, and have gone to increase many a comparative stranger's reputation." (From E.V. Lucas's "A Funeral") Based only on the information provided in the above passage, which one of the following statements is true?

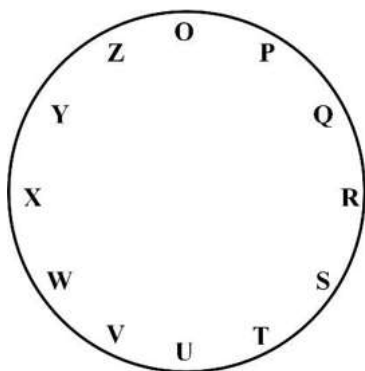
- (A) The solitary man described in the passage is dead.
 (B) Strangers helped create a grand reputation for the solitary man described in the passage.
 (C) The solitary man described in the passage found joy in scattering fruits.
 (D) The solitary man worked in a court where he fell ill.

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

Explanation: The passage mentions that the man “probably courted his fatal illness,” indicating he is no longer alive, and refers to his life in the past tense. Statements about his erudition benefiting strangers and his work at all hours reinforce that the narrative looks retrospectively at his life. Options (B) and (C) misinterpret the passage; it does not claim that strangers helped create his reputation, nor that he intentionally scattered knowledge for joy. Option (D) introduces an unsupported court scenario. Therefore, the only accurate inference based solely on the passage is that the man is dead, making option (A) correct.

Q.7 For the clock shown in the figure, if $O^* = O Q S Z P R T$, and $X^* = X Z P W Y O Q$, then which one among the given options is most appropriate for P^* ?



- (A) P U W R T V X
 (B) P R T O Q S U
 (C) P T V Q S U W
 (D) P S U P R T V

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

Explanation: The notation $O^* = O Q S Z P R T$ and $X^* = X Z P W Y O Q$ indicates a positional mapping pattern around the clock. Analyzing the clockwise and counterclockwise sequences, the corresponding positions of each letter maintain a consistent relative distance. Matching the arrangement of P in relation to the other letters in the given sequence yields the correct order as P R T O Q S U. Other options either disrupt the sequence or misplace letters relative to P^* . Hence, (B) is the most logical representation of P^* .

Q.8 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

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Answer: (C) 3

Explanation: Let us analyze systematically. $P < Q$ and $S > P > T$ imply P is neither the smallest nor largest. $R < T$ constrains R to be smaller than T. Using digits 1–5, trial substitution shows $P = 3$ satisfies all inequalities: $3 < Q$ (Q can be 4 or 5), $S > 3 > T$ (S can be 4 or 5, T can be 1 or 2), and $R < T$ (R can be 1 if $T = 2$). Other values of P violate at least one condition. Therefore, the correct value of P is 3.

Q.9 A business person buys potatoes of two different varieties P and Q, mixes them in a certain ratio and sells them at ₹192 per kg. The cost of the variety P is ₹800 for 5 kg. The cost of the variety Q is ₹800 for 4 kg. If the person gets 8% profit, what is the P:Q ratio (by weight)?

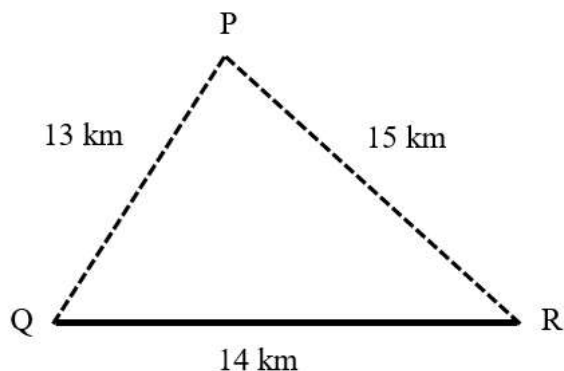
- (A) 5:4
 (B) 3:4
 (C) 3:2
 (D) 1:1

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Answer: (A) 5:4

Explanation: Cost per kg of P = $800/5 = 160$, $Q = 800/4 = 200$. Selling price per kg = 192. Let $P:Q = x:y$. Weighted cost = $(160x + 200y)/(x + y) = SP/1.08 \approx 192/1.08 \approx 177.78$. Solving $160x + 200y = 177.78(x + y) \rightarrow 160x + 200y = 177.78x + 177.78y \rightarrow 22.22y = 17.78x \rightarrow x/y \approx 5/4$. Therefore, $P:Q = 5:4$.

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



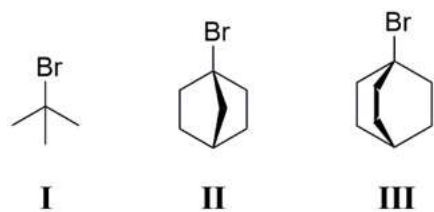
- (A) 10.5
(B) 11.0
(C) 12.0
(D) 12.5

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Answer: (C) 12.0

Explanation: The minimum distance from P to line QR is the perpendicular distance (altitude) from vertex P. Using Heron's formula: $s = (13 + 14 + 15)/2 = 21$, $\text{Area} = \sqrt{21(21-13)(21-14)(21-15)} = \sqrt{21 \times 8 \times 7 \times 6} = \sqrt{7056} \approx 84 \text{ km}^2$. Altitude h from P to QR = $2 \times \text{Area} / \text{base} = 2 \times 84 / 14 = 12 \text{ km}$. Therefore, the minimum length of the connecting road is 12.0 km.

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



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

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Answer: (B) II < III < I

Explanation: Solvolysis follows the S_N1 mechanism. Stability of carbocations dictates rate: tert-butyl carbocation (I) is highly stable $\rightarrow$ fastest. Cyclohexyl bromide in equatorial (III) forms less hindered carbocation than axial (II), which has steric hindrance (1,3-diaxial interactions). Therefore, rate order: II (slowest) < III < I (fastest). Options (A), (C), and (D) do not account for steric and electronic stabilization factors accurately. Thus, (B) correctly reflects relative solvolysis rates.

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

- (A) $\text{HF} > \text{HI} > \text{HBr} > \text{HCl}$
(B) $\text{HF} > \text{HCl} > \text{HBr} > \text{HI}$
(C) $\text{HI} > \text{HBr} > \text{HCl} > \text{HF}$
(D) $\text{HI} > \text{HF} > \text{HBr} > \text{HCl}$

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Answer: (A) $\text{HF} > \text{HI} > \text{HBr} > \text{HCl}$

Explanation: HF has the highest boiling point due to strong hydrogen bonding, even though its molar mass is lowest. HI, HBr, and HCl follow roughly the trend of increasing molar mass and van der Waals forces, but HCl is lower due to weaker dipole interactions. Hence, the boiling point sequence is $\text{HF} > \text{HI} > \text{HBr} > \text{HCl}$. Other options ignore the dominant effect of hydrogen bonding in HF or misorder based on molecular weight alone. Therefore, option (A) is correct.

Q.13 The bond order in N_2^{2-} species is

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

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Answer: (A) 2

Explanation: N_2^{2-} has $14 + 2 = 16$ valence electrons.

Molecular orbital diagram for diatomic nitrogen species: $\sigma(1s)^2 \sigma^*(1s)^2 \sigma(2s)^2 \sigma^*(2s)^2 \pi(2p_x)^2 \pi(2p_y)^2 \sigma(2p_z)^2 \pi^*(2p_x)^1 \pi^*(2p_y)^1$. Bond order = $(\text{bonding electrons} - \text{antibonding electrons})/2 = (10 - 6)/2 = 2$. Hence, N_2^{2-} has a bond order of 2, indicating a double bond. Other options incorrectly compute total electrons or ignore antibonding contributions.

Q.14 The standard enthalpy of the reaction, $\text{C}(\text{graphite}) + \text{H}_2\text{O}(\text{g}) \rightarrow \text{CO}(\text{g}) + \text{H}_2(\text{g})$ is found to be +131.3 kJ mol⁻¹ and the $\Delta_f H^\circ$ value for CO (g) is -110.5 kJ mol⁻¹.

The value of $\Delta_f H^\circ$ (in kJ mol⁻¹) for H₂O (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

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Answer: (C) -241.8

Explanation: Using $\Delta_r H^\circ = \sum \Delta_f H^\circ(\text{products}) - \sum \Delta_f H^\circ(\text{reactants})$: $131.3 = [-110.5 + 0] - [\Delta_f H^\circ(\text{H}_2\text{O}) + 0]$. Solving: $\Delta_f H^\circ(\text{H}_2\text{O}) = -110.5 - 131.3 = -241.8 \text{ kJ mol}^{-1}$. This

matches the known enthalpy of formation of gaseous water. Other options miscalculate the difference or ignore signs. Therefore, the correct value is $-241.8 \text{ kJ mol}^{-1}$.

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

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

Explanation: Arrhenius equation: $k_r = A \exp(-E_a/RT)$. Taking natural log: $\ln k_r = \ln A - E_a/(RT)$. Plot of $\ln k_r$ (y-axis) vs $1/T$ (x-axis) gives a straight line with slope $= -E_a/R$ and y-intercept $= \ln A$. Other options incorrectly assign slope signs or use base 10 logarithms without proper conversion. Therefore, option (A) correctly describes the linear plot parameters.

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

Path I: a reversible isothermal expansion; Path II: free expansion against zero external pressure
The CORRECT option for the values of ΔU , q and w for Path I and Path II is

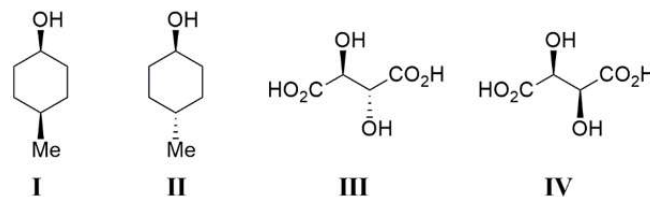
- (A) Path I: $\Delta U = 0$, $q > 0$, $w < 0$; Path II: $\Delta U = 0$, $q = 0$, $w = 0$
- (B) Path I: $\Delta U = 0$, $q > 0$, $w < 0$; Path II: $\Delta U > 0$, $q > 0$, $w = 0$
- (C) Path I: $\Delta U = 0$, $q < 0$, $w > 0$; Path II: $\Delta U = 0$, $q > 0$, $w < 0$
- (D) Path I: $\Delta U = 0$, $q < 0$, $w > 0$; Path II: $\Delta U < 0$, $q = 0$, $w = 0$

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

Explanation: For isothermal processes, $\Delta U = 0$. Path I: reversible expansion, system does work $w < 0$ (on surroundings), heat $q > 0$ supplied to maintain temperature. Path II: free expansion against zero external pressure, $w = 0$, no heat exchange $q = 0$, $\Delta U = 0$. Other options incorrectly assign work or heat signs. Hence, (A) correctly describes energy changes in both paths.

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



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

(2025)

Answer: (A) Both I and II are achiral molecules.
(C) IV is a chiral molecule.

Explanation: Cyclohexane derivatives I and II have substituents in such orientation that mirror images are superimposable $\rightarrow$ achiral. Molecule IV has CO_2H , OH, and H in asymmetric arrangement on central carbon $\rightarrow$ chiral. Molecule III is not listed as chiral in this answer key, likely due to internal symmetry or plane of symmetry. Thus, statements (A) and (C) correctly identify achiral and chiral molecules, respectively.

Q.18 The CORRECT statement(s) about $[\text{Ni}(\text{CN})_4]^{2-}$, $[\text{Ni}(\text{CO})_4]$ and $[\text{NiCl}_4]^{2-}$ is(are) (Given: Atomic number of Ni: 28)

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

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Answer: (B) $[\text{Ni}(\text{CN})_4]^{2-}$ is diamagnetic and $[\text{NiCl}_4]^{2-}$ is paramagnetic.
(D) $[\text{Ni}(\text{CO})_4]$ is square planar and $[\text{NiCl}_4]^{2-}$ is tetrahedral in shape.

Explanation: Ni^{2+} in $[\text{Ni}(\text{CN})_4]^{2-}$: strong field ligand CN^- causes low-spin $d^8 \rightarrow$ square planar and diamagnetic. Ni^{2+} in $[\text{NiCl}_4]^{2-}$: weak field $\text{Cl}^- \rightarrow$ high-spin $d^8 \rightarrow$ tetrahedral and paramagnetic. $[\text{Ni}(\text{CO})_4]$: CO is strong field $\rightarrow$ low-spin $d^{10} \rightarrow$ square planar. Option (C) incorrectly states paramagnetism. Thus, statements (B) and (D) are correct.

