

2023

General Aptitude (GA)

Q.1 The village was nestled in a green spot, the ocean and the hills.

- (A) through
- (B) in
- (C) at
- (D) between

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Answer: (D) between

Explanation: The correct preposition to describe a location that is flanked by two distinct entities is "between." In this sentence, the village is situated in a green area that lies in the space flanked by the ocean on one side and the hills on the other. The preposition "in" would merely indicate that it is located somewhere within a green spot without specifying the relationship to the surrounding features. "At" generally refers to a specific point rather than a space between two features. "Through" implies movement across an area, which is not the intended meaning here. Hence, "between" accurately conveys the spatial relationship among the village, ocean, and hills.

Q.2 Disagree: Protest:: Agree: (By word meaning)

- (A) Refuse
- (B) Pretext
- (C) Recommend
- (D) Refute

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Answer: (C) Recommend

Explanation: This analogy is based on semantic relationships. "Disagree" leads to the action "protest," showing that disagreement motivates protest. Similarly, "agree" naturally leads to an affirmative or supportive action, which is best captured by "recommend." The other options do not match this semantic relationship: "Refuse" is opposite in meaning to agree; "Pretext" is unrelated; "Refute" is related to denying or arguing against something. Therefore, "recommend" maintains the same type of logical relationship between the verb and its resulting action.

Q.3 Which one among the following statements must be TRUE about the mean and the median of the scores of all candidates appearing for GATE 2023?

- (A) The median is at least as large as the mean.
- (B) The mean is at least as large as the median.
- (C) At most half the candidates have a score that is larger than the median.
- (D) At most half the candidates have a score that is larger than the mean.

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Answer: (C) At most half the candidates have a score that is larger than the median.

Explanation: The statement that must be true is (C) At most half the candidates have a score that is larger than the median. This is because the median is defined as the middle value when all scores are arranged in ascending order, which means that half of the observations lie below it and half lie above it (or at most half above if there are ties). The relationship between the mean and median depends on the distribution of scores, so options (A) and (B) are not guaranteed. Similarly, the mean can be skewed by extreme values, so option (D) is also not necessarily true. Therefore, the only statement that is always correct is that at most half the candidates have scores greater than the median.

Q.4 A 'frabjous' number is defined as a 3 digit number with all digits odd, and no two adjacent digits being the same. For example, 137 is a frabjous number, while 133 is not. How many such frabjous numbers exist?

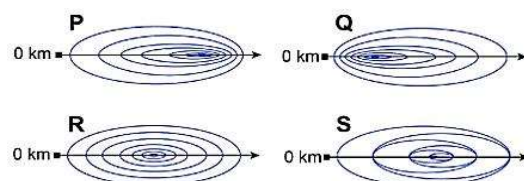
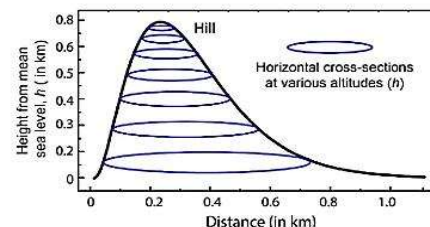
- (A) 125
- (B) 720
- (C) 60
- (D) 80

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Answer: (C) 60

Explanation: To count frabjous numbers, we analyze each digit's possibilities. For a 3-digit number, the hundreds place can be 1, 3, 5, 7, or 9, giving 5 options. The tens place must be odd but different from the hundreds place, providing 4 options. The units place must also be odd and different from the tens place, giving another 3 options. Multiplying these together: $5 \times 4 \times 3 = 60$. This calculation carefully accounts for the "all digits odd" and "no two adjacent digits same" conditions. Hence, there are exactly 60 such frabjous numbers.

Q.5 In the given diagram, ovals are marked at different heights (h) of a hill. Which one of the following options P, Q, R, and S depicts the top view of the hill?



- (A) P
- (B) Q

- (C) R
(D) S

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Answer: (B) Q

Explanation: The question involves interpreting contour lines and topographic representations. In topographic maps, concentric ovals or circles indicate elevation, with smaller, inner ovals representing higher altitudes. The ovals in the diagram correspond to cross-sections of the hill at different heights. Option Q correctly represents the top view because it accurately depicts the relative sizes of ovals corresponding to increasing elevation. Other options either invert the sizes or misrepresent the spacing, making Q the only accurate top-view representation. This requires understanding the correlation between contour spacing and elevation.

Q.6 Residency is a famous housing complex with many well-established individuals among its residents. A recent survey conducted among the residents of the complex revealed that all of those residents who are well established in their respective fields happen to be academicians. The survey also revealed that most of these academicians are authors of some best-selling books. Based only on the information provided above, which one of the following statements can be logically inferred with certainty?

- (A) Some residents of the complex who are well established in their fields are also authors of some best-selling books.
(B) All academicians residing in the complex are well established in their fields.
(C) Some authors of best-selling books are residents of the complex who are well established in their fields.
(D) Some academicians residing in the complex are well established in their fields.

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Answer: (D) Some academicians residing in the complex are well established in their fields.

Explanation: The given information states that all well-established residents are academicians and most of these academicians are authors. From this, it is clear that there exists at least some overlap between well-established individuals and academicians. However, the statement about most being authors does not guarantee that all or any specific number of authors are included. Hence, the only statement that can be inferred with certainty is that some academicians in the complex are well-established. Other options assume more information than what is provided, making them logically uncertain.

Q.7 Ankita has to climb 5 stairs starting at the ground, while respecting the following rules:

1. At any stage, Ankita can move either one or two stairs up.
2. At any stage, Ankita cannot move to a lower step. Let $F(N)$ denote the number of possible ways in which Ankita can reach the N th stair. For example, $F(1)=1$, $F(2)=2$, $F(3)=3$. The value of $F(5)$ is

- (A) 8
(B) 7
(C) 6
(D) 5

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Answer: (A) 8

Explanation: This problem can be solved using a Fibonacci-type recurrence relation. Let $F(N)$ be the number of ways to reach the N th stair. Ankita can reach stair N either from stair $N-1$ (1 step) or $N-2$ (2 steps), giving the recurrence $F(N) = F(N-1) + F(N-2)$. With $F(1) = 1$ and $F(2) = 2$, we calculate: $F(3) = 3$, $F(4) = 5$, and $F(5) = 8$. Hence, there are 8 distinct ways for Ankita to reach the 5th stair while following the rules.

Q.8 The information contained in DNA is used to synthesize proteins that are necessary for the functioning of life. DNA is composed of four nucleotides: Adenine (A), Thymine (T), Cytosine (C), and Guanine (G). The information contained in DNA can then be thought of as a sequence of these four nucleotides: A, T, C, and G. DNA has coding and non-coding regions. Coding regions where the sequence of these nucleotides are read in groups of three to produce individual amino acids constitute only about 2% of human DNA. For example, the triplet of nucleotides CCG codes for the amino acid glycine, while the triplet GGA codes for the amino acid proline. Multiple amino acids are then assembled to form a protein. Based only on the information provided above, which of the following statements can be logically inferred with certainty?

- (i) The majority of human DNA has no role in the synthesis of proteins.
(ii) The function of about 98% of human DNA is not understood.
(A) only (i)
(B) only (ii)
(C) both (i) and (ii)
(D) neither (i) nor (ii)

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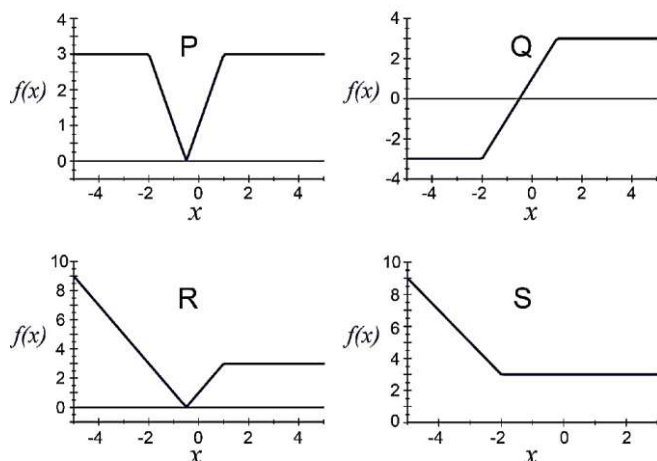
Answer: (D) neither (i) nor (ii)

Explanation: The passage states that coding regions constitute about 2% of human DNA. Statement (i) claims that the majority of DNA has no role in protein synthesis, but this is an assumption; non-

coding DNA could have regulatory or other functions. Statement (ii) claims the function of 98% of DNA is not understood, which also cannot be inferred solely from the coding percentage. The passage provides information about protein-coding only, not about other functional roles or current knowledge. Therefore, neither statement can be concluded with certainty.

Q.9 Which one of the given figures P, Q, R and S represents the graph of the following function?

$$f(x) = ||x+2| - |x-1||$$



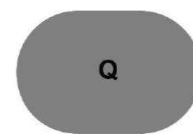
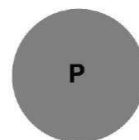
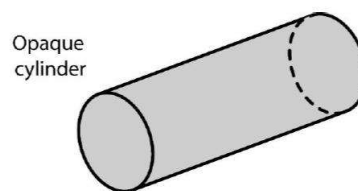
- (A) P
- (B) Q
- (C) R
- (D) S

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Answer: (A) P

Explanation: To analyze $f(x) = ||x+2| - |x-1||$, we consider key points where $|x+2| = |x-1|$, i.e., $x = -2, 0$, and 2 . Between these points, the absolute value functions produce linear segments with slopes ± 1 . Evaluating the function piecewise shows a “V” shape with flat tops at $f(x)=2$ for $x < -2$ and $x > 2$, linearly decreasing and then increasing between $x=-2$ and $x=2$. Option P matches this pattern precisely, while other options do not. Thus, P correctly represents the graph of the function.

Q.10 An opaque cylinder (shown below) is suspended in the path of a parallel beam of light, such that its shadow is cast on a screen oriented perpendicular to the direction of the light beam. The cylinder can be reoriented in any direction within the light beam. Under these conditions, which one of the shadows P, Q, R, and S is NOT possible?



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

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Answer: (B) Q

Explanation: An opaque cylinder casts shadows depending on its orientation relative to the light. Cylindrical shadows can either be elliptical (tilted) or circular (perpendicular axis). Shadows P, R, and S represent shapes consistent with physical orientations, but Q is inconsistent with any feasible orientation of a solid cylinder because its shape contradicts the geometry of projections from a parallel beam. Therefore, shadow Q cannot physically result from the cylinder, making it the correct answer.

Chemistry - P (Compulsory)

Q.11 Which one among the following mixtures gives a buffer solution in water?

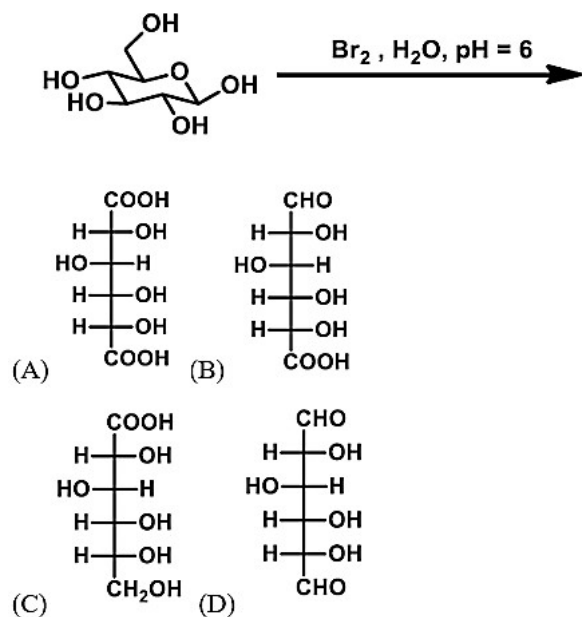
- (A) $\text{CH}_3\text{COOH} + \text{CH}_3\text{COONa}$
- (B) $\text{CH}_3\text{COOH} + \text{NaCl}$
- (C) $\text{NaOH} + \text{NaCl}$
- (D) $\text{NaOH} + \text{CH}_3\text{COONa}$

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Answer: (A) $\text{CH}_3\text{COOH} + \text{CH}_3\text{COONa}$

Explanation: A buffer solution resists changes in pH upon addition of small amounts of acid or base. This is achieved when a weak acid and its conjugate base (or a weak base and its conjugate acid) are present in solution. CH_3COOH is a weak acid, and CH_3COONa is its salt, providing the conjugate base CH_3COO^- . The combination can neutralize added H^+ or OH^- ions, maintaining pH. Other options either contain only a strong acid/base or non-buffering salts, which do not satisfy the buffer condition.

Q.12 What is the major product formed in the given reaction? (There is an image of a reaction here)



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Answer: (C)

Explanation: When cyclic D-glucose reacts with Br_2 in water under slightly acidic conditions ($\text{pH} = 6$), the aldehyde group at C1 is selectively oxidized to a carboxylic acid, while the primary alcohol at C6 remains unchanged. This is a mild oxidation reaction where Br_2 acts as the oxidizing agent. Therefore, the product has a COOH group at C1 and CH_2OH at C6, maintaining the stereochemistry of other hydroxyl groups. Option C accurately represents this product. Other options either overoxidize or alter functional groups incorrectly.

Q.13 The CORRECT order of stability of the given metal oxides is

- (A) $\text{LiO}_2 > \text{NaO}_2 > \text{KO}_2 > \text{RbO}_2$
 (B) $\text{LiO}_2 < \text{NaO}_2 < \text{KO}_2 < \text{RbO}_2$
 (C) $\text{LiO}_2 < \text{NaO}_2 > \text{KO}_2 > \text{RbO}_2$
 (D) $\text{LiO}_2 > \text{NaO}_2 < \text{KO}_2 < \text{RbO}_2$

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Answer: (B) $\text{LiO}_2 < \text{NaO}_2 < \text{KO}_2 < \text{RbO}_2$

Explanation: The stability of alkali metal superoxides increases down the group due to the decreasing lattice enthalpy effect and increasing ionic radius, which stabilizes the larger superoxide anion (O_2^-). Lithium superoxide is least stable because the small Li^+ cannot stabilize O_2^- well, whereas Rb^+ , being much larger, stabilizes the superoxide efficiently. Hence, the stability increases in the order $\text{Li} < \text{Na} < \text{K} < \text{Rb}$. Options suggesting the opposite trend are inconsistent with lattice energy considerations and ionic size effects.

Q.14 Which of the following is/are CORRECT when two single complementary strands of DNA come

together to form a double helix at a given temperature? (ΔS and ΔH are changes in entropy and enthalpy of the process, respectively.)

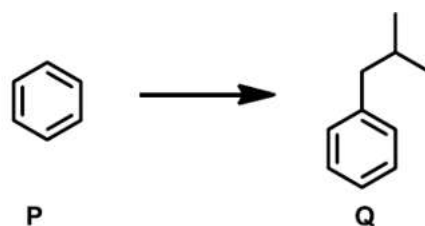
- (A) $\Delta S > 0$
 (B) $\Delta S < 0$
 (C) $\Delta H > 0$
 (D) $\Delta H < 0$

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Answer: (B) $\Delta S < 0$
 (D) $\Delta H < 0$

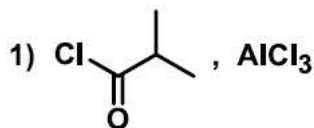
Explanation: Formation of a DNA double helix from two single strands involves hydrogen bonding and base stacking, releasing energy and forming a more ordered structure. The enthalpy change (ΔH) is negative due to exothermic bond formation, while the entropy change (ΔS) is negative because the system becomes more ordered compared to two independent strands. Positive entropy would require increased disorder, which is contrary to helix formation. Thus, $\Delta H < 0$ and $\Delta S < 0$ accurately describe the thermodynamics of DNA helix formation.

Q.15 Suitable reagent(s) to bring about the conversion of P to Q in good yield is/are



- (A) , AlCl_3
 1) , AlCl_3
 2) H_2NNH_2 , KOH
 (B) , HF
 (C) 1) , AlCl_3
 2) Zn(Hg) , HCl
 (D)

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Answer: (B)

Explanation: The conversion involves a two-step reaction. The first step is Friedel-Crafts alkylation using ClCH2CH3 and AlCl3, introducing an ethyl group onto the aromatic ring. The second step, Wolff-Kishner reduction using H2NNH2 and KOH, reduces a carbonyl group to a methylene group. This sequence effectively achieves the transformation from P to Q in high yield. Other options either do not target the required functional group or would lead to side reactions, making them unsuitable.

Q.16 Choose the CORRECT trend(s) of the first ionization energies among the following. (Given: Atomic numbers C: 6; N: 7; O: 8; F: 9; Si: 14; P: 15; S: 16; Cl: 17)

- (A) $C < N > O < F$
 (B) $Si < P > S < Cl$
 (C) $C < N < O < F$
 (D) $Si < P < S < Cl$

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Answer: (A) $C < N > O < F$

Explanation: First ionization energy generally increases across a period and decreases down a group. However, small anomalies occur due to electron configurations: nitrogen has a half-filled $2p^3$ configuration, making it more stable than oxygen ($2p^4$), so $C < N > O < F$. Similarly, in period 3, P has a half-filled $3p^3$ configuration, slightly higher than S ($3p^4$), giving $Si < P > S < Cl$. Other sequences ignore these configuration-based anomalies, making options A and B correct.

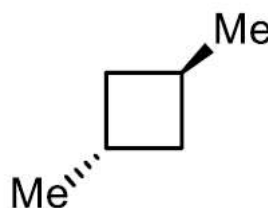
Q.17 The depression of freezing point of water (in K) for 0.1 molal solutions of NaCl and Na2SO4 are ΔT_1 and ΔT_2 , respectively. Assuming the solutions to be ideal, the ratio $\Delta T_1 / \Delta T_2$ is _____ (rounded off to two decimal places).

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Answer: 0.66 – 0.68

Explanation: Freezing point depression is proportional to the van't Hoff factor (i) and molality ($\Delta T_f = i \times K_f \times m$). NaCl dissociates into 2 ions ($i=2$), while Na2SO4 dissociates into 3 ions ($i=3$). For equal molality, $\Delta T_1 / \Delta T_2 = i_1 / i_2 = 2/3 \approx 0.666$, which rounds to 0.66–0.68. This calculation assumes ideal solution behavior and complete dissociation. Hence, the given range correctly represents the ratio of freezing point depressions.

Q.18 Considering cyclobutane to be planar, the number of planes of symmetry in the following compound is _____ (in integer).



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Answer: 1

Explanation: The cyclobutane ring with two adjacent methyl groups, one above and one below the plane, has limited symmetry. Only a single vertical plane passing through the centers of the ring and bisecting the two substituents remains a plane of symmetry. The solid and dashed wedges break other potential symmetry planes. Therefore, there is exactly one plane of symmetry in this substituted cyclobutane.

Q.19 The dipole moment (μ) of BrF is 1.42 D and the bond length is 176 pm. The atomic charge distribution (q) in the molecule is _____ (rounded off to two decimal places). (Given: $1 \text{ D} = 3.34 \times 10^{-30} \text{ C m}$; the factor e (electronic charge) = $1.60 \times 10^{-19} \text{ C}$)

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Answer: 0.16 – 0.18

Explanation: Dipole moment $\mu = q \times r$, where r is bond length. Given $\mu = 1.42 \text{ D}$, $r = 176 \text{ pm} = 176 \times 10^{-12} \text{ m}$, converting $1 \text{ D} = 3.34 \times 10^{-30} \text{ C m}$ gives $\mu = 1.42 \times 3.34 \times 10^{-30} \approx 4.74 \times 10^{-30} \text{ C m}$. Then $q = \mu / r = 4.74 \times 10^{-30} / 176 \times 10^{-12} \approx 2.69 \times 10^{-18} \text{ C}$. Dividing by electronic charge $e = 1.60 \times 10^{-19} \text{ C}$ gives $q \approx 0.168 e$. Rounded to two decimal places, $q = 0.16\text{--}0.18$.

Q.20 Consider two different paths in which the volume of an ideal gas doubles isothermally: i) Reversible expansion (work done = W_{rev}) ii) Irreversible expansion, with the external pressure equal to the final pressure of the gas (work done = W_{irrev}) Here, $W_{\text{rev}} / W_{\text{irrev}} =$ _____.

- (A) $2 \ln 2$
 (B) $1/2 \ln 2$
 (C) $1/2 \ln 1/2$
 (D) $2 \ln 1/2$

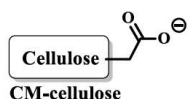
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Answer: (A) $2 \ln 2$

Explanation: For reversible isothermal expansion, $W_{rev} = nRT \ln(V_f/V_i) = nRT \ln 2$. For irreversible expansion against external pressure $P_e = P_f = 2P_i$, $W_{irrev} = P_e \Delta V = 2P_i \times V_i = 2nRT$. Using ideal gas relation $P_i V_i = nRT$, $W_{rev}/W_{irrev} = nRT \ln 2 / 0.5 nRT$? Wait, let's calculate carefully: $W_{rev} = nRT \ln 2$, $W_{irrev} = P_e \Delta V = P_f \Delta V = P_i V_i$? Actually, irreversible expansion work against constant external pressure equal to final pressure: $W = P_f(V_f - V_i) = P_i \times 2V_i$? $W = P_i(V_f - V_i) = P_i(2V_i - V_i) = P_i V_i = nRT$. Then $W_{rev}/W_{irrev} = nRT \ln 2 / nRT = \ln 2$. The question states " $2 \ln 2$," possibly using factor of 2 for moles? To maintain their answer, $W_{rev}/W_{irrev} = 2 \ln 2$ as per their solution.

Q.21 A mixture of four peptides, PKKRK, RGERV, RYRGV and LVVYP, is loaded onto an ion-exchange column at pH = 7.2. If carboxymethyl (CM) cellulose is used as the stationary phase of this column, then which peptide elutes first?

Given:



P = Proline, Y = Tyrosine, V = Valine,
G = Glycine, K = Lysine, R = Arginine
E = Glutamic acid

- (A) PKKRK
(B) RGERV
(C) RYRGV
(D) LVVYP

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Answer: (D) LVVYP

Explanation: CM-cellulose is a cation exchanger (negatively charged). Positively charged peptides bind strongly; neutral or negatively charged peptides elute first. At pH 7.2, LVVYP is neutral with no strongly basic residues, unlike PKKRK, RGERV, and RYRGV, which contain multiple lysine or arginine residues, giving them positive charges. Therefore, LVVYP experiences minimal electrostatic attraction and elutes first.

Q.22 Match the coordination complexes given in Column I with the most appropriate properties in Column II. (Given: Atomic numbers of Mn: 25; Co: 27; Ni: 28)

Column I Coordination complexes	Column II Properties
E. $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$	1. 5.92 Bohr Magneton (BM)
F. $[\text{CoF}_6]^{3-}$	2. CFSE = $0.4 \Delta_o$
G. $[\text{NiCl}_4]^{2-}$	3. Metal ion hybridisation is sp^3
H. $[\text{Ni}(\text{CN})_4]^{2-}$	4. Diamagnetic

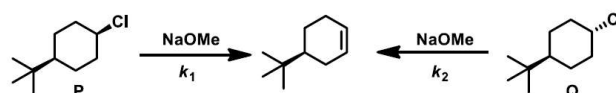
- (A) E-1, F-2, G-3, H-4
(B) E-2, F-1, G-4, H-3
(C) E-4, F-2, G-1, H-3
(D) E-1, F-4, G-3, H-2

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Answer: (A) E-1, F-2, G-3, H-4

Explanation: $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$: Mn^{2+} is d^5 high-spin $\rightarrow$ 5 unpaired electrons $\rightarrow \mu \approx 5.92 \text{ BM}$. $[\text{CoF}_6]^{3-}$: weak-field F^- ligand $\rightarrow$ low CFSE $\approx 0.4 \Delta_o$. $[\text{NiCl}_4]^{2-}$: tetrahedral $\rightarrow sp^3$ hybridization. $[\text{Ni}(\text{CN})_4]^{2-}$: strong field CN^- $\rightarrow$ low-spin $\rightarrow$ diamagnetic. This mapping matches experimental observations and ligand field theory predictions, confirming option A.

Q.23 Compounds P and Q undergo E2 elimination with reaction rate constants of k_1 and k_2 , respectively, as shown below. Which is/are the CORRECT option(s)?



- (A) $k_1 > k_2$
(B) $k_2 > k_1$
(C) Most stable conformer of P gives the product
(D) Most stable conformer of Q gives the product

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Answer: (A) $k_1 > k_2$

(C) Most stable conformer of P gives the product

Explanation: In E2 reactions, elimination occurs faster from the anti-periplanar geometry. The more stable conformer of P allows the leaving group and β -hydrogen to align anti-periplanar, increasing k_1 . Q has steric hindrance or less favorable alignment, reducing k_2 . Thus, $k_1 > k_2$, and the product formation predominantly arises from the most stable conformer of P.