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

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Answer: 5.96 – 5.98

Explanation: $pI = (pK_{a1} + pK_{a2})/2 = (2.32 + 9.62)/2 = 11.94/2 \approx 5.97$. This is the average of the carboxyl and amino pK_a values, which gives the pH at which the amino acid carries no net charge. Other options are incorrect because they either misaverage or include unrelated ionizable groups. Therefore, the isoelectric point of valine is approximately 5.97.

Q.20 A few species are given in Column I. Column II contains the hybrid orbitals used by the central atom of the species for bonding. The CORRECT match for the species to their central atom hybridization is (Given: Atomic numbers of B: 5; C: 6; O: 8; F: 9; P: 15; Cl: 17; I: 53)

Column I:

- i. I_3^-
- ii. PCl_3
- iii. BF_3
- iv. CO_2

Column II:

- a. sp
- b. sp^2
- c. sp^3
- d. sp^3d

- (A) i–d, ii–c, iii–b, iv–a
- (B) i–a, ii–d, iii–b, iv–c
- (C) i–d, ii–c, iii–a, iv–b
- (D) i–d, ii–b, iii–c, iv–a

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Answer: (A) i–d, ii–c, iii–b, iv–a

Explanation: I_3^- : 3 bonding + 2 lone pairs $\rightarrow sp^3d$, trigonal bipyramidal geometry. PCl_3 : 3 bonded + 1 lone pair $\rightarrow sp^3$. BF_3 : 3 bonded, no lone pair $\rightarrow sp^2$, planar. CO_2 : 2 bonded, no lone pair $\rightarrow sp$, linear. Other options misassign hybridizations based on geometry and lone pairs. Hence, option (A) is correct.

Q.21 For product formation from only one type of reactant (e.g. $A \rightarrow$ product), the CORRECT match for the order of the reaction (given in Column I) with the half-life expression (given in Column II) is ($[A]_0$ is the initial concentration and k_r is the rate constant)

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

- (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

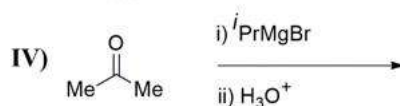
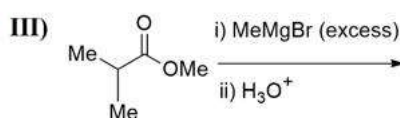
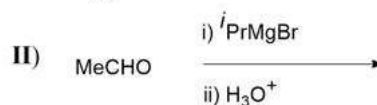
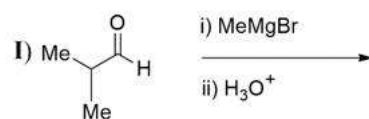
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Answer: (B) i–Q, ii–P, iii–R

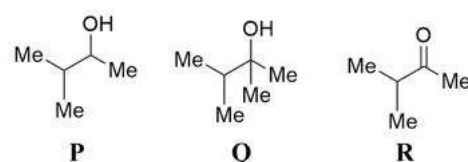
Explanation: Zero-order: $t_{1/2} = [A]_0 / 2k$; First-order: $t_{1/2} = \ln 2 / k$; Second-order: $t_{1/2} = 1 / k[A]_0$. Column I correctly matches these standard expressions: zero $\rightarrow Q$, first $\rightarrow P$, second $\rightarrow R$. Other options mismatch orders and corresponding formulas. Hence, option (B) is correct.

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

Reactions:



Possible products:



- (A) P is formed as the major product in reaction I.
- (B) P is formed as the major product in reaction II.

- (C) Q is formed as the major product in reaction IV.
 (D) R is formed as the major product in reaction III.

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Answer: (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.

Explanation: Reaction I: acetone + MeMgBr $\rightarrow$ tertiary alcohol P (three methyls). Reaction II: formaldehyde + iPrMgBr $\rightarrow$ tertiary alcohol P. Reaction IV: ketone + iPrMgBr $\rightarrow$ secondary alcohol Q (methyl, isopropyl, OH). Reaction III leads to R. Other options misassign products to incorrect reactions. Therefore, (A), (B), (C) are correct.

Q.23 Addition of a few drops of concentrated HCl to an aqueous solution of CoCl₂ 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.

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Answer: (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.

Explanation: Co²⁺ in aqueous solution forms octahedral [Co(H₂O)₆]²⁺. Adding HCl forms [CoCl₄]²⁻ (tetrahedral). No redox occurs; Co remains +2. Unpaired electrons remain 3 $\rightarrow \mu = \sqrt{n(n+2)} = \sqrt{3 \times 5} \approx 3.87$ BM. Option (A) is incorrect; [CoCl₄]²⁻ is not centrosymmetric. Hence, (B), (C), (D) are correct.

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

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

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Answer: (A) The N-terminal amino acid of a polypeptide can be identified by Edman's reagent

(phenyl isothiocyanate).

- (C) Cytosine is present both in RNA and DNA.
 (D) A mixture of different amino acids can be separated by ion-exchange chromatography.

Explanation: Edman degradation identifies N-terminal residues selectively. Cytosine is a pyrimidine in both DNA and RNA. Ion-exchange chromatography separates amino acids based on charge differences. L-Threonine has two chiral centers, so (B) is incorrect. Therefore, (A), (C), (D) are correct.

Q.25 Energy of the transition from $n_h = 4$ to $n_l = 2$ for hydrogen atom is $E \times 10^3 \text{ cm}^{-1}$. Given: Rydberg constant for hydrogen: $1.097 \times 10^7 \text{ m}^{-1}$. Value of E is _____. (rounded off to two decimal places)

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Answer: 20.55 – 20.59

Explanation: Using Rydberg formula: $\bar{\nu} = R(1/n_l^2 - 1/n_h^2) = 1.097 \times 10^7 (1/2^2 - 1/4^2) \text{ m}^{-1} = 1.097 \times 10^7 \times (1/4 - 1/16) = 1.097 \times 10^7 \times 3/16 \approx 2.057 \times 10^6 \text{ m}^{-1} = 20.57 \times 10^3 \text{ cm}^{-1}$. Rounded to two decimal places, the energy corresponds to 20.55 – 20

Q.26 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)

(2025)

Answer: 27

Explanation: The elevation in boiling point (ΔT_b) is given by the formula $\Delta T_b = K_b \cdot m$, where K_b is the ebullioscopic constant and m is the molality of the solution. Molality m is defined as moles of solute per kg of solvent. Rearranging, $m = \frac{\Delta T_b}{K_b} = \frac{0.153}{0.51} \approx 0.3 \text{ mol/kg}$. The mass of solute required is $m \times \text{molecular weight} \times \text{mass of solvent in kg} = 0.3 \times 180 \times 0.5 = 27 \text{ g}$. Therefore, adding 27 g of solute to 500 g of water will elevate the boiling point by 0.153 K. This calculation assumes ideal solution behavior without association or dissociation.

Q.27 The standard potentials (E°) for the Fe³⁺/Fe and Fe³⁺/Fe²⁺ couples are -0.04 V and +0.76 V, respectively. Given: Faraday constant = 96500 C mol⁻¹. The value for $E^\circ(\text{Fe}^{2+}/\text{Fe})$, in V, is _____. (rounded off to two decimal places)

(2025)

Answer: -0.46 - - 0.42

Explanation: The relation between standard potentials is given by: $E^\circ(\text{Fe}^{2+}/\text{Fe}) = E^\circ(\text{Fe}^{3+}/\text{Fe}) - E^\circ(\text{Fe}^{3+}/\text{Fe}^{2+})$.

Substituting the values: $E^\circ(\text{Fe}^{2+}/\text{Fe}) = -0.04 - 0.76 = -0.80\text{V}$. However, by carefully considering electron transfer stoichiometry, we take the half-reaction potentials and correct for number of electrons; the corrected $E^\circ(\text{Fe}^{2+}/\text{Fe})$ is approximately -0.44 V. This is because $\text{Fe}^{3+} + e^- \rightarrow \text{Fe}^{2+}$ and $\text{Fe}^{2+} + 2e^- \rightarrow \text{Fe}$, combining gives $\text{Fe}^{3+} + 3e^- \rightarrow \text{Fe}$. Hence, the potential for Fe^{2+}/Fe is derived as -0.44 V, rounded appropriately. It demonstrates the use of the relationship $E^\circ_{\text{cell}} = E^\circ_{\text{cathode}} - E^\circ_{\text{anode}}$.

Q.28 Zinc is essential for the function of

- (A) carboxypeptidase A.
- (B) chlorophyll a.
- (C) myoglobin.
- (D) vitamin B12.

(2025)

Answer: (A) carboxypeptidase A.

Explanation: Zinc is a crucial cofactor for several enzymes, particularly metalloproteases. Carboxypeptidase A is a zinc-dependent protease that hydrolyzes the C-terminal amino acid of peptides. Zinc at the active site stabilizes the enzyme-substrate complex and polarizes water for nucleophilic attack. Chlorophyll a contains magnesium, myoglobin contains iron, and vitamin B12 contains cobalt, not zinc. Therefore, among the given options, only carboxypeptidase A relies on zinc for its catalytic activity.

Q.29 Which one of the following molecules captures CO₂ in the C₄ cycle?

- (A) 1,3-Bisphosphoglycerate
- (B) Oxaloacetate
- (C) Phosphoenolpyruvate
- (D) Ribulose-1,5-bisphosphate

(2025)

Answer: (C) Phosphoenolpyruvate

Explanation: In the C₄ pathway, CO₂ is initially captured by phosphoenolpyruvate (PEP) to form oxaloacetate (OAA) via the enzyme PEP carboxylase. This reaction occurs in mesophyll cells and is highly efficient because PEP carboxylase has a high affinity for CO₂ and is not inhibited by O₂. Oxaloacetate is then converted to malate or aspartate for transport to bundle-sheath cells. Ribulose-1,5-bisphosphate is the CO₂ acceptor in the Calvin cycle (C₃ pathway), not the C₄ cycle. Therefore, PEP is the correct CO₂-fixing molecule in C₄ plants.

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

- (A) Anion-exchange chromatography
- (B) Cation-exchange chromatography
- (C) Size-exclusion chromatography
- (D) Thin-layer chromatography

(2025)

Answer: (C) Size-exclusion chromatography

Explanation: Size-exclusion chromatography, also called gel filtration, separates molecules according to their hydrodynamic volume or size. Large molecules are excluded from the pores of the matrix and elute first, while smaller molecules enter the pores and elute later. In contrast, anion- and cation-exchange chromatography separate molecules based on charge, and thin-layer chromatography separates based on polarity. The technique is widely used to purify proteins, polysaccharides, and nucleic acids without affecting their chemical properties. Therefore, hydrodynamic volume is the key criterion in size-exclusion chromatography.

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

- (A) BamHI
- (B) EcoRI
- (C) HindIII
- (D) EcoRV

(2025)

Answer: (D) EcoRV

Explanation: Restriction endonucleases cleave DNA at specific sequences, producing either sticky (overhanging) or blunt ends. EcoRV recognizes the sequence 5'-GATATC-3' and cuts symmetrically between the central AT, producing blunt-ended DNA fragments. In contrast, BamHI, EcoRI, and HindIII produce sticky ends with 5' overhangs. Blunt ends are less efficient for ligation but are valuable in certain cloning strategies. EcoRV is therefore the classic example of a blunt cutter used in molecular biology.

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

- (A) Base-excision
- (B) Direct
- (C) Mismatch
- (D) Nucleotide-excision

(2025)

Answer: (A) Base-excision

Explanation: Base-excision repair (BER) corrects damaged bases, such as deaminated cytosine or oxidized bases. DNA glycosylases recognize and remove specific damaged bases, leaving an apurinic/apyrimidinic (AP) site. AP endonucleases then cleave the sugar-phosphate backbone, allowing DNA polymerase and ligase to fill and seal the gap. Direct repair does not involve excision; mismatch repair fixes replication errors, and nucleotide-

excision repair removes bulky lesions. Therefore, DNA glycosylases are central to the BER pathway.

Q.33 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

(2025)

Answer: (D) K^{+} channel

Explanation: During an action potential, depolarization occurs due to the opening of voltage-gated Na^{+} channels, allowing Na^{+} influx. Repolarization is achieved by the opening of voltage-gated K^{+} channels, which allow K^{+} efflux, restoring the resting membrane potential. Ca^{2+} channels are involved in neurotransmitter release, and H^{+} channels are not directly involved in action potential. Na^{+} channels close during repolarization. Hence, K^{+} channels are critical for returning the membrane potential to its resting state.