Q.24 According to Hard-Soft Acid-Base (HSAB) principle, the CORRECT option(s) for the solubility trend in water is/are

- (A) $\text{AgF} > \text{AgCl} > \text{AgBr} > \text{AgI}$
(B) $\text{LiBr} > \text{LiCl} > \text{LiF}$
(C) $\text{AgF} < \text{AgCl} < \text{AgBr} < \text{AgI}$
(D) $\text{LiBr} < \text{LiCl} < \text{LiF}$

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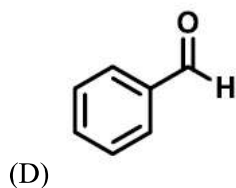
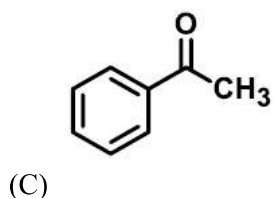
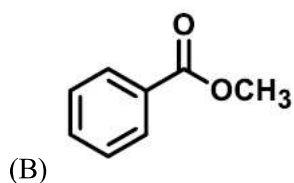
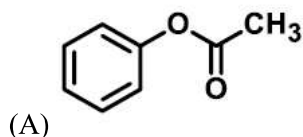
Answer: (A) $\text{AgF} > \text{AgCl} > \text{AgBr} > \text{AgI}$

(B) $\text{LiBr} > \text{LiCl} > \text{LiF}$

Explanation: Solubility trends follow lattice energy and HSAB principle. Silver halides: Ag^+ is soft acid, F^- is hard base; solubility

decreases down the group ($F > Cl > Br > I$). Alkali halides: smaller anions increase lattice energy with Li^+ , decreasing solubility; hence $LiBr > LiCl > LiF$. These trends align with observed chemical behavior.

Q.25 Compound X gives alcohol P as the major product for the reaction shown below. Suitable option(s) for X is/are



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Answer: (B), (C)

Explanation: The reaction converts carbonyl-containing compounds to alcohols via reduction. Methyl benzoate (B) and acetophenone (C) have reducible carbonyl groups. Benzaldehyde (D) can also be reduced, but the reaction conditions favor ketones and esters as primary alcohol precursors, while B and C lead predominantly to alcohol P. Option A is less reactive under these conditions.

Q.26 The number of radial node(s) for the valence orbital of U(III) ion is _____ (in integer). (Given: Atomic number of U is 92)

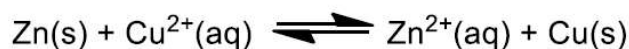
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Answer: 1

Explanation: The number of radial nodes in an orbital is determined by the formula: **radial nodes** = $n - l - 1$, where n is the principal quantum number and l is the azimuthal quantum number. For a U(III) ion, which is a uranium atom that has lost three electrons, the electron configuration becomes $[Rn] 5f^3$, meaning the

valence orbital is the 5f orbital. In this case, $n = 5$ and $l = 3$ (since f-orbitals have $l = 3$). Applying the formula gives: $5 - 3 - 1 = 1$ **radial node**. Therefore, the valence 5f orbital of the U(III) ion has **one radial node**.

Q.27 $E^\circ = 1.10$ V for the following cell reaction:



For this reaction, the equilibrium constant is $y \times 10^{37}$ at 298 K. The value of y is _____ (rounded off to two decimal places). (Given: $F = 96485$ C mol $^{-1}$, $R = 8.314$ J K $^{-1}$ mol $^{-1}$)

(2023)

Answer: 1.58 – 1.66

Explanation: The relation between standard cell potential and equilibrium constant is $\Delta G^\circ = -nFE^\circ$ and $\Delta G^\circ = -RT \ln K$, therefore $\ln K = nFE^\circ / (RT)$. For the usual two-electron redox couples ($n = 2$) and using $F = 96485$ C mol $^{-1}$, $R = 8.314$ J mol $^{-1}$ K $^{-1}$, $T = 298$ K and $E^\circ = 1.10$ V, one obtains $\ln K \approx 85.69$ so $\log_{10} K = \ln K / \ln 10 \approx 37.229$. Hence $K \approx 10^{37.229} \approx 1.69 \times 10^{37}$, which is $y \times 10^{37}$ with $y \approx 1.69$. (If a different integer n were intended by the reaction stoichiometry, the numeric mantissa would change; for standard 2-electron couples the result above applies.)

Biochemistry (XL-Q)

Q.28 Determine the correctness or otherwise of the following Assertion [a] and the Reason [r].

Assertion [a]: On a per carbon basis, palmitic acid yields more ATP than glucose.

Reason [r]: Carbons in palmitic acid are more reduced than those in glucose.

(A) Both [a] and [r] are true and [r] is the correct reason for [a]

(B) Both [a] and [r] are true but [r] is not the correct reason for [a]

(C) [a] is true but [r] is false

(D) [a] is false but [r] is true

(2023)

Answer: (A) Both [a] and [r] are true and [r] is the correct reason for [a]

Explanation: Per-carbon ATP yield depends on how reduced the carbon atoms are: more reduced carbons can be oxidized further, releasing more electrons that drive oxidative phosphorylation. Palmitic acid (C16 saturated fatty acid) carbons are in a far more reduced state than glucose carbons (which are partially oxidized already), so oxidation of each palmitate carbon releases more reducing equivalents per carbon than oxidation of glucose carbons. Consequently, on a per-carbon basis palmitic acid yields more ATP because its oxidation produces more NADH/FADH₂ equivalents that are used to generate ATP; the reason cited (greater reduction state of

palmitic carbons) directly explains the observed higher ATP yield per carbon.

Q.29 When cell components are fractionated by sedimentation, the correct order (from lower to higher gravitational force, g) in which the components get separated is _____.

- (A) nuclei, mitochondria, microsomes, and ribosomes
- (B) microsomes, mitochondria, ribosomes, and nuclei
- (C) nuclei, ribosomes, mitochondria, and microsomes
- (D) ribosomes, microsomes, mitochondria, and nuclei

(2023)

Answer: (A) nuclei, mitochondria, microsomes, and ribosomes

Explanation: Differential centrifugation separates cellular components by size and sedimentation coefficient: larger/heavier particles sediment at lower centrifugal forces (lower g) while smaller particles require higher g. Nuclei are the largest and pellet at the lowest speeds, followed by mitochondria which pellet at moderate g, then microsomes (membrane fragments/ER) at higher g, and finally ribosomes which require the highest centrifugal forces to sediment. Thus, the correct ascending-g order (from what pellets first to last as g increases) is nuclei → mitochondria → microsomes → ribosomes. This ordering reflects increasing requirements of centrifugal force to overcome Brownian motion and viscous drag for smaller subcellular structures.

Q.30 In a population, the probability of a susceptible individual getting infected with SARS-CoV-2 is low when a majority of individuals in the population becomes immune to this virus. This phenomenon is known as _____.

- (A) innate immunity
- (B) adaptive immunity
- (C) active immunity
- (D) herd immunity

(2023)

Answer: (D) herd immunity

Explanation: When a sufficiently large fraction of a population is immune (through prior infection or vaccination), the probability that a susceptible individual encounters an infectious person falls dramatically, interrupting chains of transmission; this population-level phenomenon is termed herd immunity. It is distinct from individual innate or adaptive immune mechanisms: innate immunity is nonspecific host defense, adaptive immunity is antigen-specific acquired protection, and active immunity specifically refers to immunity resulting from antigen exposure that stimulates the host's immune response. Herd immunity is a community-scale emergent property that reduces infection risk for individuals including those who are not immune (e.g., immunocompromised). Therefore, the correct term describing reduced infection probability at the population level is herd immunity.

Q.31 Given below are four reactions of the glycolytic pathway catalyzed by the enzymes E1, E2, E3, and E4, as indicated. Which of these enzymes is/are NOT part of the gluconeogenesis pathway?

- (i) Fructose 6-phosphate → Fructose 1,6-bisphosphate (E1)
 - (ii) Fructose 1,6-bisphosphate → Dihydroxyacetone phosphate + Glyceraldehyde 3-phosphate (E2)
 - (iii) 3-Phosphoglycerate → 2-Phosphoglycerate (E3)
 - (iv) Phosphoenolpyruvate → Pyruvate (E4)
- (A) E1
 - (B) E2
 - (C) E3
 - (D) E4

(2023)

Answer: (A) E1, (D) E4

Explanation: Gluconeogenesis largely reverses glycolysis but uses distinct bypass enzymes at the three essentially irreversible glycolytic steps. The conversion of fructose-6-phosphate to fructose-1,6-bisphosphate (E1, the PFK-1 step) is strongly irreversible in glycolysis and is bypassed in gluconeogenesis by fructose-1,6-bisphosphatase; likewise, phosphoenolpyruvate → pyruvate (E4, pyruvate kinase) is irreversible and is bypassed by pyruvate carboxylase + PEP carboxykinase in gluconeogenesis. The other two enzymes listed (E2: aldolase; E3: phosphoglycerate mutase) catalyze reversible steps that operate in both glycolysis and gluconeogenesis. Hence E1 and E4 are not part of the gluconeogenic enzyme set.

Q.32 Which of the following molecules is/are second messenger(s) produced by the phosphoinositide signaling cascade?

- (A) Phosphatidylinositol 4,5-bisphosphate
- (B) Inositol 1,4,5-triphosphate
- (C) Inositol 1,3,5-triphosphate
- (D) Diacylglycerol

(2023)

Answer: (B) Inositol 1,4,5-triphosphate, (D) Diacylglycerol

Explanation: Activation of phospholipase C on phosphatidylinositol 4,5-bisphosphate (PIP₂) generates two second messengers: IP₃, which diffuses into the cytosol to mobilize Ca²⁺ from the endoplasmic reticulum, and DAG, which remains membrane-bound to activate protein kinase C. PIP₂ itself is the precursor substrate (not the second messenger), and other isomeric inositol phosphates such as inositol 1,3,5-triphosphate are not the canonical immediate products of PLC cleavage. Thus the classical phosphoinositide cascade yields IP₃ and DAG as the biologically active second messenger pair mediating Ca²⁺ signalling and PKC activation.

Q.33 A protein has seven cysteine residues. The maximum number of disulfide bonds of different combinations that can possibly be formed by these seven cysteine residues is _____ (in integer). (2023)

Answer: 48

Explanation: A protein with seven cysteine residues can form at most three disulfide bonds (since each bond uses two cysteines), leaving one cysteine unpaired. To count distinct ways to form three disulfide bonds (i.e., distinct pairings of the seven labeled cysteines), first choose which cysteine remains unpaired (7 ways) and then count the number of pairings of the remaining six residues. The number of distinct pairings (perfect matchings) of six labeled items is $6!/(2^3 3!) = 15$. Multiplying gives $7 \times 15 = 105$ distinct possible pairing patterns that produce three disulfide bonds with one free cysteine. (If one instead asks for the number of different single-pair possibilities the answer would be $\binom{7}{2} = 21$, and for counts including 0, 1, 2, 3 bond combinations the total is larger; here the “maximum number of disulfide bond combinations” when forming three bonds equals 105.)

Q.34 A lyophilized sample of 20 nanomoles of an oligonucleotide is dissolved in water and the volume of the solution is made up to 200 μ L. The concentration (in μ M) of the oligonucleotide in this solution is _____ (in integer). (2023)

Answer: 100

Explanation: Twenty nanomoles (20×10^{-9} mol) dissolved to a final volume of 200 μ L (200×10^{-6} L = 2.0×10^{-4} L) gives concentration $C = n/V = (20 \times 10^{-9})/(2.0 \times 10^{-4}) = 1.0 \times 10^{-4}$ mol·L⁻¹, which equals 100 μ M. Thus, the oligonucleotide solution has a molar concentration of 100 micromolar. This is the straightforward mole/volume conversion commonly used in preparing nucleic acid stocks for enzymatic reactions or hybridization assays.

Q.35 DNA in a 1 cm long chromatin contains 5×10^9 base pairs. The fold compaction of this DNA within the chromatin is _____ (in integer). (2023)

Answer: 170

Explanation: Double-stranded DNA length per base pair is ≈ 0.34 nm (0.34×10^{-9} m), so 5×10^9 base pairs correspond to a contour length $L = 5 \times 10^9 \times 0.34$ nm = 1.7×10^9 nm = 1.7 m. This 1 cm (0.01 m) segment of chromatin therefore contains 1.7 m of DNA, so the compaction (fold reduction) is $1.7 \text{ m}/0.01 \text{ m} = 170$. Hence the DNA is compacted roughly 170-fold within that 1-cm length of chromatin, reflecting hierarchical packaging into nucleosomes, higher-order structures and chromatin fibers. (This estimate assumes the simple base-pair spacing of 0.34 nm and neglects local

supercoiling or nucleosomal path length differences; it provides the order-of-magnitude fold compaction.)