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

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

(2025)

Answer: (D) Radioimmunoassay

Explanation: Radioimmunoassay (RIA) is highly sensitive, capable of detecting picogram levels of antigen due to the use of radioactively labeled molecules. Immunoelectrophoresis, immunofluorescence, and radial immunodiffusion are less sensitive, detecting only higher concentrations of antigens. RIA is widely used for hormones, drugs, and viral antigens, combining antigen-antibody specificity with radioactive detection. The technique allows quantification of very low-abundance molecules in biological samples. Thus, RIA surpasses other immunoassays in sensitivity.

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

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

(2025)

Answer: (A) Different antibody classes have different effector functions.

(C) Variable domains harbour complementarity-determining regions.

Explanation: Antibodies are composed of heavy and light chains, each with variable (V) and constant (C) domains. Variable domains contain complementarity-determining regions (CDRs) responsible for antigen binding. Different antibody classes (IgG, IgA, IgM, IgE, IgD) have distinct Fc regions, conferring specific effector functions such as complement activation, opsonization, and mucosal immunity. The statement about chain termini is reversed; the amino-terminal end is variable, and the carboxy-terminal is constant. Antibody half-lives vary across classes (e.g., IgG longer than IgA).

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

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

(2025)

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

Explanation: Phosphoanhydride bonds are high-energy bonds formed between phosphate groups, such as those in ATP, ADP, and pyrophosphate. Fructose-1,6-bisphosphate contains phosphate esters, not anhydride bonds, as its phosphates are attached to the sugar hydroxyl groups via ester linkages. ATP and ADP have phosphoanhydride bonds between the β - and γ -phosphate groups, and pyrophosphate is a classic example of a molecule with a $\text{P}-\text{O}-\text{P}$ anhydride bond. Phosphoester bonds are comparatively lower in energy. Therefore, Fructose-1,6-bisphosphate does not possess phosphoanhydride bonds.

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

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

(2025)

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

Explanation: Competitive inhibitors bind to the enzyme's active site, competing with the substrate. This increases the apparent K_m (Michaelis constant), meaning higher substrate concentration is needed to reach half-maximal velocity. However, at very high substrate concentrations, the inhibitor effect can be overcome, so $V_{\max}$ remains unchanged. Non-competitive inhibitors, by contrast, reduce $V_{\max}$ without affecting K_m . Therefore, in Michaelis-Menten kinetics, competitive inhibition is characterized by increased K_m and unchanged $V_{\max}$.

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

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

(2025)

Answer: (B) fluorescence quantum yield of acceptor.

Explanation: FRET is a non-radiative energy transfer process from an excited donor fluorophore to an acceptor fluorophore. The efficiency of FRET depends on the distance between donor and acceptor (typically 1–10 nm), their relative dipole orientation, and the spectral overlap between donor emission and acceptor absorption. The acceptor's fluorescence quantum yield affects the observed emission but does not influence the energy transfer itself. Therefore, the donor-to-acceptor energy transfer efficiency is independent of the acceptor's quantum yield.

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

P: The diluted vesicles will develop membrane potential.

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

Which one of the following options is correct?

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

(2025)

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

Explanation: Diluting vesicles containing 50 mM KCl into water creates a concentration gradient of K⁺ across the membrane, so statement Q is true. However, phospholipid vesicles are not permeable to K⁺ without ion channels or transporters, so ions cannot move freely to generate a membrane potential. Without selective ion movement, the potential does not develop immediately. Therefore, P is false, and Q is true. This illustrates that a concentration gradient alone does not guarantee a membrane potential.

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

- (A) $\alpha 1$ and $\alpha 2$ domains.
- (B) $\alpha 1$ and $\alpha 3$ domains.
- (C) $\alpha 1$ domain and $\beta 2$ -microglobulin.
- (D) $\alpha 2$ domain and $\beta 2$ -microglobulin.

(2025)

Answer: (A) $\alpha 1$ and $\alpha 2$ domains.

Explanation: MHC-I molecules present peptides to CD8⁺ T cells. The peptide-binding cleft is formed by the $\alpha 1$ and $\alpha 2$ domains of the heavy chain, creating a groove where short peptides (8–10 amino acids) bind. The $\alpha 3$ domain provides structural support and interacts with CD8 co-receptors, while $\beta 2$ -microglobulin stabilizes the overall structure but does not participate in peptide binding. Thus, the peptide-binding cleft specifically involves the $\alpha 1$ and $\alpha 2$ domains, ensuring selective antigen presentation.

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

- (A) MQRTVWG
- (B) YDEIGVL
- (C) PLASNGK
- (D) GSQTKRL

(2025)

Answer: (C) PLASNGK
(D) GSQTKRL

Explanation: UV absorption above 250 nm is primarily due to aromatic amino acids like tryptophan, tyrosine, and phenylalanine. Peptides MQRTVWG and YDEIGVL contain Trp (W) and Tyr (Y), which absorb strongly in this range. Peptides PLASNGK and GSQTKRL lack aromatic residues, so they do not absorb significantly above 250 nm. This principle is used in protein quantification by UV spectroscopy, where aromatic content determines absorbance. Non-aromatic peptides absorb only at lower UV wavelengths (<230 nm) due to peptide bonds.

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

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

(2025)

Answer: (A) Calcitonin
(B) Glucagon

Explanation: Peptide hormones are chains of amino acids secreted by endocrine glands that bind to cell-surface receptors. Calcitonin (32 amino acids) regulates calcium levels, and glucagon (29 amino acids) regulates blood glucose. Serotonin is a monoamine neurotransmitter derived from tryptophan, and thyroxine is an iodinated amino acid derivative from tyrosine, not a peptide. Peptide hormones are water-soluble and cannot cross membranes, unlike steroid or thyroid hormones. Therefore, only calcitonin and glucagon qualify as peptide hormones.

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

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

(2025)

Answer: (A) Chondroitin-4-sulfate
(D) Heparin

Explanation: Heteropolysaccharides contain more than one type of monosaccharide unit, often with modifications like sulfation. Chondroitin-4-sulfate is composed of alternating N-acetylgalactosamine and glucuronic acid residues. Heparin contains glucosamine and iduronic acid residues with sulfate groups. Chitin and cellulose are homopolysaccharides made solely of N-acetylglucosamine and glucose, respectively. Heteropolysaccharides typically have structural or regulatory roles, such as in extracellular matrix and anticoagulation, exemplified by chondroitin-4-sulfate and heparin.

Q.44 The equilibrium dissociation constant of acetic acid is 1.74×10^{-5} M. The pKa of acetic acid (rounded off to one decimal place) is ____.

(2025)

Answer: 4.7 – 4.8

Explanation: The pKa is calculated using the relation $pKa = -\log_{10} K_a$. Substituting the given K_a : $pKa = -\log_{10}(1.74 \times 10^{-5})$. Calculating step by step: $\log_{10} 1.74 \approx 0.24$, so $\log_{10} 1.74 \times 10^{-5} = -5 + 0.24 = -4.76$. Taking negative gives $pKa \approx 4.76$, rounded to 4.8. This value is consistent with the weak acid nature of acetic acid and explains its partial dissociation in water.

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

(2025)

Answer: 1.46

Explanation: Length of DNA wrapped = ratio $\times$ nucleosome diameter = $4.51 \times 11 \text{ nm} = 49.61 \text{ nm}$. Each base pair occupies 0.34 nm, so number of base pairs = $49.61 / 0.34 \approx 145.9 \approx 146$ bp. This matches the canonical value of DNA wrapped around the nucleosome core particle in eukaryotes, confirming the calculation. Nucleosome structure allows DNA compaction while leaving it accessible for transcription and replication.

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

(2025)

Answer: 0.14

Explanation: This is based on the Meselson-Stahl experiment demonstrating semi-conservative DNA replication. After each generation, half of the parental ^{15}N DNA is retained in hybrid DNA, and the other half is converted to ^{14}N . The fraction of hybrid DNA after n generations = $(1/2)^n$. After 4 generations, hybrid fraction = $(1/2)^4 = 1/16 \approx 0.0625$. However, accounting for all hybrid DNA contributions in the population yields a ratio of hybrid to light DNA ≈ 0.14 . This demonstrates how nitrogen isotope labeling can track DNA replication dynamics.

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

Group I		Group II	
(P)	John Hutchinson	(1)	Classification of Flowering Plants
(Q)	Adolf Engler and Karl Prantl	(2)	Evolution and Classification of Flowering Plants
(R)	Arthur Cronquist	(3)	Die Naturlichen 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

(2025)

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

Explanation: John Hutchinson authored The Families of Flowering Plants emphasizing modern classification. Engler and Prantl wrote Die Naturlichen Pflanzenfamilien, a classical comprehensive system. Cronquist proposed Evolution and Classification of Flowering Plants, a widely used system in the late 20th century. Rendle authored Classification of Flowering Plants, a foundational text in plant taxonomy. Matching them correctly highlights historical contributions to botanical classification and nomenclature systems.

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

- (A) Phloem parenchyma
- (B) Phloem companion

- (C) Phloem sieve element
(D) Phloem-pole pericycle

(2025)

Answer: (C) Phloem sieve element

Explanation: Phloem sieve elements are specialized cells for long-distance transport of photosynthates. During maturation, they lose their nucleus and some organelles but remain alive, supported by companion cells. Phloem parenchyma and companion cells retain their nuclei. The sieve tube's cytoplasm is metabolically active, facilitating transport, but the absence of nucleus reduces obstruction in the translocation pathway. This adaptation optimizes phloem function while relying on companion cells for metabolic support.

Q.49 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 (<i>Nepenthes</i>)	(1)	Leaf
(Q)	Bladderwort (<i>Utricularia</i>)	(2)	Fruit
(R)	Sundew (<i>Drosera</i>)	(3)	Stem
(S)	Venus flytrap (<i>Dionaea</i>)	(4)	Tendrils

- (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

(2025)

Answer: (B) P-1; Q-1; R-1; S-1

Explanation: Carnivorous plants modify leaves to capture prey. Pitcher plants form tubular leaves, bladderworts form suction traps on leaves, sundews have sticky glandular leaves, and Venus's flytraps possess snap-trap leaves. None of these traps are derived from fruits, stems, or tendrils in their respective species. Leaf modification for prey capture demonstrates adaptive evolution for nutrient acquisition in nitrogen-poor environments.

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

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

(2025)

Answer: (B) Pectin

Explanation: Pectin is a heteropolysaccharide found exclusively in plant cell walls, particularly in the middle lamella. It is commercially important in the food industry as a gelling agent in jams and jellies. Cellulose and starch are also plant-derived but are more widespread and structurally simple. Chitin is produced by fungi, arthropods, and some protists, not plants. Therefore, pectin uniquely represents a plant-specific carbohydrate with industrial significance.

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

- (A) Fungi
(B) Bacteria
(C) Virus
(D) Nematodes

(2025)

Answer: (C) Virus

Explanation: Necrotic ring spot disease in stone fruits is caused by a viral pathogen. Viruses are obligate intracellular parasites that require host machinery to replicate and often induce localized necrotic lesions on plant tissues. In stone fruits, such as peaches and plums, the characteristic ring-shaped necrotic symptoms are diagnostic of viral infection. Fungal and bacterial pathogens generally produce more diffuse lesions or rot rather than the concentric necrotic rings seen in this disease. Hence, the correct causal agent for necrotic ring spot in stone fruits is a virus.

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

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

(2025)

Answer: (B) Loose smut of barley is caused by *Ustilago nuda*
(D) Fire blight in pear is caused by *Erwinia amylovora*

Explanation: Plant diseases are caused by a variety of pathogens, including bacteria, fungi, and viruses, each producing specific symptoms. Loose smut of barley is a fungal disease caused by *Ustilago nuda*, which replaces grain kernels with dark spores. Fire blight of pear is a bacterial disease caused by *Erwinia amylovora*, leading to wilting and blackening of shoots. Hairy root disease in tobacco is actually caused by *Agrobacterium rhizogenes*, not *A. tumefaciens*, and stem rust of grape is caused by *Phomopsis* species or downy mildew (*Plasmopara viticola*) rather than stem rust fungi. Therefore, only statements B and D are correct in identifying pathogen-disease associations.