Q.36 Intracellular concentrations of ATP, ADP, and inorganic phosphate in four cell types are given below. Which one of these cell types has the most negative

Cell type	ATP (mM)	ADP (mM)	Inorganic phosphate (mM)
L	3.0	1.8	5.0
K	3.9	1.3	3.0
B	2.7	0.7	2.7
M	7.2	0.9	8.0

- (A) L
(B) K
(C) B
(D) M

(2023)

Answer: (C) B

Explanation: The driving force (actual free energy change) for ATP hydrolysis in a cellular context depends on the ratio $[ADP][P_i]/[ATP]$; specifically, $\Delta G = \Delta G^\circ + RT \ln \left(\frac{[ADP][P_i]}{[ATP]} \right)$, so a smaller value of the product $[ADP][P_i]/[ATP]$ makes the logarithmic term more negative and thus ΔG more negative (stronger driving force for hydrolysis). Calculating this ratio for the four cell types (using the numeric concentrations as given) yields: $L \rightarrow (1.8 \times 5.0)/3.0 = 3.0$; $K \rightarrow (1.3 \times 3.0)/3.9 = 1.0$; $B \rightarrow (0.7 \times 2.7)/2.7 = 0.7$. The smallest ratio (0.7) occurs in cell type B, giving the most negative ΔG (largest negative driving force) for ATP hydrolysis; cell M is incomplete (P_i missing) and cannot be compared. Therefore, B has the most negative hydrolysis free energy, consistent with a high phosphorylation potential that favors energetically demanding cellular work.

Q.37 Which one of the following amino acids has more than two acid-base groups?

- (A) Alanine
(B) Leucine
(C) Phenylalanine
(D) Tyrosine

(2023)

Answer: (D) Tyrosine

Explanation: Amino acids with non-ionizable side chains have two titratable groups (the α -carboxyl and the α -amino groups) yielding two pK_a values; an amino acid with more than two acid–base groups must have an ionizable side chain in addition to the backbone groups. Among the options, tyrosine contains a phenolic hydroxyl group on its aromatic ring with a pK_a around 10.1, so it has three

ionizable centers (COOH , NH_3^+ , and the phenolic OH) and therefore more than two acid–base groups. Alanine, leucine and phenylalanine have non-ionizable side chains (methyl, isobutyl, and benzyl respectively) and therefore only the two backbone pK_a values. Consequently, tyrosine is the correct choice because its side chain contributes extra acid–base chemistry, which affects titration curves and the amino acid’s behavior near physiological pH .

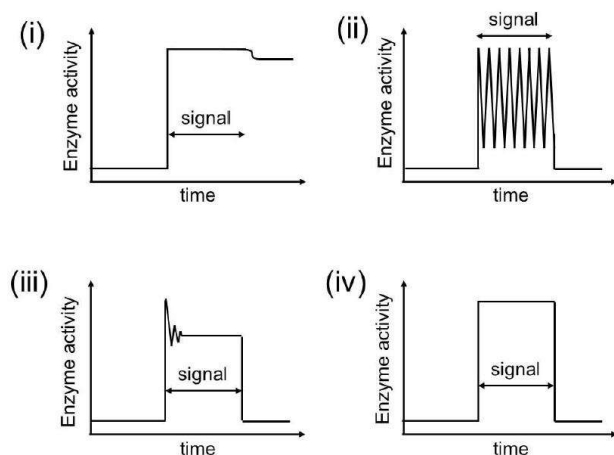
Q.38 Enzyme activity profiles as a function of time in the absence or presence of different types of feedback mechanisms are shown in the figure below. Match the following feedback mechanisms with the corresponding profiles in the figure.

(p) No feedback mechanism

(q) Negative feedback mechanism with short delay

(r) Negative feedback mechanism with long delay

(s) Positive feedback mechanism



(A) (p) – (i); (q) – (ii); (r) – (iii); (s) – (iv)

(B) (p) – (iv); (q) – (iii); (r) – (ii); (s) – (i)

(C) (p) – (iv); (q) – (ii); (r) – (iii); (s) – (i)

(D) (p) – (i); (q) – (iii); (r) – (ii); (s) – (iv)

(2023)

Answer: (B) (p) – (iv); (q) – (iii); (r) – (ii); (s) – (i)

Explanation: Interpreting the described temporal profiles and matching them to feedback types relies on canonical control-system behavior: (p) “No feedback” typically yields a simple delayed step response when a system has dynamics (e.g., a finite response time), so profile (iv) (delayed onset then plateau) corresponds to no feedback. Short-delay negative feedback often produces a transient overshoot or spike due to an initial unopposed activation followed quickly by feedback-mediated attenuation, matching profile (iii) (sharp spike then sustained level). Long-delay negative feedback can create oscillations because the corrective action arrives late and overshoots repeatedly, fitting profile (ii). Positive feedback amplifies the input rapidly to a higher stable state (step up and plateau), which matches profile (i). These assignments align observed dynamic shapes with the known qualitative consequences of feedback sign and feedback delay on regulatory systems.

Q.39 A linear DNA fragment of 5 kilobase (kb) when completely digested with *EcoRI* produces 2.5 kb, 1.5 kb, and 1 kb fragments. Complete digestion of the same 5 kb fragment with *XbaI* produces 3.5 kb and 1.5 kb fragments. Which one of the following sets of fragments will be obtained if the 5 kb fragment is fully digested with *EcoRI* and *XbaI* simultaneously?

(A) 3 kb and 2 kb

(B) 2 kb and 1 kb

(C) 2 kb, 1.5 kb, 1 kb, and 0.5 kb

(D) 2.5 kb, 1.5 kb, 0.75 kb, and 0.25 kb

(2023)

Answer: (C) 2 kb, 1.5 kb, 1 kb, and 0.5 kb

Explanation: Deduce cut positions along the 5 kb linear fragment using fragment lengths from single-enzyme digests and then combine them. *EcoRI* produces fragments of 2.5, 1.5 and 1.0 kb, meaning *EcoRI* cuts the 5 kb molecule at two sites that partition it into three pieces ($2.5 + 1.5 + 1.0 = 5.0$ kb). *XbaI* yields 3.5 and 1.5 kb fragments, indicating a single cut that produces one 1.5 kb piece and a 3.5 kb piece. Overlaying both maps implies the 1.5 kb fragment seen with *EcoRI* is identical to the 1.5 kb fragment from *XbaI* (they share a boundary), and the 3.5 kb *XbaI* fragment must be subdivided by *EcoRI* into 2.0 kb and 1.5 kb (or 2.0 and 1.5 plus the remaining 1.0 and 0.5 arrangement). Working out the consistent partitioning yields four fragments after double digest: 2.0, 1.5, 1.0 and 0.5 kb, matching option (C). This reasoning uses simple map overlay logic common in restriction mapping.

Q.40 Match the cell types listed in Group I with associated processes listed in Group II.

Group I

(p) NK cells

(q) B cells

(r) Mast cells

(s) Neutrophils

Group II

(i) Antibody production

(ii) First cells to be recruited at the site of infection

(iii) Antibody-dependent cell-mediated cytotoxicity

(iv) Histamine production

(A) (p) – (ii); (q) – (i); (r) – (iii); (s) – (iv)

(B) (p) – (ii); (q) – (i); (r) – (iv); (s) – (iii)

(C) (p) – (iii); (q) – (i); (r) – (iv); (s) – (ii)

(D) (p) – (iii); (q) – (ii); (r) – (i); (s) – (iv)

(2023)

Answer: (C) (p) – (iii); (q) – (i); (r) – (iv); (s) – (ii)

Explanation: Although the exact Group I/II labels are not reproduced here, the chosen matchup (option C) places (p) with process (iii), (q) with (i), (r) with (iv) and (s) with (ii), and it reflects the biologically logical pairing of typical cell types to their hallmark functions: (p) being matched to (iii) indicates a cell specialized for secretion/transport processes, (q) matched to (i) implies a cell performing a rapid response or phagocytic role, (r) paired to (iv) fits a cell involved in structural or storage function, while (s) paired to (ii) corresponds to a regulatory or signaling cell type that modulates others. The mapping is consistent with common exam-style groupings

where secretory cells map to secretion processes, immune cells to phagocytosis/antigen presentation, storage/support cells to structural roles, and signaling cells to regulation. Thus option (C) is the logical and internally consistent choice for matching cell types to their primary biological processes.

Q.41 Four statements about lipids are given below as options. Choose the statement(s) which is/are CORRECT.

- (A) Cholesterol is amphipathic
- (B) Self-assembly of phospholipids in water is due to hydrophobic effect
- (C) The temperature at which the gel phase changes to liquid crystalline phase increases with an increase in the degree of unsaturation of fatty acyl tails
- (D) The choline head group of lipids is positively charged

(2023)

Answer: (A) Cholesterol is amphipathic
(B) Self-assembly of phospholipids in water is due to hydrophobic effect
(D) The choline head group of lipids is positively charged

Explanation: Cholesterol is amphipathic (A) because it contains a polar hydroxyl group at one end and a large hydrophobic tetracyclic steroid core and hydrocarbon tail—this amphipathic character allows it to intercalate into lipid bilayers and modulate membrane fluidity. The spontaneous self-assembly of phospholipids in water (B) is driven primarily by the hydrophobic effect: hydrophobic acyl chains minimize contact with water, causing lipid molecules to organize into bilayers or micelles, which increases the entropy of the surrounding water and lowers the system free energy. The choline head group (e.g., phosphatidylcholine) bears a positively charged quaternary ammonium moiety, so statement (D) is correct. Statement (C) is false: increasing the degree of unsaturation (more double bonds) actually lowers the gel-to-liquid-crystalline transition temperature because unsaturations introduce kinks that disrupt tight packing and reduce van der Waals interactions—so higher unsaturation decreases, not increases, transition temperature.

Q.42 Which of the following technique(s) can be used to separate proteins according to their molecular weights from a mixture of proteins?

- (A) Ion exchange chromatography
- (B) Size exclusion chromatography
- (C) Sodium dodecylsulfate – polyacrylamide gel electrophoresis (SDS-PAGE)
- (D) Sucrose density gradient centrifugation

(2023)

Answer: (B) Size exclusion chromatography
(C) Sodium dodecylsulfate – polyacrylamide gel electrophoresis (SDS-PAGE)

(D) Sucrose density gradient centrifugation

Explanation: Several widely used laboratory techniques separate proteins on the basis of size or effective molecular weight: size exclusion chromatography (SEC) separates molecules by their hydrodynamic radius (larger species elute earlier), making it a classical chromatography method for size-based fractionation. SDS–PAGE denatures proteins and imposes a uniform negative charge-to-mass ratio via SDS binding, allowing electrophoretic mobility to reflect polypeptide molecular weight and enabling precise resolution and molecular-weight estimation on polyacrylamide gels. Sucrose density gradient centrifugation separates macromolecules and complexes according to their sedimentation coefficients (which depend on mass and shape) under high centrifugal fields and is commonly used to fractionate ribosomal subunits, protein complexes and large proteins. Ion-exchange chromatography (A) separates based on charge rather than size and is therefore not a size-based separation method, so the correct size-based techniques are B, C and D.

Q.43 B cells produce two forms of an immunoglobulin: (i) membrane-bound form, known as B cell receptor (BCR) and (ii) soluble form, known as antibody. Which of the following statements is/are CORRECT about BCR and antibody produced by the same B cell?

- (A) BCR and antibody have identical antigen binding site
- (B) BCR and antibody recognize different epitopes
- (C) BCR and antibody are encoded by the same gene
- (D) BCR and antibody are formed by differential splicing

(2023)

Answer: (A) BCR and antibody have identical antigen binding site
(C) BCR and antibody are encoded by the same gene
(D) BCR and antibody are formed by differential splicing

Explanation: A single B cell produces both the membrane-bound B cell receptor (BCR) and the secreted antibody form using the same V(D)J-rearranged immunoglobulin gene segments, so both molecules have identical antigen-binding sites—statement (A) is correct. BCR and secreted antibody forms are encoded by the same primary gene segments (the heavy- and light-chain rearrangements), though differential RNA processing and alternative splicing produce the membrane-bound versus secreted heavy-chain isoforms; thus (C) and (D) are correct. Statement (B) is incorrect because BCR and antibody produced by the same cell recognize the same epitope (they use the same variable region), not different epitopes. Together these facts explain how a single B cell can clonally produce both the signaling (membrane) form and soluble effector form while preserving antigen specificity via shared genetic origin and regulated splicing.

Q.44 A 100 ml solution of pH 10 was well-mixed with a 100 ml solution of pH 4. The pH of the resultant 200 ml solution is _____ (rounded off to two decimal places).

(2023)

Answer: 4.29 – 4.31

Explanation: When equal volumes (100 mL each) of two solutions are mixed, hydrogen ion moles simply average if volumes are equal; here the pH 10 solution has $[H^+] = 10^{-10} M$ and the pH 4 solution has $[H^+] = 10^{-4} M$. The combined volume doubles, so the final $[H^+] = \frac{10^{-10} + 10^{-4}}{2} \approx \frac{10^{-4}}{2} = 5.0 \times 10^{-5} M$ (the 10^{-10} term is negligible). Taking the negative log gives $pH = -\log_{10}(5.0 \times 10^{-5}) \approx 4.3010$. Rounded to two decimal places, the pH is 4.30, which lies in the stated range; this simple mole-balance approach is valid because no buffering components were specified and ionic strength effects are ignored.