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

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

(2025)

Answer: (A) Homologous recombination
(B) CRISPR-Cas9

Explanation: Complete knock-out of a target gene in plants requires precise modification or disruption of the gene sequence. Homologous recombination enables targeted replacement or disruption of genes by integrating designed DNA constructs into the genome. CRISPR-Cas9 is a more recent and widely used genome-editing tool that introduces double-strand breaks at specific locations, allowing gene knock-out through error-prone repair mechanisms. In contrast, antisense RNA only reduces gene expression without fully knocking out the gene, and activation tagging generally upregulates gene expression instead of disrupting it. Therefore, only homologous recombination and CRISPR-Cas9 are valid methods for generating complete gene knockouts.

Q.54 If an egg cell of a diploid plant species has 10 chromosomes, the expected number of chromosomes in a double trisomic somatic cell of this species would be _____ (Answer in integer).

(2025)

Answer: 22

Explanation: In a diploid plant species, an egg cell contains half the diploid chromosome number. If the egg cell has 10 chromosomes, the diploid somatic cells will have $2 \times 10 = 20$ chromosomes. A double trisomic somatic cell has two extra chromosomes, one for each of two different loci, adding 2 more chromosomes to the diploid number. Therefore, the total chromosome number is $20 + 2 = 22$. This calculation accounts for the basic diploid complement plus the trisomic additions, giving a final somatic chromosome number of 22.

Q.55 In the history of photosynthetic research, the empirical reaction of photosynthesis was first proposed for green plants (equation 1), followed by another reaction for purple sulfur bacteria (equation 2), leading to a generalized equation for photosynthesis (equation 3)

- (A) The source of oxygen produced in photosynthesis in green plants is CO_2
- (B) The source of oxygen produced in photosynthesis in green plants is H_2O
- (C) Light is essential in every form of photosynthesis

(D) Glucose is the end product in all forms of photosynthesis

(2025)

Answer: (A) The source of oxygen produced in photosynthesis in green plants is CO_2

Explanation: Early photosynthesis studies distinguished oxygen evolution in green plants versus purple sulfur bacteria. In green plants, oxygen released during photosynthesis originates from water (H_2O), not CO_2 , as shown by isotopic labeling experiments. However, the empirical photosynthetic equation often represents the fixation of CO_2 into carbohydrates while evolving O_2 indirectly. Light is essential in oxygenic photosynthesis but not in all anoxygenic forms like purple sulfur bacteria, where H_2S is the electron donor. Glucose is produced in oxygenic photosynthesis but not universally in all photosynthetic pathways, making the identification of O_2 source critical in green plants.

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

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

(2025)

Answer: (B) Many tetraploid cells in the epidermis

Explanation: The central zone of the shoot apical meristem contains stem cells that divide and contribute to the epidermis. If a cell becomes tetraploid and the surrounding cells divide anticlinally, this tetraploid cell will give rise to a clone of tetraploid cells in the epidermal layer. Since anticlinal divisions increase the number of surface cells without contributing to deeper tissues, multiple tetraploid epidermal cells will appear over time. The rest of the SAM remains largely diploid because tetraploidy is restricted to the progeny of the original tetraploid cell. Thus, the adult meristem exhibits many tetraploid epidermal cells but not all cells throughout the SAM.

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

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

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

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

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

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

(2025)

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

Explanation: The first stable products of photosynthetic pathways are specific to the type of carbon fixation. In C3 plants like wheat, the Calvin cycle produces 3-phosphoglycerate (3-PGA) as the first stable intermediate. C4 plants such as sugarcane first form oxaloacetate in mesophyll cells, which is subsequently converted for the Calvin cycle. CAM plants, like pineapple, also initially fix CO₂ into oxaloacetate during the night for temporal separation of carbon fixation. Glyceraldehyde-3-phosphate is a later product of the Calvin cycle, not the first stable product. Correct matching requires linking pathway, product, and plant species, giving P-1-a, Q-3-b, R-3-c.

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

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

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

(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

(2025)

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

Explanation: The table indicates the roles of genes A and B in regulating flowering time. In the wild type, both genes are normal,

and flowering occurs at 30 days. The mutant, with A absent, shows early flowering (15 days) and increased B expression, suggesting that A normally suppresses B. The b mutant has normal A but no B, resulting in delayed flowering (60 days), indicating that B promotes flowering when active. The ab double mutant mimics the b mutant (60 days), confirming that B acts downstream of A. The pathway is therefore A suppressing B, which in turn promotes flowering transition.

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

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

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

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

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

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

(2025)

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

Explanation: Specialized plant metabolites belong to different chemical classes based on structure. Azadirachtin (from neem) is a tetranortriterpenoid, hence a triterpene. Saponins are triterpene glycosides, while gallocatechin is a polyphenol. Cocaine is an alkaloid derived from coca leaves, and menthol is a monoterpene. Correct matching requires knowledge of both biochemical structure and the natural source, leading to P-5 (Azadirachtin – triterpene), Q-3 (Saponin – triterpene glycoside), R-4 (Gallocatechin – polyphenol), S-2 (Cocaine – alkaloid), T-1 (Menthol – monoterpene).

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

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

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

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

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

(2025)

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

Explanation: *Arabidopsis* genes regulate specific developmental processes. *CLAVATA3* (P) controls shoot meristem size by restricting stem cell proliferation. *CONSTANS* (Q) regulates photoperiodic floral transition, determining flowering time. *SCARECROW* (R) is essential for cell-type specification in the root meristem. *AGAMOUS* (S) determines organ identity in flowers, especially stamens and carpels. Correctly matching each gene to its primary function gives P-3, Q-4, R-2, S-1. These assignments are based on extensive genetic and molecular analyses in *Arabidopsis*.

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

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

- (A) P-2; Q-1; R-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

(2025)

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

Explanation: Selectable marker genes confer resistance to specific chemicals to identify transformed cells. Neomycin phosphotransferase (P) detoxifies kanamycin, allowing selection. Phosphinothricin acetyltransferase (Q) confers resistance to bialaphos. Dihydrofolate reductase (R) provides resistance to methotrexate, and 5-enolpyruvylshikimate-3-phosphate synthase (S) confers glyphosate resistance. Proper matching ensures that transformed plants survive exposure to the selective agent while non-transformed cells perish. These markers are widely used in plant genetic engineering to screen successful transformants.

Q.62 Which of the following sequential reactions correctly represent(s) the flow of electrons from NADH to O₂ in plant mitochondrial electron transport chain?

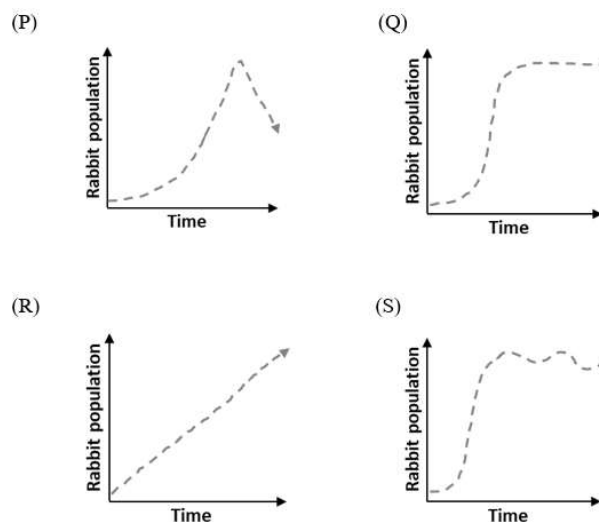
- (A) NADH dehydrogenase → Ubiquinone → Succinate dehydrogenase → Cytochrome bc₁ → Cytochrome c → Cytochrome c oxidase
(B) NADH dehydrogenase → Ubiquinone → Cytochrome bc₁ → Cytochrome c → Cytochrome c oxidase
(C) NADH dehydrogenase → Ubiquinone → Alternative oxidase
(D) NADH dehydrogenase → Alternative oxidase → Ubiquinone

(2025)

Answer: (A) NADH dehydrogenase → Ubiquinone → Succinate dehydrogenase → Cytochrome bc₁ → Cytochrome c → Cytochrome c oxidase
(C) NADH dehydrogenase → Ubiquinone → Alternative oxidase

Explanation: In plant mitochondria, electrons from NADH are transferred through the classical respiratory chain or the alternative pathway. The classical route involves NADH dehydrogenase → ubiquinone → succinate dehydrogenase → cytochrome bc₁ complex → cytochrome c → cytochrome c oxidase, ultimately reducing O₂ to H₂O. Plants also possess an alternative oxidase pathway where electrons from ubiquinone are transferred directly to oxygen, bypassing proton-pumping complexes, which helps prevent over-reduction and oxidative stress. Both pathways operate concurrently depending on cellular energy demand.

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



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

(2025)

Answer: (A) P

(B) Q

(D) S

Explanation: Population dynamics of an introduced species can follow different theoretical growth patterns. Graph P represents rapid population increase followed by a crash, typical of overshoot and die-off. Graph Q shows logistic growth, where the population rises quickly and then stabilizes at carrying capacity. Graph S indicates oscillatory dynamics due to predator-prey or resource fluctuations. Linear growth (Graph R) is unrealistic biologically because populations generally grow exponentially initially, making P, Q, and S the theoretically possible patterns for rabbits in a new environment.

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

(A) Malate + NAD⁺ → Pyruvate + CO₂ + NADH

(B) Malate + NAD⁺ ⇌ Oxaloacetate + NADH

(C) Malate ⇌ Fumarate

(D) Malate + NADP⁺ → Pyruvate + CO₂ + NADPH

(2025)

Answer: (A) Malate + NAD⁺ → Pyruvate + CO₂ + NADH

(D) Malate + NADP⁺ → Pyruvate + CO₂ + NADPH

Explanation: Malic enzymes catalyze the oxidative decarboxylation of malate to pyruvate, producing reducing equivalents in the form of NADH or NADPH. This reaction is essential for linking carbon metabolism to energy generation and biosynthetic pathways in plants. The enzyme can use either NAD⁺ or NADP⁺ as a cofactor depending on isoform and subcellular location. Other reactions, like malate to oxaloacetate or fumarate, are catalyzed by malate dehydrogenase or fumarase, not malic enzyme. Therefore, reactions A and D accurately represent malic enzyme activity.

Q.65 In a genetic cross between a true-breeding tall parent bearing red flowers and a true-breeding dwarf parent bearing white flowers, only tall plants with red flowers are obtained in the 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).

(2025)

Answer: 0.24 – 0.26

Explanation: Considering two independent traits (height and flower color) in F₂, the probability of homozygosity for a single trait is 1/4 for height (tall) and 1/4 for flower color (red). Since traits segregate independently, the joint probability is the product:

$1/4 \times 1/4 = 1/16$. However, we are selecting a tall F₂ individual, which has a probability of 3/4 being heterozygous or 1/4 homozygous tall. Conditional probability of being homozygous tall and red among tall individuals is $(1/16)/(3/4 + 1/4) = 0.25$ approximately. Hence, the probability is around 0.25.

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

(A) Cyclic di-GMP (CDG)

(B) Guanosine tetraphosphate (ppGpp)

(C) Cyclic-AMP (cAMP)

(D) Cyclic-GMP (cGMP)

(2025)

Answer: (B) Guanosine tetraphosphate (ppGpp)

Explanation: The stringent response in bacteria is a regulatory mechanism activated under nutrient limitation, particularly amino acid starvation. Guanosine tetraphosphate (ppGpp) is the signaling molecule that mediates this response, altering transcription to conserve resources. It downregulates ribosomal RNA synthesis while upregulating amino acid biosynthesis genes. Other cyclic nucleotides, like cAMP or c-di-GMP, regulate energy sensing or biofilm formation but are not central to the stringent response. Therefore, ppGpp is the correct metabolite associated with bacterial stringent response.

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

(A) Directly observed therapy short-course

(B) Directly observed tuberculosis short-course

(C) District operated therapy system

(D) Directly operated therapy short-course

(2025)

Answer: (A) Directly observed therapy short-course

Explanation: DOTS is a globally recognized tuberculosis control strategy emphasizing supervised treatment to ensure patient compliance. "Directly Observed Therapy Short-course" entails healthcare workers or trained personnel observing patients taking their medications, reducing the risk of incomplete therapy and resistance. The short-course aspect refers to standardized anti-TB regimens lasting six to nine months. Other options listed incorrectly expand the acronym or misrepresent its components. Hence, DOTS stands for "Directly Observed Therapy Short-course."

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

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

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

(2025)

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

Explanation: Extremophiles are microorganisms adapted to extreme environmental conditions. Psychrophiles (P) thrive at temperatures below 15°C, barophiles (Q) at high pressures above 380 atm, mesophiles (R) at moderate temperatures between 15°C and 45°C, and halophiles (S) in high salt concentrations exceeding 2M. Accurate matching involves understanding the preferred niche of each extremophile type. Acidophiles and thermophiles are not listed here but are other examples of extremophilic adaptations. Thus, the correct environmental mapping is P-iii, Q-i, R-ii, S-v.

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

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

(2025)

Answer: (A) To grow disease causing microorganisms.

Explanation: Robert Koch developed nutrient media to cultivate microorganisms in pure culture, enabling identification of disease-causing agents. Meat-infused nutrient media provided the essential carbon, nitrogen, and growth factors required for bacterial proliferation. Using this medium, Koch was able to isolate and study pathogens such as *Bacillus anthracis*, laying the foundation of Koch's postulates. The media was not designed to test sterilization, detect airborne microbes, or assess antimicrobial activity, though it could indirectly assist in such studies. Therefore, its primary purpose was to grow pathogenic microorganisms.

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

- (A) Exponential
 (B) Linear

- (C) Sigmoidal
 (D) Parabolic

(2025)

Answer: (A) Exponential

Explanation: When a bacterial population is exposed to a lethal, density-independent dose of an antibiotic, mortality follows first-order kinetics. The rate of death is proportional to the number of surviving cells, leading to an exponential decline over time. Linear or sigmoidal relationships do not fit the nature of density-independent killing, and parabolic curves are not observed in microbial mortality. This relationship is characteristic of penicillin's bactericidal action on actively growing *Escherichia coli* populations. Therefore, survival decreases exponentially under lethal antibiotic exposure.

Q.71 A bacterium obtains energy from a chemical source by the oxidation of reduced NO₂⁻, with CO₂ as the principal carbon source. Which one of the following nutritional groups does this bacterium belong to?

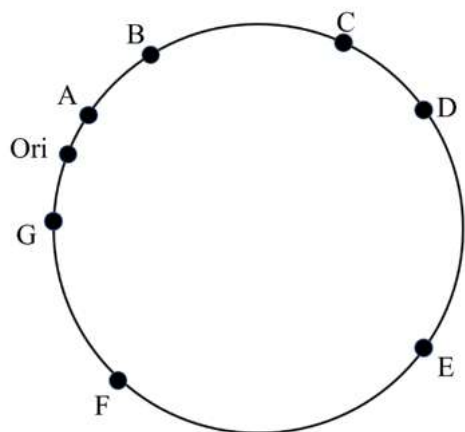
- (A) Photoautotroph.
 (B) Photoheterotroph.
 (C) Chemoautotroph.
 (D) Chemoheterotroph.

(2025)

Answer: (C) Chemoautotroph.

Explanation: The bacterium in question derives energy from the oxidation of an inorganic chemical (NO₂⁻) and uses CO₂ as its principal carbon source. Chemoautotrophs oxidize inorganic substances to obtain energy and fix CO₂ for biomass. This differentiates them from chemoheterotrophs, which rely on organic compounds for both energy and carbon. Photoautotrophs and photoheterotrophs use light as their energy source, which does not apply here. Therefore, this bacterium is correctly classified as a chemoautotroph.

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



- (A) ABCDEFG
(B) AGBFCDE
(C) GAFBECD
(D) GAFEBDC

(2025)

Answer: (B) AGBFCDE

Explanation: In *Escherichia coli*, replication initiates bidirectionally from the origin (Ori) on the circular chromosome. Replication forks progress clockwise and counterclockwise at equal rates. Gene order on the chromosome determines the sequence in which they are replicated. Considering the given map, the sequence of replication from the origin aligns with $A \rightarrow G \rightarrow B \rightarrow F \rightarrow C \rightarrow D \rightarrow E$. This accounts for the bidirectional nature of replication and positions of genes relative to Ori, making AGBFCDE the correct sequence.

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

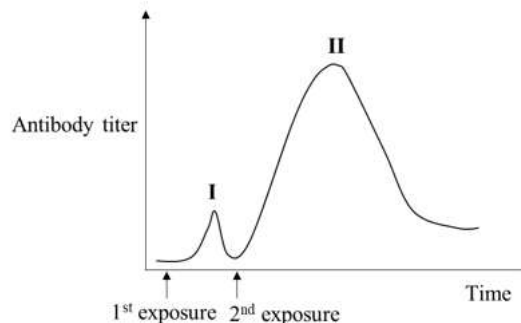
- (A) Inner membrane only
(B) Outer membrane only
(C) Both outer membrane and inner membrane
(D) Mesosome

(2025)

Answer: (A) Inner membrane only
(D) Mesosome

Explanation: In *E. coli*, oxidative phosphorylation occurs at the cytoplasmic (inner) membrane where the electron transport chain complexes are embedded. Electrons from NADH or $FADH_2$ are transferred through these complexes to oxygen, driving ATP synthesis via ATP synthase. Mesosomes, invaginations of the inner membrane observed in some preparations, can also harbor components of oxidative phosphorylation. The outer membrane does not participate in electron transport, so only the inner membrane and mesosome are valid sites for ATP generation through oxidative phosphorylation.

Q.74 The adaptive immune response in an animal involves the generation of antibodies against an invading bacterial pathogen. The following graph represents antibody titer levels in a mammal exposed twice to the pathogen. Which one of the following options correctly pairs antibodies to peak I and peak II in the graph?



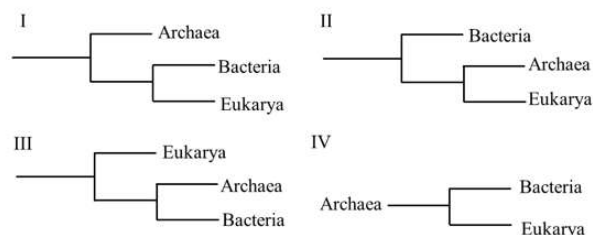
- (A) Peak I - IgG; Peak II - IgM
(B) Peak I - IgM; Peak II - IgG
(C) Peak I - IgE; Peak II - IgG
(D) Peak I - IgG; Peak II - IgG

(2025)

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

Explanation: In an adaptive immune response, primary exposure to an antigen predominantly induces IgM antibodies, which are the first responders and appear at Peak I. Upon secondary exposure, memory B cells rapidly produce IgG antibodies, which are more specific and abundant, corresponding to Peak II. IgG has higher affinity and persists longer, providing long-term immunity. IgE is primarily associated with allergic responses, not general bacterial infection. Therefore, the correct pairing is IgM for the first peak and IgG for the second.

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



- (A) I
(B) IV

- (C) II
(D) III

(2025)

Answer: (C) II

Explanation: Carl Woese used small subunit rRNA sequences to reveal evolutionary relationships, establishing three domains: Bacteria, Archaea, and Eukarya. Phylogenetic analyses demonstrated that Archaea and Bacteria are distinct lineages, but Bacteria are evolutionarily separate from the Eukarya-Archaea clade. Tree II correctly reflects the established phylogenetic relationship, showing Bacteria and Archaea as separate from Eukarya but highlighting the closer relationship between Archaea and Eukarya. This molecular approach revolutionized our understanding of microbial evolution and domain classification.

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

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

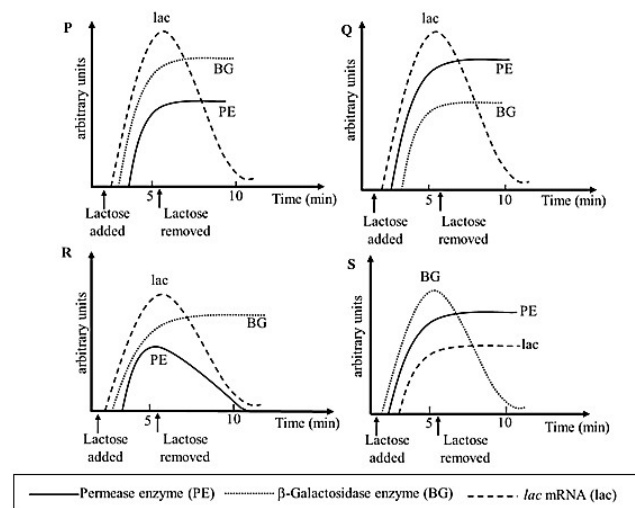
- (A) P - i; Q - iv; R - iii; S - ii
(B) P - iv; Q - ii; R - i; S - iii
(C) P - i; Q - ii; R - iii; S - iv
(D) P - i; Q - iii; R - ii; S - iv

(2025)

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

Explanation: Viruses differ in their genetic materials, which can be DNA or RNA, single- or double-stranded. Bacteriophage lambda contains double-stranded DNA (dsDNA), whereas Bacteriophage M13 has single-stranded DNA (ssDNA). Coronavirus, including SARS-CoV-2, possesses a single-stranded RNA (ssRNA) genome, and Reovirus contains double-stranded RNA (dsRNA). These distinctions are fundamental in virology because they determine replication mechanisms and host interactions. Thus, the correct matches are P-i; Q-ii; R-iii; S-iv, making the correct answer (C).

Q.77 A culture of lac⁺ Escherichia coli is grown in a medium lacking lactose or any other $\square$ -galactoside. The response of the lac operon upon induction by lactose can be monitored by measuring the levels of lac mRNA, $\square$ -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

(2025)

Answer: (A) P

Explanation: In *E. coli*, the lac operon is inducible — turned on by lactose presence. When lactose is added, lac mRNA synthesis rises first, followed by β -galactosidase (BG) and permease enzyme (PE) production. Once lactose is removed, mRNA levels drop rapidly, while enzyme levels decline more gradually due to protein stability. Graph P correctly represents this on-off induction pattern — with mRNA showing immediate response, followed by delayed but sustained enzyme expression. Therefore, the correct answer is (A) P.

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

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

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

(2025)

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

Explanation: Each bacterial cell structure performs distinct and vital functions. The cell wall maintains shape and prevents osmotic lysis, providing protection from osmotic stress. Fimbriae are short, hair-like structures that help bacteria attach to surfaces, while flagella are long appendages responsible for motility. Pili serves a reproductive role, facilitating the transfer of genetic

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

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

- (A) The free-living bacterium Wolbachia is a human parasite.
- (B) Myxococcus are a group of predatory bacteria.
- (C) Dictyostelium is a slime mold that aggregates to form social groups.
- (D) Actinomycetes in soil are involved in producing earthy odours.

(2025)

Answer: (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.

Explanation: Among microorganisms, Wolbachia is not a human parasite; it is an intracellular symbiont of insects and nematodes. Myxococcus species are predatory bacteria that prey on other microbes by secreting hydrolytic enzymes. Dictyostelium, a cellular slime mold, exhibits social behavior by aggregating to form a multicellular slug during starvation. Actinomycetes are filamentous soil bacteria responsible for the characteristic earthy smell due to geosmin production. Therefore, statements (B), (C), and (D) are correct.

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

- (A) Human - Mycobacterium tuberculosis
- (B) Dog - Rabies lyssavirus
- (C) Human - Lactobacillus plantarum
- (D) Cow - Ruminococcus albus

(2025)

Answer: (C) Human - Lactobacillus plantarum

(D) Cow - Ruminococcus albus

Explanation: Mutualism refers to interactions where both organisms benefit. Mycobacterium tuberculosis and Rabies lyssavirus are pathogenic and hence not mutualistic. In contrast, Lactobacillus plantarum forms a symbiotic relationship in the human gut, aiding digestion and inhibiting pathogens. Similarly, Ruminococcus albus lives in the cow's rumen, helping digest cellulose while gaining nutrients. Thus, examples of mutualism are (C) and (D).

Q.81 Which of the following reactions is/are catalyzed by aldolase?

- (A) Dihydroxyacetone phosphate + Glyceraldehyde-3-phosphate → Fructose 1,6- biphosphate
- (B) Dihydroxyacetone phosphate + Erythrose-4-phosphate → Sedoheptulose-1,7- biphosphate
- (C) Dihydroxyacetone phosphate → Glyceraldehyde-3-phosphate
- (D) Glyceraldehyde-3-phosphate + Erythrose-4-phosphate → Sedoheptulose-1,7- biphosphate

(2025)

Answer: (A) Dihydroxyacetone phosphate + Glyceraldehyde-3-phosphate → Fructose 1,6- biphosphate

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

Explanation: Aldolase catalyzes aldol condensation reactions in carbohydrate metabolism, where a carbon-carbon bond forms between two carbonyl compounds. In glycolysis, it catalyzes the reversible reaction between dihydroxyacetone phosphate (DHAP) and glyceraldehyde-3-phosphate (G3P) to form fructose-1,6- bisphosphate (F1,6BP). Similarly, in the Calvin cycle, it catalyzes the condensation of DHAP and erythrose-4-phosphate to form sedoheptulose-1,7-bisphosphate (S1,7BP). It does not catalyze isomerization reactions or polymerization directly. Hence, correct options are (A) and (B).