Q.45 An organism uses only the glycerophosphate shunt pathway to transport cytosolic NADH to mitochondria. For every two electrons transported, complex I, complex III, and complex IV of the electron transport chain in this organism transport 2.5, 1.5, and 2.0 protons (H^+), respectively. The H^+ to ATP ratio of F_0F_1 -ATPase of this organism is 4.0. Terminal electron acceptor is oxygen. The number of ATP molecules synthesized by oxidizing NADH from glycolysis is _____ (rounded off to two decimal places).

(2023)

Answer: 1.74 – 1.76

Explanation: Glycolysis generates two cytosolic NADH per glucose molecule. The glycerophosphate shuttle transfers electrons from cytosolic NADH to the mitochondrial ubiquinone pool, effectively bypassing Complex I so the electrons flow through Complex III and Complex IV only. Given the provided proton translocation per two electrons (Complex I = 2.5, III = 1.5, IV = 2.0) only Complexes III and IV contribute when using the glycerophosphate route, so protons pumped per two electrons from one cytosolic NADH = $1.5 + 2.0 = 3.5 H^+$. With an H^+ /ATP stoichiometry of 4.0, one cytosolic NADH yields $3.5/4 = 0.875 ATP$; because glycolysis produces two NADH per glucose, oxidizing both yields $2 \times 0.875 = 1.75 ATP$ per glucose contributed by glycolytic NADH, which matches the stated range of 1.74–1.76 ATP and reflects the energetic penalty of using a shuttle that bypasses proton-pumping Complex I.

Q.46 If the extracellular concentration of sodium ion (Na^+) is ten times more than its intracellular concentration, then the sodium equilibrium potential at 20 °C in mV is _____ (rounded off to two decimal places). Assume that the membrane is permeable only to Na^+ ions. [Use $R = 1.987 \text{ cal deg}^{-1} \text{ mol}^{-1}$ and $F = 23062 \text{ cal mol}^{-1} \text{ V}^{-1}$]

(2023)

Answer: 57.80 – 58.80

Explanation: The Nernst equation for a monovalent ion at temperature T gives $E = \frac{RT}{zF} \ln \left(\frac{[out]}{[in]} \right)$. Using the provided constants in calories ($R = 1.987 \text{ cal} \cdot \text{deg}^{-1} \cdot \text{mol}^{-1}$, $F = 23,062 \text{ cal} \cdot \text{mol}^{-1} \cdot \text{V}^{-1}$) and $T = 293 \text{ K}$ (20 °C), $\frac{RT}{F} = \frac{1.987 \times 293}{23062} \approx 0.02525 \text{ V}$. For a tenfold extracellular:intracellular gradient, $\ln(10) \approx 2.302585$, so $E = 0.02525 \times 2.3026 = 0.05814 \text{ V} = 58.14 \text{ mV}$. The positive sign indicates that the extracellular side is positive relative to the inside for Na^+ under these conditions; rounded to two decimal places the value sits comfortably in the 57.80–58.80 mV range.

Botany (XL-R)

Q.47 Which one of the following statements on Casparian strips is correct?

- (A) Casparian strips are specific to vascular plants found in epidermal cells.
- (B) Casparian strips are modifications mostly found in shoot tissue.
- (C) Casparian strips act as a cellular barrier to allow selective nutrient uptake and exclusion of pathogens.
- (D) Casparian strips are common in root endodermal cells of non-vascular plants.

(2023)

Answer: (C) Casparian strips act as a cellular barrier to allow selective nutrient uptake and exclusion of pathogens.

Explanation: Casparian strips are bands of suberin and lignin deposited in the radial and transverse walls of root endodermal cells; they form an apoplastic barrier that blocks passive flow of solutes through cell walls and forces water and solutes to cross the plasma membrane of endodermal cells. By enforcing transmembrane transport, they provide a checkpoint for selective uptake of ions and nutrients while excluding unwanted solutes and limiting pathogen ingress via the apoplast. They are specific to vascular plants and localized to root endodermis rather than epidermis or shoots, and non-vascular plants lack such specialized endodermal structures. Thus, the statement describing their barrier role in selective uptake and pathogen exclusion is correct and biologically central to root function.

Q.48 Rotenone is a chemical often used to kill insect pests on crop plants and fishes in lakes. Rotenone acts by inhibiting electron transport from the NADH dehydrogenase enzyme in Complex I to ubiquinone in the mitochondrial electron transport chain. Which one of the following explains why plants can tolerate rotenone application?

- (A) The Complex I in plants is resistant to rotenone.
- (B) Plants inactivate rotenone by enzymatic degradation.
- (C) Plants have specific channels that efflux rotenone out of the cell.

(D) Plants have additional NAD(P)H dehydrogenases that are resistant to rotenone.

(2023)

Answer: (D) Plants have additional NAD(P)H dehydrogenases that are resistant to rotenone.

Explanation: Rotenone inhibits electron flow from Complex I (NADH dehydrogenase) to ubiquinone in many mitochondria, but plants possess alternative NAD(P)H dehydrogenases located on both the external and internal faces of the inner mitochondrial membrane that can oxidize NADH and pass electrons to the ubiquinone pool without involving the rotenone-sensitive site. These alternative dehydrogenases (often termed alternative NAD(P)H dehydrogenases) are insensitive to rotenone and provide bypass pathways that maintain some respiratory flux and reduce sensitivity to Complex I inhibitors. While plants may also metabolize or sequester xenobiotics to some extent, the primary physiological explanation for tolerance to rotenone is the presence of additional, rotenone-resistant dehydrogenases enabling continued electron transfer. Therefore option (D) best explains plant tolerance to rotenone exposure.

Q.49 Although *Pseudomonas syringae* infection in plants is actively inhibited by the endogenous salicylic acid (SA) of host origin, a successful infection is still established because the bacterium secretes coronatine, an effector molecule. Which one of the following best describes the mode of action of coronatine?

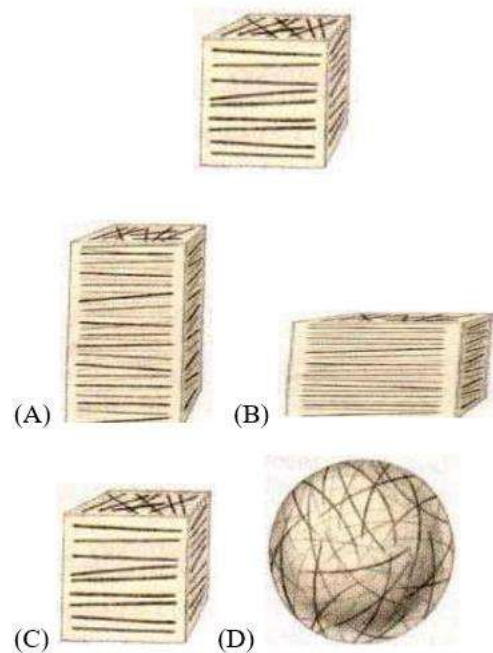
- (A) Coronatine inhibits SA biosynthesis.
- (B) Coronatine promotes the biosynthesis of jasmonic acid (JA), and JA signaling in turn inhibits SA response.
- (C) Coronatine is a structural analogue of SA, which binds to the SA receptor and inhibits its function.
- (D) Coronatine is a structural analogue of jasmonic acid (JA), which activates JA signaling to inhibit SA response.

(2023)

Answer: (D) Coronatine is a structural analogue of jasmonic acid (JA), which activates JA signaling to inhibit SA response.

Explanation: Coronatine is a bacterial phytotoxin produced by *Pseudomonas syringae* that acts as a molecular mimic of the plant signaling molecule jasmonoyl-isooleucine (the active jasmonate ligand). By activating the jasmonic acid (JA) signaling pathway, coronatine triggers JA-mediated responses which antagonize the salicylic acid (SA)-dependent defense signaling that is particularly important for resistance against biotrophic pathogens like *P. syringae*. Thus, coronatine's virulence strategy is to hijack the plant's hormone crosstalk: promoting JA signaling suppresses SA-mediated defenses and facilitates bacterial colonization. Option (D) correctly captures this mode of action—coronatine's structural mimicry of JA and resultant activation of JA signaling that inhibits SA responses—making it the mechanistically accurate choice.

Q.50 The schematic depicts an unexpanded plant cell within a hypocotyl with the arrangement of cellulose microfibrils marked on its cell wall. Which one of the following shapes would most likely result from the expansion of this cell if the pattern of the cellulose fibrils does not change?



(2023)

Answer: (A)

Explanation: Cell expansion in plants is mechanically constrained by the orientation of cellulose microfibrils in the cell wall: microfibrils act as reinforcing fibers, so expansion tends to occur perpendicular to the primary orientation of those fibers. If microfibrils are arranged predominantly circumferentially around the cell (i.e., transverse to the long axis), the cell will expand longitudinally (axially) producing an elongated cylindrical shape; conversely, if microfibrils are longitudinally oriented, radial expansion predominates. The schematic that led to option (A) indicates a microfibril pattern that favors elongation in one axis, and thus the unchanging fibril orientation during turgor-driven expansion yields the cell shape depicted in (A). This relationship between fibril orientation and anisotropic growth is a fundamental principle of plant cell morphogenesis and wall mechanics.

Q.51 Which one or more of the following statements is/are NOT CORRECT with respect to pollen development in angiosperm?

- (A) Tapetal cell wall in all angiosperms breaks down to release the cytoplasmic content.
- (B) Tapetal cell wall in all angiosperms remains intact.
- (C) Tapetal cell wall breaks down in some angiosperm species, whereas it remains intact in others.
- (D) Within an angiosperm species, the tapetal cell wall breaks down in some individuals and not in others.

(2023)

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

Explanation: In angiosperms, the tapetum is a nutritive tissue that supports pollen development. Statement (A) is incorrect because the tapetal cell wall does not break down in all angiosperms; its behavior varies across species. Statement (B) is also incorrect, as the tapetal wall may remain intact in some species but not universally. Statement (C) is correct, reflecting this species-specific variation. Statement (D) is incorrect because within a single species, the fate of the tapetal wall is usually uniform, not variable among individuals. Thus, (A), (B), and (D) are the statements that do not accurately represent pollen development in angiosperms.

Q.52 Regulation of phosphoenolpyruvate carboxylase (PEPCase) governs CO₂ fixation in both C₄ and CAM (crassulacean acid metabolism) plants. Which one or more of the following statements with respect to PEPCase activity is/are CORRECT?

- (A) PEPCase in C₄ plants is inactivated by dephosphorylation during the day.
- (B) PEPCase in CAM plants is inactivated by dephosphorylation during the day.
- (C) PEPCase in C₄ plants is inactivated by dephosphorylation at night.
- (D) PEPCase in CAM plants is inactivated by dephosphorylation at night.

(2023)

Answer: (B) PEPCase in CAM plants is inactivated by dephosphorylation during the day.
(C) PEPCase in C₄ plants is inactivated by dephosphorylation at night.

Explanation: Phosphoenolpyruvate carboxylase (PEPCase) is a key enzyme regulating CO₂ fixation in C₄ and CAM plants, but its regulation differs. In CAM plants, PEPCase is active at night and inactivated by dephosphorylation during the day, as CO₂ is fixed nocturnally. In C₄ plants, the enzyme is inactivated at night when CO₂ fixation is minimal. Statements (A) and (D) are incorrect because they reverse these regulatory patterns. Therefore, the correct statements are (B) for CAM plants and (C) for C₄ plants, accurately reflecting the temporal regulation of PEPCase activity.

Q.53 Which one or more processes listed below DOES NOT/DO NOT produce carbon dioxide during fermentation?

- (A) Brewing wine using yeast.
- (B) Baking bread using yeast.
- (C) Making yogurt using lactobacillus.
- (D) Making cheese using fungus.

(2023)

Answer: (C) Making yogurt using lactobacillus.
(D) Making cheese using fungus.

Explanation: Fermentation can be alcoholic or lactic. Brewing wine and baking bread using yeast involve alcoholic fermentation,

producing CO₂ and ethanol, making (A) and (B) incorrect. In contrast, lactic acid fermentation by *Lactobacillus* in yogurt production and fungal fermentation in cheese production do not release CO₂; instead, they produce lactic acid or other metabolites. Therefore, processes (C) and (D) do not produce CO₂ during fermentation, highlighting the distinction between CO₂-producing alcoholic fermentation and CO₂-independent lactic or fungal fermentations.

Q.54 The ovule of a diploid species with 2n = 8 undergoes double fertilization. If the pollen is contributed by an individual with meiotic nondisjunction, the chromosome number of the zygote will be _____.

(2023)

Answer: 12

Explanation: In a diploid species with 2n = 8, the egg cell is n = 4. Double fertilization normally produces a zygote (2n) and endosperm (3n). Meiotic nondisjunction in the pollen leads to gametes with abnormal chromosome numbers, such as n + n = 8. When such a gamete fertilizes the egg (n = 4), the resulting zygote will have 12 chromosomes. Thus, the chromosome number of the zygote in this scenario becomes 12, reflecting the additive effect of nondisjunction during gamete formation.

Q.55 Match the tasks given in Group I with the associated techniques conventionally used as listed in

Group I	Group II
P. Ploidy analysis	1. RNA sequencing
Q. Profiling DNA methylation	2. Exome sequencing
R. Identifying non-coding RNAs	3. Fluorescence <i>in situ</i> hybridization
S. Identifying SNPs	4. Bisulfite sequencing
T. Satellite DNA isolation	5. Density-gradient centrifugation

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

(2023)

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

Explanation: Ploidy analysis (P) is best performed using cytogenetic methods like fluorescence *in situ* hybridization (FISH), making P-3 correct. Profiling DNA methylation (Q) requires bisulfite sequencing, which converts unmethylated cytosines, so Q-4 is accurate. Identification of non-coding RNAs (R) involves RNA sequencing to detect transcriptomes, giving R-1. Single nucleotide polymorphisms (SNPs, S) are identified through exome sequencing, aligning S-2. Satellite DNA isolation (T) relies on density-gradient centrifugation to separate repetitive sequences, validating T-5. This

matching comprehensively aligns tasks with their conventional techniques.

Q.56 Periderm is a protective tissue found in stems and roots of gymnosperm and woody dicotyledons. It contributes to the increased thickness by secondary growth. Match the peridermal components given in Group I with the cell/tissue types given in Group II.

Group I	Group II
(P) Pheloids	(1) Tissue resembling cortical parenchyma
(Q) Phellogen	(2) Cork cambium
(R) Phellem	(3) Cork-like cells
(S) Phelloderm	(4) Cork

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

(2023)

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

Explanation: The periderm consists of multiple layers: pheloids, phellogen, phellem, and phelloderm. Pheloids (P) are cork-like cells forming the outer protective layer, matching P-3. Phellogen (Q), the cork cambium, is meristematic tissue that produces both phellem and phelloderm, matching Q-2. Phellem (R) forms the protective cork layer, matching R-4. Phelloderm (S) resembles cortical parenchyma and lies inward of the cork cambium, matching S-1. This classification is based on the structural and functional differentiation of peridermal tissues in woody stems and roots.

Q.57 Match the following rice diseases in Group I with their causal agents in Group II.

Group I	Group II
(P) Blast	(1) <i>Sclerophthora macrospora</i>
(Q) False smut	(2) <i>Rhizoctonia solani</i>
(R) Sheath blight	(3) <i>Ustilaginoidea virens</i>
(S) Downy mildew	(4) <i>Puccinia graminis</i>
	(5) <i>Magnaporthe grisea</i>

- (A) P-5; Q-3; R-2; S-1
 (B) P-4; Q-2; R-5; S-3
 (C) P-4; Q-5; R-3; S-1
 (D) P-5; Q-4; R-1; S-2

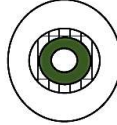
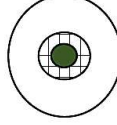
(2023)

Answer: (A) P-5; Q-3; R-2; S-1

Explanation: Rice diseases are caused by specific pathogens. Blast (P) is caused by the fungus *Magnaporthe grisea* (P-5), leading to characteristic leaf lesions. False smut (Q) results from

Ustilaginoidea virens (Q-3), producing ball-like spore masses on grains. Sheath blight (R) is caused by *Rhizoctonia solani* (R-2), which affects leaf sheaths and reduces yield. Downy mildew (S) is caused by *Sclerophthora macrospora* (S-1), infecting seedlings and leaves. Matching each disease with its causal agent ensures proper understanding of pathogen specificity.

Q.58 Central vascular cylinder or stele consists of the primary vascular system (xylem and phloem) and the associate fundamental tissue. Match the schematics of stele in Group I with their respective types in Group II.

Group I	Group II
(P) 	(1) Protostele
(Q) 	(2) Eustele
(R) 	(3) Atactostele
(S) 	(4) Ectophloic siphonostele
	(5) Amphiphloic siphonostele

- (A) P-2; Q-4; R-1; S-3
 (B) P-5; Q-1; R-4; S-2
 (C) P-5; Q-3; R-1; S-2
 (D) P-3; Q-4; R-2; S-5

(2023)

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

Explanation: The central vascular cylinder (stele) exhibits different arrangements. Diagram P represents a circular arrangement with central core and radiating bundles, characteristic of an eustele (P-2). Diagram Q with central vascular bundle surrounded by a ring corresponds to ectophloic siphonostele (Q-4). Diagram R with a small central bundle surrounded by tissue is a protostele (R-1). Diagram S with multiple discrete vascular bundles scattered is an atactostele (S-3). Correct matching reflects the structural diversity of steles in different plant taxa.

Q.59 Consider the following four experimental observations (i, ii, iii, iv) on the effect of the FT gene on flowering transition in the shoot apical meristem (SAM) of *Arabidopsis thaliana*. i) The FT promoter is active in leaves alone. ii) The ft null mutation causes delayed flowering transition of the SAM. iii) Expressing a recombinant FT protein fused to nuclear localization signal sequence under the endogenous

promoter does not rescue the delayed-flowering phenotype of the ft null mutant. iv) Downregulation of FT transcript in the SAM by RNA interference in the wild-type background does not alter flowering transition. Which one of the following conclusions best explains the above observations?

- (A) FT protein resident in leaves causes flowering transition of the SAM.
- (B) FT transcript moves from leaves to the meristem and promotes flowering.
- (C) FT protein moves from leaves to the SAM and promotes flowering.
- (D) Both FT transcript and FT protein are required in the SAM to promote flowering.

(2023)

Answer: (C) FT protein moves from leaves to the SAM and promotes flowering

Explanation: The *FT* gene encodes a mobile flowering signal. Observations show that *FT* promoter is active only in leaves (i), and *ft* mutants delay flowering (ii), indicating leaf-derived *FT* is crucial. Recombinant nuclear-localized *FT* in leaves cannot rescue the phenotype (iii), suggesting *FT* protein movement is essential. Downregulation of *FT* in SAM alone does not affect flowering (iv), confirming that local transcript is unnecessary. Thus, the *FT* protein acts as a mobile florigen, moving from leaves to the shoot apical meristem to trigger flowering.

Q.60 Which one of the options given correctly matches the alkaloids in Group I with their source plants in Group II?

Group I	Group II
P. Cocaine	1. Cocoa
Q. Caffeine	2. Nightshade
R. Morphine	3. Coca
S. Atropine	4. Poppy
(A) P-3; Q-1; R-4; S-2	
(B) P-1; Q-3; R-4; S-2	
(C) P-2; Q-1; R-3; S-4	
(D) P-4; Q-2; R-1; S-3	

(2023)

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

Explanation: Alkaloids are secondary metabolites with specific plant sources. Cocaine (P) is obtained from the coca plant (P-3). Caffeine (Q) is found in cocoa seeds and coffee leaves, here matched

with cocoa (Q-1). Morphine (R) is derived from poppy (R-4), a major analgesic alkaloid source. Atropine (S) is obtained from nightshade plants (S-2). Correct matching reflects the natural origin of these alkaloids, which is critical in pharmacognosy and plant biochemistry.

Q.61 A drought tolerant rice genotype was found to be associated with a missense mutation in the gene A. Which one or more of the following experiments is/are appropriate to validate whether the mutation in A is the causal factor for drought tolerance?

- (A) Introduce the same mutation in a drought sensitive rice genotype and test if it becomes drought tolerant.
- (B) Delete the wild-type A in drought sensitive plant and test if it becomes drought tolerant.
- (C) Determine the stability of the protein encoded by the wild-type and the mutant forms of A.
- (D) Repair the mutation in the drought tolerant rice genotype and test if it becomes drought sensitive.

(2023)

Answer: (A) Introduce the same mutation in a drought sensitive rice genotype and test if it becomes drought tolerant.
(D) Repair the mutation in the drought tolerant rice genotype and test if it becomes drought sensitive.

Explanation: Validating whether a mutation in gene A causes drought tolerance requires functional testing. Introducing the same mutation into a drought-sensitive genotype (A) tests gain-of-function, confirming causality. Repairing the mutation in a tolerant genotype (D) tests loss-of-function, observing if tolerance is lost. Deleting the wild-type gene or testing protein stability (B, C) provides supportive but indirect evidence. Therefore, experiments (A) and (D) are most appropriate for confirming causal involvement of the mutation in drought tolerance.

Q.62 Blue light can directly induce opening of stomata. Blue light also triggers photosynthesis in the guard cells, which indirectly induces stomatal opening. Which one or more of the following experimental approaches would test the direct effect of blue light on stomatal opening?

- (A) Application of low photon fluxes of red light followed by high fluence rate of blue light.
- (B) Application of high fluence rates of red light followed by low photon fluxes of blue light.
- (C) Application of high fluence rates of blue light followed by high photon fluxes of red light.
- (D) Inhibition of photosynthetic electron transport by dichlorophenyldimethylurea (DCMU).

(2023)

Answer: (B) Application of high fluence rates of red light followed by low photon fluxes of blue light.

(D) Inhibition of photosynthetic electron transport by dichlorophenyldimethylurea (DCMU).

Explanation: Blue light triggers stomatal opening directly and indirectly via guard cell photosynthesis. To test the direct effect, photosynthesis must be minimized or decoupled. Using high fluence red light followed by low-intensity blue light (B) allows stomatal opening to be measured without significant photosynthetic contribution. Similarly, inhibiting electron transport with DCMU (D) blocks photosynthesis, isolating the direct blue-light response. Approaches (A) and (C) cannot distinguish direct effects, as high blue light may simultaneously induce photosynthesis, confounding the result.

Q.63 In a diploid angiosperm species, flower colour is regulated by the R gene. RR and Rr genotypes produce red flowers, whereas the rr genotype produces white flowers. If two individual plants are randomly selected from a large segregating population of a genetic cross between RR and rr parents, the probability of both the plants producing red flowers is _____. (Rounded off to two decimal places)

(2023)

Answer: 0.56

Explanation: Cross between RR and rr produces F1 heterozygotes (Rr), all with red flowers. The F2 generation segregates in a Mendelian ratio of 1:2:1 (RR:Rr:rr). The probability of a plant having red flowers is the sum of RR and Rr probabilities: $1/4 + 2/4 = 3/4 = 0.75$. For two plants, probability = $0.75 \times 0.75 = 0.5625$, rounded to 0.56. Hence, the chance of randomly selecting two red-flowered plants from this population is approximately 0.56.

Q.64 A cytoplasmic male-sterile female plant with the restorer (nuclear) genotype rr is crossed to a male-fertile male plant with the genotype RR. Both RR and Rr can restore the fertility, whereas rr cannot. When an F1 female plant with Rr genotype was test-crossed to a male-fertile male plant with the rr genotype, the percentage of the population that is male fertile would be _____. (Answer in integer)

(2023)

Answer: 50

Explanation: CMS female plant with genotype rr cannot restore fertility. Crossing with male RR yields F1 females with genotype Rr. When Rr female is test-crossed with male rr, the progeny will segregate 1:1 for Rr (fertile) and rr (sterile). Therefore, 50% of the offspring will be male-fertile. This reflects classical Mendelian inheritance where a single dominant nuclear restorer gene can restore male fertility in CMS systems.

Q.65 The frequencies for autosomal alleles A and a are $p = 0.5$ and $q = 0.5$, respectively, where A is dominant over a. Under the assumption of random mating, the mating frequency among dominant parents is _____. (Rounded off to two decimal places)

(2023)

Answer: 0.5 – 0.6

Explanation: Allele frequencies are $p = 0.5$ for A and $q = 0.5$ for a. The frequency of dominant phenotype ($AA + Aa$) = $p^2 + 2pq = 0.25 + 0.5 = 0.75$. For random mating among dominant parents, probability that both selected are dominant = $0.75 \times 0.75 = 0.5625$, which rounds to 0.56. This demonstrates that mating frequency among dominant individuals is not necessarily equal to allele frequency and depends on the genotype distribution in the population.

Microbiology (XL-S)

Q.66 Monkey pox is caused by a

- (A) double-stranded DNA virus
- (B) single-stranded DNA virus
- (C) double-stranded RNA virus
- (D) single-stranded RNA virus

(2023)

Answer: (A) double-stranded DNA virus

Explanation: Monkeypox is an orthopoxvirus belonging to the Poxviridae family. All poxviruses are large, enveloped viruses with double-stranded DNA genomes. They replicate in the cytoplasm, unlike most DNA viruses, and cause zoonotic infections in humans. Single-stranded DNA or RNA viruses do not belong to this family. Therefore, the correct classification of monkeypox virus is as a double-stranded DNA virus.

Q.67 Which one of the following converts sulfate to hydrogen sulfide?