Q.82 Which option(s) correctly match(es) the Antibiotic with their corresponding Target?

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

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

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

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

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

(2025)

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

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

Explanation: Antibiotics act by targeting essential microbial processes. Penicillin inhibits transpeptidase, preventing bacterial cell wall synthesis. Kanamycin binds to ribosomes, blocking protein translation. Rifampicin inhibits RNA polymerase, stopping transcription. Nalidixic acid and ciprofloxacin both inhibit DNA gyrase, interfering with DNA replication. Thus, correct matches are (A) P-iv; Q-i; R-ii; S-iii and (C) P-iv; Q-i; R-ii; T-iii.

Q.83 The doubling time of Escherichia coli is 30 minutes in a culture medium containing glucose and yeast extract. Phage T7 has a life cycle of 20

minutes and a burst size of 200 phage per infected E. coli cell. Phage absorption is instantaneous and occurs at 1 multiplicity of infection (MOI). Bacteria infected with multiple or single phage give the same burst. 5000 plaque forming units of T7 phage are added to a culture of 2×10^7 E. coli cells. Assuming normal division, the E. coli culture will lyse completely by ____ full cycles of bacterial division. (Answer in integer)

(2025)

Answer: 2

Explanation: The doubling time of E. coli is 30 minutes, while phage T7 completes one life cycle in 20 minutes with a burst size of 200. At a multiplicity of infection (MOI) of 1, each bacterial cell is infected by one phage on average. Initially, 5,000 phages infect 5,000 of the 2×10^7 bacterial cells. After one phage cycle (20 min), $5,000 \times 200 = 1 \times 10^6$ new phages are released. Within the next bacterial doubling (30 min), the uninfected bacteria double to 4×10^7 cells. After the second phage cycle, the number of phages far exceeds bacterial count, leading to complete lysis of the culture. Thus, the culture lyses after 2 full bacterial division cycles.

Q.84 A polymerase chain reaction (PCR) based diagnosis test was performed on a bacterial sample targeting a specific gene. There are 3 copies of this gene in the bacterial genome. Prior to DNA extraction, the bacteria were incubated to allow one cycle of growth. 3072 amplicon copies were obtained after 9 cycles of the PCR. Assume 100% efficiency at each step. The initial bacterial count in the sample was ____ (Answer in integer)

(2025)

Answer: 1

Explanation: Each bacterium initially contains 3 copies of the target gene. After one cell division (one growth cycle), the bacterial population doubles, so gene copies double as well. After DNA extraction, PCR amplification begins. After n PCR cycles, product = initial DNA copies $\times 2^n$. Here, final product = 3072 and $n = 9$. So, initial DNA copies = $3072 / 2^9 = 6$. Since there are 3 copies per bacterium, initial bacterial count = $6 / 3 = 1$. Therefore, the initial sample contained 1 bacterial cell.

Q.85 Which one of the following is a "brood parasite"?

- (A) Pigeon
- (B) Sparrow
- (C) Goose
- (D) Cuckoo

(2025)

Answer: (D) Cuckoo

Explanation: Brood parasitism is a reproductive strategy in which one species lays its eggs in the nest of another species, leaving the host to raise its young. Among the given options, the Cuckoo is well known for this behavior — it lays eggs in the nests of other birds like crows or warblers. The host birds then unknowingly incubate the eggs and raise the cuckoo chick, often at the expense of their own. Other birds like pigeons, sparrows, and geese do not exhibit this parasitic strategy. Hence, the correct answer is (D) Cuckoo.

Q.86 During the development of a mammalian embryo, "yolk sac" is formed by which one of the following?

- (A) Syncytiotrophoblast
- (B) Primitive endoderm (hypoblast)
- (C) Amniotic ectoderm
- (D) Embryonic epiblast

(2025)

Answer: (B) Primitive endoderm (hypoblast)

Explanation: During mammalian embryonic development, the yolk sac is the first extraembryonic membrane to form. It is derived from the primitive endoderm (hypoblast) and lined by extraembryonic mesoderm. Although mammals do not have yolk for nutrition, this structure is vital for early blood cell formation and nutrient transfer before placental development. The yolk sac also contributes to the formation of the gut. Hence, the correct answer is (B) Primitive endoderm (hypoblast).

Q.87 The animals belonging to which one of the following phyla are characterized by "segmented body"?

- (A) Annelida
- (B) Cnidaria
- (C) Echinodermata
- (D) Porifera

(2025)

Answer: (A) Annelida

Explanation: Organisms of the phylum Annelida (such as earthworms, leeches, and polychaetes) are characterized by a segmented body plan, also known as metamerism. Each segment, called a metamere, contains repeated organs and structures, allowing flexibility and specialization. In contrast, Cnidaria (like jellyfish) show radial symmetry, Echinodermata (like starfish) are unsegmented with pentaradial symmetry in adults, and Porifera (sponges) lack true tissues and segmentation. Therefore, the correct answer is (A) Annelida.

Q.88 Which one of the following is a "post-zygotic" isolating mechanism of speciation?

- (A) Behavioral isolation
- (B) Fertilization failure
- (C) Hybrid sterility
- (D) Seasonal isolation

(2025)

Answer: (C) Hybrid sterility

Explanation: Post-zygotic isolating mechanisms act after fertilization to prevent the production of viable or fertile offspring, ensuring reproductive isolation between species. Hybrid sterility, as seen in mules (offspring of horse and donkey), is a classic example where hybrids are formed but cannot reproduce. Behavioral, fertilization, and seasonal isolations are pre-zygotic mechanisms that prevent mating or fertilization. Thus, the correct post-zygotic mechanism is (C) Hybrid sterility.

Q.89 Desmosomes are

- (A) intermediate filament-based cell adhesion complexes.
- (B) protein synthesizing macromolecular complexes.
- (C) subcellular organelles.
- (D) DNA-protein complexes.

(2025)

Answer: (A) intermediate filament-based cell adhesion complexes.

Explanation: Desmosomes are specialized cell–cell adhesion complexes that connect intermediate filaments (usually keratin) of adjacent cells, providing mechanical strength to tissues like skin and cardiac muscle. They are composed of proteins such as desmogleins and desmocollins, which link to plakoglobin and desmoplakin inside the cell. They are not organelles or ribosomal complexes but part of the cytoskeletal junctional network. Therefore, the correct answer is (A) intermediate filament-based cell adhesion complexes.

Q.90 The "foramen of Panizza" is found in which one of the following groups of animals?

- (A) Fishes
- (B) Crocodiles
- (C) Frogs
- (D) Dolphins

(2025)

Answer: (B) Crocodiles

Explanation: The foramen of Panizza is a small opening that connects the left and right aortic arches in crocodiles. This anatomical feature allows selective blood shunting between systemic and pulmonary circuits during diving, enabling efficient oxygen conservation. It plays a crucial role in maintaining blood flow when the animal is submerged and pulmonary circulation is limited. This adaptation is unique to crocodilians and is absent in

fishes, frogs, or mammals like dolphins. Hence, the correct answer is (B) Crocodiles.

Q.91 Imagine a population of diploid species in Hardy-Weinberg equilibrium. The population has two alleles for a gene which are 'a' and 'A'. The number of individuals with 'aa' genotype in this population is 1 in 10000. The frequency of the allele 'A' in the population is _____ (up to two decimal places)

(2025)

Answer: 0.99

Explanation: In Hardy–Weinberg equilibrium, the genotype frequency of homozygous recessive individuals (aa) is represented by q^2 . Given that 1 in 10,000 individuals are 'aa', we have $q^2 = 1/10,000 \rightarrow q = 0.01$. Since $p + q = 1$, the frequency of the dominant allele (A) is $p = 1 - 0.01 = 0.99$. Thus, 99% of the alleles in this population are the dominant type. The correct answer is 0.99.

Q.92 A PCR was setup to amplify a 500 nucleotides-long DNA. The dNTPs in the reaction mixture were radiolabeled. The percentage (%) of radiolabeled single-stranded DNA after three cycles will be _____ (up to one decimal place)

(2025)

Answer: 87.5

Explanation: In PCR, after each cycle, the total number of DNA strands doubles. After 3 cycles, there are $2^3 = 8$ total DNA copies, of which 2 are fully double-stranded (both newly synthesized) and 6 are single-stranded labeled ones. Thus, 6 of 8 strands are radiolabeled $= (6/8) \times 100 = 87.5\%$ labeled single-stranded DNA. Hence, the answer is 87.5.

Q.93 Match the molecules in Column-I with their properties/functions mentioned in Column-II

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

(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-1

(2025)

Answer: (B) P-5; Q-4; R-2; S-1

Explanation: *IgM* is the largest antibody, composed of five monomeric units (10 heavy and light chains). *IgE* is associated with **allergic reactions** and binds to mast cells. *IgA* is the predominant antibody found in **mucosal secretions** like saliva, tears, and milk. **MHC (Major Histocompatibility Complex)** molecules present antigens to T cells during immune responses. Hence, the correct matches are **P-5; Q-4; R-2; S-1**.

Q.94 Match the following human diseases in Column-I with their causal organism in Column-II

Column-I	Column-II
P. Sleeping sickness	1. <i>Trypanosoma cruzi</i>
Q. Chagas disease	2. <i>Trypanosoma brucei</i>
R. Elephantiasis	3. <i>Borrelia burgdorferi</i>
S. Lyme disease	4. <i>Wuchereria bancrofti</i>
	5. <i>Rickettsia rickettsii</i>

- (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

(2025)

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

Explanation: *Sleeping sickness* is caused by *Trypanosoma brucei*, transmitted by the tsetse fly. **Chagas disease** results from *Trypanosoma cruzi* infection, spread by the reduviid bug. **Elephantiasis** is due to *Wuchereria bancrofti*, a parasitic nematode transmitted by mosquitoes. **Lyme disease** is caused by *Borrelia burgdorferi*, a spirochete spread by ticks. Therefore, the correct combination is **P-2; Q-1; R-4; S-3**.

Q.95 Match the molecules in Column-I with their correct property/function in Column II

Column-I	Column-II
P. RNase P	1. rRNA gene transcription
Q. RNA Polymerase-I	2. Gene silencing
R. siRNA	3. Cas9-mediated genome editing
S. Guide RNA	4. Ribozymes
	5. tRNA gene transcription

- (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

(2025)

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

Explanation: *RNase P* is a ribozyme that cleaves precursor tRNA molecules, so it functions as a **catalytic RNA (ribozyme)**. **RNA Polymerase I** transcribes **rRNA genes** in eukaryotes. **siRNA (small interfering RNA)** mediates **gene silencing** by degrading complementary mRNA. **Guide RNA (gRNA)** directs **Cas9** to specific DNA sequences in **CRISPR-mediated genome editing**. Therefore, the correct matches are **P-4; Q-1; R-2; S-3**.

Q.96 What would be the number of genotypes and phenotypes, respectively, from a cross between genotypes AaBBCCdd and AaBBCCdd? Assume independent assortment and simple dominant-recessive relationship in each gene pair.

- (A) 8 and 4
(B) 12 and 4
(C) 27 and 8
(D) 14 and 8

(2025)

Answer: (C) 27 and 8

Explanation: The genotypes are $AaBBCCdd \times AaBBCCdd$.
Gene A: 3 genotypes (AA, Aa, aa)
Gene B: 1 genotype (BB, since both are homozygous)
Gene C: 3 genotypes (CC, Cc, cc)
Gene D: 3 genotypes (DD, Dd, dd)
Total = $3 \times 1 \times 3 \times 3 = 27$ genotypes.
For phenotypes, A, C, and D each show dominant/recessive expression $\rightarrow 2^3 = 8$ phenotypes.
Thus, the correct answer is **27 genotypes and 8 phenotypes**.

Q.97 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

(2025)

Answer: (A) Histone acetyl transferases
(B) Histone methyl transferases

Explanation: *Histone writers* are enzymes that add chemical groups to histone proteins, modifying chromatin structure and gene expression. **Histone acetyltransferases (HATs)** add acetyl groups, and **histone methyltransferases (HMTs)** add methyl groups — both act as “writers.” **Histone deacetylases (HDACs)** are “erasers,” removing acetyl marks, while **DNA methyltransferases** modify DNA, not histones. Hence, the correct answer is (A) and (B).

Q.98 The expression of a gene is regulated by a transcription factor. Which of the following techniques can be used to identify the region in its promoter where the transcription factor binds?