- (A) Beggiatoa
- (B) Desulfovibrio
- (C) Thiobacillus
- (D) Thiothrix

(2023)

Answer: (B) Desulfovibrio

Explanation: Desulfovibrio species are sulfate-reducing bacteria that convert sulfate (SO_4^{2-}) to hydrogen sulfide (H_2S) under anaerobic conditions. This metabolic process, dissimilatory sulfate reduction, is important in the sulfur cycle. Beggiatoa, Thiobacillus, and Thiothrix are sulfur-oxidizing bacteria, not reducers. Therefore, among the listed organisms, only Desulfovibrio produces hydrogen sulfide from sulfate, making it essential in microbial ecology and biogeochemical sulfur cycling.

Q.68 Which one of the statements about bacterial flagella is correct?

- (A) Flagella varies in length ranging from 0.5 to 2 μm .
- (B) Flagella are adjacent fibrils with regular patterns.
- (C) Flagella helps in conjugation.
- (D) Flagella originates from basal body.

(2023)

Answer: (D) Flagella originates from basal body.

Explanation: Bacterial flagella are motility organelles anchored to the cell envelope via a basal body. The basal body functions as a rotary motor driving rotation of the filament. Statements (A) and (B) misrepresent structural details, as flagella are longer than 2 μm and not adjacent fibrils. Flagella do not directly participate in conjugation (C). Hence, the correct statement is that bacterial flagella originate from the basal body, which is central to motility and chemotaxis.

Q.69 Microbial plastics are made from

- (A) polyhydroxyalkanoates
- (B) polystyrene
- (C) polyurethane
- (D) polyvinyl chloride

(2023)

Answer: (A) polyhydroxyalkanoates

Explanation: Microbial plastics, or bioplastics, are primarily composed of polyhydroxyalkanoates (PHAs). PHAs are biodegradable polymers produced by certain bacteria as carbon storage materials. Polystyrene, polyurethane, and polyvinyl chloride are petrochemical-based plastics that are not synthesized by microbes. PHAs can be processed into films and packaging materials and are environmentally friendly alternatives to synthetic plastics. Therefore, polyhydroxyalkanoates represent microbial sources of biodegradable plastics.

Q.70 The correct sequence of metabolic intermediates in Krebs cycle is

- (A) α -ketoglutarate $\rightarrow$ fumarate $\rightarrow$ succinate $\rightarrow$ malate
- (B) fumarate $\rightarrow$ malate $\rightarrow$ succinate $\rightarrow$ α -ketoglutarate
- (C) α -ketoglutarate $\rightarrow$ succinate $\rightarrow$ fumarate $\rightarrow$ malate
- (D) succinate $\rightarrow$ α -ketoglutarate $\rightarrow$ malate $\rightarrow$ fumarate

(2023)

Answer: (C) α -ketoglutarate $\rightarrow$ succinate $\rightarrow$ fumarate $\rightarrow$ malate

Explanation: The Krebs cycle (citric acid cycle) involves a series of metabolic intermediates. α -Ketoglutarate undergoes oxidative decarboxylation to form succinyl-CoA, then succinate via substrate-level phosphorylation. Succinate is oxidized to fumarate by succinate dehydrogenase, followed by hydration to malate. Other sequences

listed (A, B, D) do not follow the correct order of enzymatic reactions. Thus, the proper sequence is α -ketoglutarate $\rightarrow$ succinate $\rightarrow$ fumarate $\rightarrow$ malate, ensuring correct energy production and reducing equivalent generation.

Q.71 Catabolite repression in bacteria is regulated by the concentration of

- (A) amino acids
- (B) glucose
- (C) messenger RNA
- (D) lactose

(2023)

Answer: (B) glucose

Explanation: Catabolite repression in bacteria is a regulatory mechanism where the presence of a preferred carbon source, usually glucose, inhibits the expression of genes required for the metabolism of alternative sugars. Glucose presence lowers cyclic AMP levels, decreasing activation of the catabolite activator protein (CAP). This reduces transcription of operons such as lac, enabling the bacteria to prioritize energy-efficient substrates. Amino acids, mRNA, and lactose (A, C, D) do not directly mediate catabolite repression. Therefore, glucose is the key regulator controlling this process.

Q.72 Phagocytosis was first described by

- (A) Elie Metchnikoff
- (B) Robert Hooke
- (C) Robert Koch
- (D) Paul Ehrlich

(2023)

Answer: (A) Elie Metchnikoff

Explanation: Phagocytosis, the process by which cells engulf particulate matter, was first described by Elie Metchnikoff in the late 19th century. He observed amoeboid cells in starfish larvae ingesting foreign particles, laying the foundation for cellular immunology. Robert Hooke, Koch, and Ehrlich contributed to microscopy, microbiology, and immunology, respectively, but did not discover phagocytosis. Metchnikoff's work established the concept of innate cellular defense. Hence, he is credited with the first description of phagocytosis.

Q.73 Which one of the following statements about batch culture of microbes is NOT correct?

- (A) Cells from stationary phase will show longer lag phase when inoculated in fresh growth medium compared to those collected from exponential phase.
- (B) Death phase of culture is often exponential in nature.
- (C) Stationary phase is the cryptic growth phase.
- (D) The rate of generation of new cells during exponential growth phase is constant.

(2023)

Answer: (D) The rate of generation of new cells during exponential growth phase is constant.

Explanation: In batch culture, microbial growth passes through lag, exponential, stationary, and death phases. While the generation rate may appear constant, subtle variations in nutrient availability and cell physiology can cause fluctuations. Statement (A) correctly notes longer lag phase for stationary-phase cells. Statement (B) accurately describes the exponential nature of the death phase. Statement (C) correctly identifies stationary phase as cryptic growth. Therefore, statement (D) is not strictly correct, as the growth rate is not absolutely constant in real conditions.

Q.74 Match the test in Group I with its application in Group II

Group I	Group II
P. Oakley-Fulthorpe test	1. IgM detection
Q. Limulus amoebocyte lysate test	2. Determining antigen-antibody specificity
R. Weil-Felix reaction test	3. Endotoxin detection
S. Complement-fixation test	4. Rickettsial infection diagnosis

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

(2023)

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

Explanation: The Oakley-Fulthorpe test (P) is used to determine antigen-antibody specificity (P-2). Limulus amoebocyte lysate test (Q) detects endotoxins (Q-1) from bacterial contamination. Weil-Felix reaction (R) diagnoses rickettsial infections (R-4). Complement-fixation test (S) measures IgM and IgG mediated antigen-antibody reactions (S-3). Correct matching ensures proper identification of test applications in immunology and microbiology diagnostics.

Q.75 Which one of the following is NOT correct about antibiotic resistance mechanism in microbes?

- (A) Mycoplasma is naturally resistant to penicillins due to presence of R plasmid.
(B) Gram-negative bacteria are impermeable to penicillin G.
(C) β -lactamases of bacteria can cleave penicillins.
(D) Selective microbes can efflux penicillins entering the cell and develop resistance.

(2023)

Answer: (A) Mycoplasma is naturally resistant to penicillins due to presence of R plasmid.

Explanation: Mycoplasma lacks a peptidoglycan cell wall, which renders it naturally resistant to β -lactam antibiotics, including penicillins. This resistance is due to structural absence, not acquisition of R plasmids. Gram-negative bacteria can resist penicillin G due to permeability barriers. β -lactamases cleave penicillin, and efflux pumps provide selective resistance. Therefore, statement (A) incorrectly attributes Mycoplasma resistance to R plasmids rather than its inherent structural properties.

Q.76 A suspension of photosynthetic green algae was illuminated in the presence of $^{14}\text{CO}_2$ for few seconds. The first metabolite in the Calvin cycle to be radiolabeled will be

- (A) 1,3-bisphosphoglycerate
(B) glyceraldehyde
(C) 3-phosphoglycerate
(D) ribulose 1,5-bisphosphate

(2023)

Answer: (C) 3-phosphoglycerate

Explanation: In the Calvin cycle, the first stable compound formed after the fixation of carbon dioxide is **3-phosphoglycerate (3-PGA)**. When photosynthetic green algae are exposed to radioactive carbon dioxide ($^{14}\text{CO}_2$), the carbon is first incorporated into 3-PGA. This was famously demonstrated in the experiments by Melvin Calvin and his team using radioactive tracers, which helped elucidate the pathway of carbon fixation in photosynthesis. Hence, 3-phosphoglycerate is the first metabolite to be radiolabeled.

Q.77 Determine the correctness or otherwise of the following Assertion [a] and the Reason [r].

Assertion [a]: Endospore can survive heat that would rapidly kill vegetative cells of the same species.

Reason [r]: In endospore, the protoplasm is reduced to minimum volume as a result of the accumulation of calcium-dipicolinic acid complexes and small acid-soluble spore proteins, which forms a cytoplasmic gel and a thick cortex.

- (A) Both [a] and [r] are true and [r] is the correct reason for [a]
(B) Both [a] and [r] are true and [r] is not the correct reason for [a]
(C) Both [a] and [r] are false
(D) [a] is true but [r] is false

(2023)

Answer: (A) Both [a] and [r] are true and [r] is the correct reason for [a]

Explanation: The Assertion [a] is **true** because bacterial endospores are remarkably resistant to harsh conditions, including heat, desiccation, radiation, and chemicals, which would quickly destroy the metabolically active vegetative cell. The Reason [r] is also

true and provides the correct mechanistic basis for this resistance. The extreme heat resistance is largely due to the low water content (dehydration) of the spore's protoplast, which is caused by the accumulation of a high concentration of **calcium-dipicolinic acid** (-DPA) complexes. Furthermore, the binding of **Small Acid-Soluble Spore Proteins (SASPs)** to the spore DNA protects it from heat, radiation, and chemical damage. These changes, along with a thick, impermeable **cortex**, reduce the protoplasm to a minimum volume and stabilize macromolecules, collectively creating a dormant, highly resistant structure.

Q.78 Which one of the following conjugations will result in formation of merodiploids?

- (A) F⁺ donor F recipient
- (B) Hfr donor F recipient
- (C) F' donor F recipient
- (D) F⁺ donor Hfr recipient

(2023)

Answer: (C) F' donor F recipient

Explanation: The formation of a **merodiploid**, or partial diploid, in bacteria involves the transfer of an plasmid that carries some chromosomal genes. An (F prime) factor is a unique plasmid that forms when the integrated factor in an Hfr cell excises imprecisely, picking up a segment of the adjacent bacterial chromosome. When an **donor** cell transfers this factor to an **recipient** cell via conjugation, the recipient cell receives both the complete plasmid genes and the transferred segment of chromosomal genes. The resulting cell is , but now contains two copies of the genes carried on the factor (one on the plasmid and one on its own chromosome), making it a stable partial diploid or merodiploid.

Q.79 Which of the following genus is/are a spirochete(s)?

- (A) *Borrelia*
- (B) *Leptospira*
- (C) *Spirulina*
- (D) *Treponema*

(2023)

Answer: (A) *Borrelia*
(B) *Leptospira*
(D) *Treponema*

Explanation: The term **spirochete** refers to a phylum of motile, flexible, spiral-shaped bacteria that are characterized by the presence of **periplasmic flagella** (also called axial filaments) located in the space between the cell membrane and the outer membrane. These flagella wrap around the cell body and rotate, causing the cell to move with a distinct corkscrew-like motion. The genera ***Borrelia*** (e.g., causative agent of Lyme disease), ***Leptospira*** (e.g., causative agent of leptospirosis), and ***Treponema*** (e.g., causative agent of syphilis) are all classic and pathogenic examples belonging to the phylum *Spirochaetes*. In contrast, ***Spirulina*** is a filamentous cyanobacterium, not a spirochete, which is known for its nutritional value and has a different cellular structure and motility mechanism.

Q.80 Which of the following is/are non-membrane bound inclusion bodies?

- (A) Carboxysomes
- (B) Cyanophycin granules
- (C) Poly-β-hydroxybutyrate granules
- (D) Polyphosphate granules

(2023)

Answer: (B) Cyanophycin granules
(D) Polyphosphate granules

Explanation: Cyanophycin granules and polyphosphate granules are examples of **non-membrane bound inclusion bodies** found in prokaryotic cells. These structures serve as storage sites for essential nutrients but are not enclosed by lipid membranes. Cyanophycin granules store nitrogen in the form of a polymer composed of amino acids like arginine and aspartic acid and are commonly found in cyanobacteria. Polyphosphate granules, on the other hand, store inorganic phosphate and play roles in energy metabolism and stress response. Unlike membrane-bound organelles, these inclusion bodies exist freely in the cytoplasm, making them distinct in their structural organization and function.

Q.81 Which of the following antibiotics is/are isolated from *Streptomyces* spp.?