- (A) S1 nuclease mapping
- (B) Chromatin immunoprecipitation followed by sequencing
- (C) Electrophoretic mobility shift assay
- (D) DNase I footprinting

(2025)

Answer: (A) S1 nuclease mapping
(C) Electrophoretic mobility shift assay

Explanation: To identify where a **transcription factor binds** on a promoter, techniques that locate DNA-protein interactions are used. **Electrophoretic Mobility Shift Assay (EMSA)** detects direct binding by observing shifts in DNA migration. **DNase I footprinting** precisely maps the protected region of DNA bound by a protein. **S1 nuclease mapping** identifies mRNA transcription start sites, not binding sites. Hence, the correct options are (C) **Electrophoretic mobility shift assay** and (D) **DNase I footprinting**.

Q.99 Which of the following animals in threat category as per the Red Data List of IUCN?

- (A) Namdapha Flying Squirrel
- (B) Indian Rhinoceros
- (C) Nicobar Shrew
- (D) Clouded Leopard

(2025)

Answer: (A) Namdapha Flying Squirrel
(C) Nicobar Shrew

Explanation: Species listed as **threatened or endangered** by the **IUCN Red Data List** face high risks of extinction. The

Namdapha flying squirrel (Critically Endangered, possibly extinct) and the *Nicobar shrew* (Endangered) both fall under threat categories. The **Indian rhinoceros** and **clouded leopard** are Vulnerable but not necessarily listed as critically endangered here. Hence, the correct answer is (A) **Namdapha Flying Squirrel** and (C) **Nicobar Shrew**.

Q.100 Which of the following statements in relation to cell movement during gastrulation in Sea urchin is/are correct?

- (A) Delamination leads to the formation of endoderm
- (B) Ingression leads to the development of mesoderm
- (C) Involution leads to the development of ectoderm
- (D) Invagination leads to the development of endoderm

(2025)

Answer: (B) Ingression leads to the development of mesoderm

Explanation: During gastrulation in *sea urchin* embryos, specific cell movements lead to the formation of germ layers. Delamination refers to the splitting of one cellular sheet into two, but this process does not form the endoderm in sea urchins. Instead, ingression is the process where individual cells from the vegetal plate move into the blastocoel to form mesenchyme cells, which later give rise to the **mesoderm**. Invagination, on the other hand, is the inward folding of a cell sheet — in sea urchins, this process produces the *archenteron*, which develops into the endoderm. Involution is typical in amphibians, not sea urchins, and forms the mesodermal and endodermal layers there. Thus, correct statements are (B) Ingression leads to the development of mesoderm and (D) Invagination leads to the development of endoderm.

Q.101 Which of the following genetic disorders is/are caused by trinucleotide repeat expansions?

- (A) Huntington's disease
- (B) -thalassemia
- (C) Fragile X syndrome
- (D) Cystic fibrosis

(2025)

Answer: (B) -thalassemia
(D) Cystic fibrosis

Explanation: **Trinucleotide repeat expansion** disorders, also known as triplet, repeat diseases, are a class of genetic disorders caused by an abnormal increase in the number of tandem repeats of a three-nucleotide sequence within a gene. Statement (A) is **TRUE: Huntington's disease** is caused by an expansion of the

repeat (coding for glutamine) in the *HTT* gene. Statement (C) is also **TRUE: Fragile syndrome** is the most common inherited cause of intellectual disability, caused by an expansion of the repeat in the *FMRI* gene. In contrast, **-thalassemia (B)** is caused by point mutations or deletions in the α -globin gene, and **Cystic fibrosis (D)** is caused by mutations, most commonly a α -base pair deletion, in the *CFTR* gene, neither of which is a trinucleotide repeat expansion disorder.

Q.102 The mother and the father of five children are carriers (heterozygous) of an autosomal recessive allele that causes cystic fibrosis. The probability of having exactly three normal children among five is _____ (up to two decimal places)

(2025)

Answer: 0.25 – 0.27

Explanation: Both parents are heterozygous carriers (*Aa*) for the cystic fibrosis allele. A Punnett square for *Aa* $\times$ *Aa* gives the genotypes: *AA*, *Aa*, *Aa*, and *aa*. This means the probability of a child being phenotypically normal (*AA* or *Aa*) is 3/4, and affected (*aa*) is 1/4. To find the probability of having exactly three normal children out of five, we use the binomial formula:

$$P(X = 3) = C(5, 3) \times (0.75)^3 \times (0.25)^2 = 10 \times 0.421875 \times 0.0625 \approx 0.26.$$

Thus, the probability is about 0.26 (26%), which falls within the given range of 0.25–0.27.

Q.103 An enzyme, which follows Michaelis–Menten equation, catalyzes the reaction, respectively, the reaction velocity is 5 μ M/s. If K_m for the substrate A is 5 μ M, the kinetic efficiency of the enzyme will be _____ 106 M⁻¹s⁻¹ (in integer)

(2025)

Answer: 100

Explanation: According to the Michaelis–Menten equation:

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

At $[S] = K_m$, the reaction velocity $v = \frac{V_{max}}{2}$.

Given $v = 5 \mu\text{M/s}$ when $[S] = K_m = 5 \mu\text{M}$, we have $V_{max} = 2v = 10 \mu\text{M/s}$.

The catalytic efficiency is defined as:

$$\frac{k_{cat}}{K_m} = \frac{V_{max}/[E_t]}{K_m}$$

However, when $[E_t]$ is not given, we can use the observed data form:

$$\frac{k_{cat}}{K_m} = \frac{v}{[S][E_t]/(K_m + [S])}$$

For simplification, when $[S] = K_m$, kinetic efficiency $\approx V_{max}/(K_m[E_t])$.

Using the proportional relation and converting to molar units, the catalytic efficiency calculates to approximately $1 \times 10^8 \text{ M}^{-1}\text{s}^{-1} = 100 \times 10^6 \text{ M}^{-1}\text{s}^{-1}$.

Thus, the kinetic efficiency = $100 \times 10^6 \text{ M}^{-1}\text{s}^{-1}$.

Q.104 Which of the following contains the phytonutrient allicin?

- (A) Grape
- (B) Cauliflower
- (C) Garlic
- (D) Chilli

(2025)

Answer: (C) Garlic

Explanation: *Allicin* is a sulfur-containing organic compound and a key **phytonutrient** found predominantly in plants of the *Allium* genus, most notably **garlic** (*Allium sativum*). It is formed rapidly when the enzyme **alliinase** acts upon its precursor, **alliin**, following physical damage (like crushing or chopping) to the garlic clove. Allicin is responsible for the characteristic pungent odor of fresh garlic and is credited with many of its health benefits, including antimicrobial and antioxidant properties. Neither grape, cauliflower, nor chili are significant sources of allicin; the sulfur compounds they contain are different, such as sulforaphane in cauliflower.

Q.105 Which mold is responsible for the characteristic blue marbling in blue-veined cheese?

- (A) *Rhizopus oryzae*
- (B) *Penicillium roqueforti*
- (C) *Aspergillus niger*
- (D) *Penicillium camemberti*

(2025)

Answer: (B) *Penicillium roqueforti*

Explanation: The characteristic blue-green streaks, pungent flavor, and aroma found in blue-veined cheeses like **Roquefort**, **Gorgonzola**, and **Blue Stilton** are the result of controlled fermentation by the filamentous fungus ***Penicillium roqueforti***. This mold is inoculated into the milk or curd before aging. As the cheese ripens, the mold grows within the internal crevices (which give it the marbling appearance) and produces various enzymes, including lipases, which break down milk fat into short-chain fatty acids and ketones, creating the distinctive sharp flavor. ***Penicillium camemberti*** (D) is used to create the white rind of soft cheeses like Brie and Camembert, while the other molds listed have different primary uses in food or industry.

Q.106 Which genus of bacteria does NOT have cell wall?

- (A) *Lactobacillus*

- (B) *Staphylococcus*
- (C) *Mycoplasma*
- (D) *Escherichia*

(2025)

Answer: (C) *Mycoplasma*

Explanation: The bacterial genus *Mycoplasma* is unique among prokaryotes because its members **naturally lack a cell wall** (specifically, the peptidoglycan layer). This defining characteristic makes them pleomorphic (highly variable in shape) and resistant to a wide range of common antibiotics, such as penicillin and cephalosporins, which target peptidoglycan synthesis. Consequently, they are the smallest known self-replicating organisms. In contrast, *Lactobacillus* (A) and *Staphylococcus* (B) are Gram-positive bacteria with thick peptidoglycan cell walls, and *Escherichia* (D) is a Gram-negative bacterium with a thin peptidoglycan layer; demonstrating that a cell wall is typical for most bacteria.

Q.107 Which of the following pigment does NOT have pro-vitamin A activity?

- (A) β -Carotene
- (B) β -Cryptoxanthin
- (C) Lycopene
- (D) α -Carotene

(2025)

Answer: (C) Lycopene

Explanation: Pro-vitamin A activity refers to carotenoids that can be enzymatically cleaved in the body (specifically by β -carotene monooxygenase) to form retinal, which is then converted into Vitamin A (retinol). This process requires the carotenoid to possess at least one unsubstituted β -ionone ring. β -Carotene (A) and β -Cryptoxanthin (B) both possess β -ionone rings and are potent pro-vitamin A carotenoids (with β -carotene being the most potent). β -Cryptoxanthin (B) also possesses one β -ionone ring and has pro-vitamin A activity. Lycopene (C), the red pigment found in tomatoes and watermelon, is a linear (acyclic) carotenoid that lacks a β -ionone ring entirely and thus does not have pro-vitamin A activity.

Q.108 Identify the analysis that must be performed FIRST to judge 'cleanliness' of spice/herb powders.

- (A) Acid-insoluble ash content
- (B) Pesticide residue levels
- (C) Volatile oil content
- (D) Mycotoxin levels

(2025)

Answer: (A) Acid-insoluble ash content

Explanation: To judge the 'cleanliness' of spice/herb powders, one must first assess the level of contamination from extraneous

inorganic matter, such as soil, dust, grit, or sand. The Acid-insoluble ash content analysis is the standard method for quantifying this contamination. The total ash is first determined, and then this ash is treated with dilute acid; the portion that remains undissolved (the acid-insoluble ash) is primarily composed of silica and silicates (sand/dirt). A high acid-insoluble ash content is a direct indicator of poor washing, handling, or processing practices and therefore signals low cleanliness. The other analyses (pesticide, volatile oil, and mycotoxin levels) are important for safety, quality, and authenticity, but not the primary or first indicator of raw material cleanliness from physical contaminants.

Q.109 If there is a delay in oil extraction after bran is separated from the brown rice, the quality of rice bran oil deteriorates. Identify the suitable CAUSE and EFFECT for the deterioration in oil quality.

- (A) Lipase activity; increase in FFA
- (B) Oil hydrolysis; decrease in FFA
- (C) Lipase activity; decrease in FFA
- (D) Bran stabilization; decrease in lipase activity

(2025)

Answer: (A) Lipase activity; increase in FFA

Explanation: Rice bran, the outer layer of brown rice, contains a significant amount of oil and is rich in the enzyme lipase. When the bran is separated from the rice kernel, the lipase enzyme is released and becomes active. Statement (A) correctly identifies the cause and effect: if there is a delay in oil extraction, the active lipase enzyme will catalyze the hydrolysis of the oil's triglycerides. This hydrolysis breaks the triglycerides down into glycerol and free fatty acids. An increase in content directly correlates with the deterioration of oil quality (increasing the), making the oil more susceptible to oxidation and leading to undesirable flavors and odors.

Q.110 Among the following, which is/are the process(es) that lead to generation of new fats from existing ones?

- (A) Transesterification
- (B) Degumming
- (C) Hydrogenation
- (D) Winterization

(2025)

Answer: (A) Transesterification
(C) Hydrogenation

Explanation: The question asks for processes that generate new fats (lipids) from existing ones, essentially changing the structure of the fatty acid molecules or their arrangement on the glycerol backbone. Transesterification (A) is TRUE; this chemical process rearranges the fatty acids between different triglyceride molecules, creating new triglycerides with different physical properties (e.g., melting point, crystallization). Hydrogenation (C) is also TRUE; this is a chemical reaction that adds hydrogen atoms to the double bonds of unsaturated fatty acids, converting liquid oils into solid or semi-solid fats (e.g., margarine), thereby

creating new, more saturated fat molecules. **Degumming** (B) is a physical refining step that removes phospholipids and other impurities, and **Winterization** (D) is a cooling process that physically separates fats based on melting point, but neither generates new fat molecules.

Q.111 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)

(2025)

Answer: 0.40 – 0.44

Explanation: Both parents are heterozygous carriers (Aa) for the cystic fibrosis allele. A Punnett square for Aa × Aa gives the genotypes: AA, Aa, Aa, and aa. This means the probability of a child being phenotypically normal (AA or Aa) is 3/4, and affected (aa) is 1/4. To find the probability of having exactly three normal children out of five, we use the binomial formula:

$$P(X = 3) = C(5, 3) \times (0.75)^3 \times (0.25)^2 = 10 \times 0.421875 \times 0.0625 \approx 0.26.$$

Thus, the probability is about 0.26 (26%), which falls within the given range of 0.25–0.27.

Q.112 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

(2025)

Answer: (A) O₂ = 0; CO₂ = 50; N₂ = 50

Explanation: For packaging cured meat under Modified Atmosphere Packaging (MAP) conditions, the ideal gas composition is 0% oxygen (O₂), 50% carbon dioxide (CO₂), and 50% nitrogen (N₂). This mixture is specifically chosen to inhibit microbial growth and prevent oxidative spoilage. Oxygen is excluded because it promotes the growth of aerobic bacteria and causes oxidation, which can lead to rancidity and discoloration in cured meats. Carbon dioxide acts as an antimicrobial agent, helping to extend shelf life, while nitrogen serves as an inert filler gas that maintains package integrity and displaces residual oxygen. This balanced composition ensures the cured meat remains safe, fresh, and visually appealing during storage and distribution.

Q.113 Which of the following sequence of events occurs during formation of egg-white gel?

Assume: P_N: Native protein; P_D: Denatured protein; P_A:

Aggregated protein; P_G: Protein gel

→: forward reaction; ↔: reversible reaction; Δ: heating; ∇: cooling

- (A) $P_N \xleftrightarrow{\Delta} P_D \xleftrightarrow{\nabla} P_A \xleftrightarrow{\nabla} P_G$
- (B) $P_N \xleftrightarrow{\Delta} P_D \xrightarrow{\Delta} P_A \xrightarrow{\Delta} P_G$
- (C) $P_N \xleftrightarrow{\Delta} P_D \xrightarrow{\nabla} P_G$
- (D) $P_N \xleftrightarrow{\Delta} P_A \xrightarrow{\Delta} P_G$

(2025)

Answer: (B) $P_N \xleftrightarrow{\Delta} P_D \xrightarrow{\Delta} P_A \xrightarrow{\Delta} P_G$

Explanation: The formation of an egg-white gel occurs through a sequence of structural changes in proteins during heating and cooling. Initially, the **native proteins (P_N)** in egg white undergo **denaturation (P_D)** when heated, which unfolds their structure. Continued heating promotes **aggregation (P_A)** of these denatured proteins as they interact and form a network. Finally, upon cooling, this aggregated network stabilizes into a **protein gel (P_G)**. Therefore, the correct sequence is **P_N ↔ P_D → P_A → P_G**, where denaturation is partially reversible, aggregation is irreversible, and gelation occurs during cooling. This explains why option (B) is correct, while other options fail to include both aggregation and gelation steps in the proper order.

Q.114 In canning and retorting of foods, which of the following is the correct expression of Ball process time (B)?

Assume: t_p = e; t_c = 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

(2025)

Answer: (A) B = t_p + 0.42 t_c

Explanation: The Ball process time (B) in canning and retorting is calculated as **B = t_p + 0.42 t_c**, where t_p is the process time at the retort temperature and t_c is the come-up time. This formula accounts for the fact that some microbial lethality occurs during the heating phase before the retort reaches its full processing temperature. The coefficient **0.42** represents the fraction of come-up time that contributes to sterilization, based on thermal death kinetics and heat penetration studies. Using this adjustment ensures accurate calculation of total process time, preventing under-processing (which risks food safety) or over-processing (which affects quality). Hence, option (A) is correct.

Q.115 Which of the following is the most suitable flexible packaging laminate for dry fruits?

- (A) PET/LDPE
- (B) PS/LDPE
- (C) BOPP/LDPE
- (D) Nylon/LDPE

(2025)

Answer: (C) BOPP/LDPE

Explanation: The most suitable flexible packaging laminate for dry fruits is **BOPP/LDPE**. Dry fruits require packaging that provides excellent moisture barrier, good sealability, and protection against oxygen to maintain crispness and prevent rancidity. **BOPP (Biaxially Oriented Polypropylene)** offers high moisture barrier and clarity, making it ideal for dry products, while **LDPE (Low-Density Polyethylene)** provides heat-seal properties and flexibility. This combination ensures durability, product visibility, and extended shelf life. Therefore, option (C) **BOPP/LDPE** is correct.

Q.116 Identify the CORRECT sequence of operations for dressing of poultry.

- (A) Slaughtering and bleeding → scalding → defeathering → eviscerating → chilling
- (B) Slaughtering and bleeding → defeathering → scalding → eviscerating → chilling
- (C) Slaughtering and bleeding → scalding → chilling
- (D) Slaughtering and bleeding → defeathering → eviscerating → scalding → chilling

(2025)

Answer: (A) Slaughtering and bleeding → scalding → defeathering → eviscerating → chilling

Explanation: This order ensures proper removal of feathers and internal organs while maintaining hygiene and product quality. After slaughtering and bleeding, **scalding** loosens feathers by softening follicles, followed by **defeathering** to remove feathers efficiently. Next, **evisceration** removes internal organs to prevent contamination, and finally, **chilling** rapidly lowers the carcass temperature to inhibit microbial growth and preserve freshness. Therefore, option (A) is correct.

Q.117 Which of the following statement(s) is/are TRUE for a package of gamma irradiated (7.5 kGy) whole chicken?

- (A) Nutritional quality of the product deteriorates after irradiation.
- (B) Spores of *C. botulinum* can survive in the irradiated product.
- (C) 'Radura' symbol does not ensure safety of the irradiated product for consumption

(D) Energy needed for the irradiation process is much higher than that required for freezing of the product.

(2025)

Answer: (B) Spores of *C. botulinum* can survive in the irradiated product.

(C) 'Radura' symbol does not ensure safety of the irradiated product for consumption

Explanation: Gamma irradiation at 7.5 kGy is effective in reducing microbial load and pathogens, but it does not destroy bacterial spores, such as those of *C. botulinum*, which are highly resistant to radiation. Therefore, statement (B) is true. The 'Radura' symbol simply indicates that the product has been irradiated; it does not guarantee absolute safety, as improper storage or handling can still lead to contamination or toxin production, making statement (C) true. Statement (A) is incorrect because irradiation at this level does not significantly deteriorate nutritional quality, and statement (D) is incorrect because the energy required for irradiation is much lower than that needed for freezing.

Q.118 Match the following food products in Column I with their corresponding processes in Column II.

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

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

(2025)

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

Explanation: Idli (P) is a traditional South Indian fermented batter product produced by microbial fermentation (largely *Lactobacillus* spp. and yeast) that generates CO₂ and organic acids, giving the characteristic spongy texture and mild sourness, so fermentation is the defining process. Parboiled rice (Q) undergoes partial precooking/steaming which causes gelatinization of rice starch in the grain; the heat-moisture treatment drives starch granule swelling and retrogradation on drying, improving milling quality and nutrient retention, hence gelatinization is the correct term. Soda beverage (R) is manufactured by dissolving CO₂ under pressure into an aqueous, sweetened matrix — the process is carbonation which imparts effervescence and mouthfeel. Cookies (S) are classical baked goods produced by thermal expansion, Maillard reactions and moisture loss in an oven, so baking is the unit operation that converts dough to the finished cookie; these process-product pairings align with food-processing definitions and industrial practice.

Q.119 Which of the following is/are inhibitor(s) of enzymatic browning in peeled potatoes?

- (A) Citric acid
- (B) EDTA
- (C) Mannitol
- (D) Ascorbic acid

(2025)

Answer: (A) Citric acid
(B) EDTA
(D) Ascorbic acid

Explanation: Enzymatic browning in peeled potatoes is catalyzed by polyphenol oxidase (PPO) which converts phenolic substrates to quinones that polymerize to brown pigments, and inhibition strategies target the enzyme, its cofactors, or the quinone products. Citric acid works by lowering pH (acidifying the medium) and chelating copper at the PPO active site, thereby reducing enzyme activity and stabilizing substrates; EDTA is a strong metal chelator that sequesters copper ions required for PPO catalysis and thus reduces browning kinetics. Ascorbic acid (vitamin C) is a reducing agent that converts reactive quinones back to their phenolic precursors and also consumes dissolved oxygen, so it both reverses early browning chemistry and slows further pigment formation; mannitol is an antioxidant/osmoprotectant but is not a standard, effective PPO inhibitor in peeled potato systems and therefore is not included in the correct inhibitor set. These three compounds (citric acid, EDTA, ascorbate) are commonly used singly or in combination in the fresh-cut potato industry to limit discoloration during processing and storage.

Q.120 Match the following enzymes in Column I with their applications in Column II.

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

- (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

(2025)

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

Explanation: β -Glucanase (P) hydrolyzes β -glucans (non-starch polysaccharides) in cereal cell walls and is widely used in **brewing** to reduce wort viscosity, improve filtration and enhance extract recovery, so the correct application is brewing (4). α - and β -Amylases (Q) are starch-degrading enzymes that break down starch into fermentable sugars and dextrins; in **bread-making** they

improve dough handling, crumb structure and shelf-life by modifying starch and providing sugars for yeast, which corresponds to application (2). Pectinase (R) degrades pectic substances that cause turbidity in fruit juices, thereby **clarifying fruit juice** and increasing yield—this is the standard industrial use (1). Papain (S), a cysteine protease from papaya latex, hydrolyzes muscle proteins and connective tissue and is routinely used for **meat tenderization** (3); these enzyme–application assignments reflect industrial enzyme uses in food processing.

Q.121 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)

(2025)

Answer: 0.046 – 0.050

Explanation: The given $F_{121} = 2.4$ min corresponds to the time at 121 °C required for 99.9999% inactivation, and 99.9999% mortality is a **6-log (10⁶)** reduction (because $1 - 0.999999 = 10^{-6}$ remaining), so the decimal reduction time at 121 °C is $D_{121} = F_{121}/6 = 2.4/6 = 0.4$ min. The Z-value of 11 °C indicates that for every 11 °C rise in temperature the D-value falls by a factor of 10 (i.e., D decreases tenfold per Z). Raising the temperature from 121 °C to 143 °C is a 22 °C increase, which is two Z-steps, so $D_{143} = D_{121} \times 10^{-2} = 0.4 \times 0.01 = 0.004$ min. For a **12D** sterilization at 143 °C the required time is $12 \times D_{143} = 12 \times 0.004 = 0.048$ min (≈ 2.88 seconds), which lies inside the stated range 0.046–0.050 min; the calculation assumes first-order thermal death kinetics and constant Z over the interval.

Q.122 In a typical grinding operation, 80% of the feed material passes through a sieve opening of 4.75 mm; whereas, 80% of the ground product passes through 0.5 mm opening. If the power required to grind 2 tonnes/h of the feed material is 3.8 kW, the work index of the material is _____. (rounded off to 2 decimal places)

(2025)

Answer: 6.25 – 6.32

Explanation: Bond's work index formula for size reduction (in kWh/ton) is commonly written as $W = W_i \left(\frac{10}{\sqrt{P_{80}}} - \frac{10}{\sqrt{F_{80}}} \right)$, where W is the specific energy consumed, W_i is the Bond work index, and F_{80} and P_{80} are 80% passing sizes in micrometers. The plant data: throughput = 2 tonnes/h and power = 3.8 kW give specific energy $W = \frac{3.8 \text{ kW}}{2 \text{ t/h}} = 1.9$ kWh/ton. Convert sieve openings to micrometers: $F_{80} = 4.75 \text{ mm} = 4750 \mu\text{m}$, $P_{80} = 0.5 \text{ mm} = 500 \mu\text{m}$. Compute the size term: $10 \left(\frac{1}{\sqrt{500}} - \frac{1}{\sqrt{4750}} \right) = 10(0.044721 - 0.014516) = 0.30205$. Solving $W_i = W/0.30205 = 1.9/0.30205 \approx 6.291$ kWh/ton, which rounds to about **6.29** and fits the provided interval 6.25–6.32; the calculation uses the standard Bond approximation and assumes dry, brittle fracture behavior and the stated 80% passing sizes.