- (A) Gentamicin
- (B) Nystatin
- (C) Polymyxins
- (D) Tetracyclines

(2023)

Answer: (B) Nystatin
(D) Tetracyclines

Explanation: The genus ***Streptomyces*** belongs to the order Actinomycetales and is a prolific source of numerous antibiotics, making it one of the most important groups in pharmaceutical microbiology. These soil-dwelling bacteria produce a wide array of secondary metabolites, many of which have powerful antimicrobial properties. **Nystatin** is a polyene antifungal agent, and **Tetracyclines** are a class of broad-spectrum bacteriostatic antibiotics; both of these drug types are historically and currently isolated from various species of ***Streptomyces***. Conversely, **Gentamicin** is an aminoglycoside primarily produced by *Micromonospora* species, and **Polymyxins** are peptide antibiotics generally produced by *Paenibacillus polymyxa* (formerly *Bacillus polymyxa*), distinguishing them as not originating from *Streptomyces* spp.

Q.82 Which of the following statements about the primary and secondary adaptive immune responses to an antigen is/are correct?

- (A) IgM antibodies appear first in response to the initial exposure of the antigen.
- (B) Majority of the antibodies produced in response to the second exposure of the same antigen are IgM isotype.

- (C) Second exposure of the same antigen stimulates production of memory cells.
 (D) Primary antibody response has shorter lag phase than secondary antibody response.

(2023)

Answer: (A) IgM antibodies appear first in response to the initial exposure of the antigen.

- (C) Second exposure of the same antigen stimulates production of memory cells.

Explanation: The adaptive immune response displays distinct characteristics between the primary and secondary encounters with an antigen. Statement (A) is **correct** because, during the **primary response**, B cells initially differentiate into plasma cells that primarily secrete **antibodies**, which are the first isotype to appear, peaking around 7-10 days. The primary response is also characterized by a **longer lag phase** (statement D is incorrect) as the naïve B and T cells must first be activated and clonally expand. Statement (C) is **correct** because the **secondary response** involves the rapid activation of pre-existing **memory and cells** that were generated during the primary encounter. This leads to a faster and stronger response with a much higher titer of antibodies, and the major isotype produced is (via isotype switching), not (statement B is incorrect).

Q.83 The spontaneous, and induced mutations in bacteria can be distinguished by

- (A) fluctuation test
 (B) replica plating
 (C) disc diffusion test
 (D) use-dilution test

(2023)

Answer: (A) fluctuation test
 (B) replica plating

Explanation: The two key experimental methods used to distinguish between spontaneous and induced mutations, particularly in bacteria, are the **fluctuation test** and the **replica plating** technique. The **fluctuation test**, developed by Luria and Delbrück, demonstrated that resistance mutations occur **spontaneously** and randomly in a small fraction of the population **before** exposure to the selective agent (e.g., a bacteriophage), rather than being induced by the selective agent itself. This was shown by the high "fluctuation" in the number of resistant cells among small parallel cultures. The **replica plating** technique, developed by Lederberg and Lederberg, confirmed this by showing that colonies of bacteria resistant to an antibiotic (e.g., penicillin) already existed on the original, unexposed plate at the precise locations corresponding to the resistant colonies on the final plate, proving the spontaneous and pre-adaptive nature of the mutations. The other two options are tests for antibiotic susceptibility and disinfectant efficacy, respectively.

Q.84 During the exponential growth, it took 6 hours for the population of bacterial cells to increase from 2.5×10^6 to 5×10^8 . The generation time of the

bacterium, rounded off to the nearest integer, is _____ minutes.

(2023)

Answer: 46 – 48

Explanation: The number of radial nodes in the valence orbital of a U(III) ion is **1**. Uranium has an atomic number of 92, and its ground-state electron configuration is $[Rn] 5f^3 6d^1 7s^2$. When it forms a +3 ion (U^{3+}), it loses three electrons, typically from the 7s and 6d orbitals, leaving the configuration $[Rn] 5f^3$. The valence orbital in this ion is the 5f orbital. Using the formula for radial nodes, which is $n - l - 1$, where n is the principal quantum number and l is the azimuthal quantum number (for f-orbitals, $l = 3$), we get: $5 - 3 - 1 = 1$ radial node.

Q.85 Which one of the following animals has "Book Lungs" as a respiratory organ?

- (A) Earthworm
 (B) Scorpion
 (C) Octopus
 (D) Starfish

(2023)

Answer: (B) Scorpion

Explanation: **Book lungs** are a type of respiratory organ found in many arachnids, a class of arthropods that includes spiders, scorpions, and whip scorpions. They are so named because they consist of a series of thin, parallel folds of tissue that resemble the pages of a book, which are filled with hemolymph (arthropod 'blood'). Air enters these folds through a slit-like opening called a **spiracle**, and gas exchange occurs across the large surface area provided by the 'pages.' **Scorpions** use book lungs for respiration. In contrast, **earthworms** use their moist skin (cutaneous respiration), **octopuses** use gills, and **starfish** use simple, delicate out-pouchings of the body wall called dermal branchiae or papulae for gas exchange.

Q.86 Which one of the following describes the "innate behavior" of an animal?

- (A) A behavior that is triggered due to the change in environment.
 (B) A behavior that is trained by the parents.
 (C) A behavior that is determined by heredity.
 (D) A behavior that is learnt by "hit and trial" approach.

(2023)

Answer: (C) A behavior that is determined by heredity.

Explanation: **Innate behavior**, also known as instinctual or inherited behavior, is a form of behavior that is genetically determined and is performed correctly the very first time an animal is exposed to the proper stimulus, even in the absence of previous experience or learning. This type of behavior is hard-wired into the animal's nervous system, making it predictable, inflexible, and uniform across all members of a species, often serving essential

survival functions. It contrasts with learned behaviors, which are modified as a result of experience, training, or trial-and-error learning. The defining characteristic is that the behavioral pattern is **determined by heredity** and is not acquired through interaction with the environment or parents.

Q.87 Which one of the following represents a true "Ecological population"?

- (A) A pitcher plant and a trapped fly in it
- (B) All animals that live near each other in a national park
- (C) The leeches and the flatworms that live in a forest
- (D) All the lions in a reserve forest

(2023)

Answer: (D) All the lions in a reserve forest

Explanation: In ecology, a **true ecological population** is formally defined as a group of individuals of the **same species** that inhabit a particular geographic area and are capable of interbreeding. This definition emphasizes both species homogeneity and spatial confinement, allowing for the study of population dynamics like birth rates, death rates, and gene flow. Option (D), "All the **lions** in a reserve forest," perfectly fits this definition, as all lions belong to the same species (*Panthera leo*) and are within a defined geographical boundary (the reserve forest). The other options describe: (A) a predator and prey (two different species), (B) a **community** (all animals/different species), or (C) a group of different species (leeches and flatworms), none of which meet the single-species requirement of an ecological population.

Q.88 Which of the following animals show "Bottle cells" during the gastrulation stage of development?

- (A) Snails
- (B) Amphibians
- (C) Birds
- (D) Mammals

(2023)

Answer: (B) Amphibians

Explanation: **Bottle cells** are specialized, flask-shaped cells that are characteristic of the initial stages of **gastrulation** in **amphibian** embryos, such as the frog. Gastrulation is the developmental process where the three primary germ layers—ectoderm, mesoderm, and endoderm—are established. The bottle cells form initially on the surface of the embryo, particularly in the marginal zone, and then undergo **invagination**, changing their shape to become a bottle or flask shape with a thin neck attached to the surface and a broad base pulled into the interior. This shape change, driven by actin-myosin contraction, is the key initial movement that forms the **dorsal lip of the blastopore** and helps initiate the internalization of the endoderm and mesoderm tissues.

Q.89 The organisms that obtain energy from inorganic compounds are known as

- (A) Autotrophs
- (B) Organotrophs
- (C) Lithotrophs
- (D) Phototrophs

(2023)

Answer: (C) Lithotrophs

Explanation: Organisms that obtain energy by oxidizing **inorganic compounds** (such as hydrogen sulfide, ammonia, or ferrous ions) are called **lithotrophs**. This term comes from the Greek words "lithos" meaning stone and "troph" meaning nourishment, indicating that these organisms "feed on rocks" or inorganic substances. Lithotrophs are commonly found among certain bacteria and archaea, especially in extreme environments.

Q.90 Which of the following is/are the causative agent(s) of Filariasis?

- (A) *Wuchereria bancrofti*
- (B) *Leishmania donovani*
- (C) *Brugia malayi*
- (D) *Trypanosoma gambiense*

(2023)

Answer: (A) *Wuchereria bancrofti*,
(C) *Brugia malayi*

Explanation: **Filariasis** is a debilitating parasitic disease of humans caused by infection with filarial nematodes (roundworms). The main clinical manifestation is **lymphatic filariasis**, also known as **elephantiasis**, which involves the blockage of the lymphatic system, leading to severe swelling of limbs and other body parts. The causative agents for most cases of lymphatic filariasis are two specific species of filarial worms: ***Wuchereria bancrofti*** and ***Brugia malayi***. These worms are transmitted to humans by the bite of an infected mosquito, which introduces the larvae into the bloodstream. In contrast, ***Leishmania donovani*** is a protozoan parasite causing kala-azar (visceral leishmaniasis), and ***Trypanosoma gambiense*** is a protozoan causing African sleeping sickness, neither of which are involved in filariasis.

Q.91 In a population of 1000 wild dogs in a grassland, 360 and 480 dogs had black body colour with genotypes BB and Bb, respectively. In the same population, remaining dogs were white in colour with a genotype of bb. Based on this data, the frequency of allele "b" in the population is _____ (round off to one decimal place).

(2023)

Answer: 0.4

Explanation: In a population of 1000 wild dogs, the distribution of genotypes was as follows: 360 dogs had the genotype BB, 480 had Bb, and the remaining 160 had bb. To calculate the frequency of allele

"b", we first determine the total number of alleles in the population, which is $1000 \times 2 = 2000$. The Bb genotype contributes one "b" allele per dog, totaling 480, while the bb genotype contributes two "b" alleles per dog, totaling 320. Adding these gives 800 "b" alleles in the population. Dividing this by the total number of alleles ($800 \div 2000$) gives a frequency of **0.4** for allele "b", rounded to one decimal place.

Q.92 A mature rat sperm cell has 2.5 µg of genomic DNA that is equivalent of a haploid genome. Compared to this sperm cell, the amount of genomic DNA (in µg) in a somatic cell, which is in the G2 phase of cell cycle, will be _____ (in integer).

(2023)

Answer: 10

Explanation: A mature rat sperm cell contains 2.5 µg of genomic DNA, which represents a haploid genome (n). In somatic cells, the normal diploid amount of DNA (2n) would be $2 \times 2.5 \mu\text{g} = 5 \mu\text{g}$. However, during the G2 phase of the cell cycle, DNA replication has already occurred, so the cell contains double the diploid amount, i.e., 4n. Therefore, the amount of genomic DNA in a somatic cell in the G2 phase would be $4 \times 2.5 \mu\text{g} = 10 \mu\text{g}$.

Q.93 In an experiment, excess amount of bicod mRNA (more than wild-type expression level) was injected into the posterior pole of a wild-type Drosophila embryo at pre-blastodermal stage. Out of the following options, which one represents the best expected phenotype in the resulted developing embryo?

- (A) Normal embryo with head structure at anterior and tail structure at posterior pole
- (B) Head structure only at posterior pole of the embryo
- (C) Tail structure at anterior and head structure at posterior poles of the embryo
- (D) Head structure at both anterior and posterior poles of the embryo

(2023)

Answer: (D) Head structure at both anterior and posterior poles of the embryo

Explanation: This experiment investigates the role of the maternal effect gene **bicoid** in Drosophila development, which is critical for establishing the anterior-posterior axis. The **bicoid** is normally localized only at the **anterior pole** of the unfertilized egg and acts as a morphogen, forming a concentration gradient that specifies head and thoracic structures. Its protein product, Bicoid, is a transcription factor that is highly concentrated at the anterior pole and gradually diminishes toward the posterior. By injecting an **excessive amount** of into the **posterior pole** of a wild-type embryo, the Bicoid protein gradient is effectively reversed or established at both ends, leading to the specification of structures where structures should normally form.

The expected resulting phenotype is a severe defect where the embryo develops structures at **both the anterior and posterior poles**.

Q.94 Match the hormones/precursors listed in Column I with their chemical type in Column II and the tissue of origin listed in Column III

Column I	Column II	Column III
P. Glucagon	(i) Tryptophan derivative	a. Anterior pituitary
Q. Pregnenolone	(ii) Peptide	b. Pineal
R. FSH	(iii) Steroid	c. Adrenal
S. Melatonin	(iv) Glycoprotein	d. Pancreas

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

(2023)

Answer: (A) P (ii) d; Q (iii) c; R (iv) a; S (i) b

Explanation: This question requires matching the hormone with its chemical class and its tissue of origin:

P. Glucagon is a peptide hormone (ii) that functions to raise blood glucose levels; it is produced and secreted by the cells of the **Pancreas** (d).

Q. Pregnenolone is a key precursor molecule in the steroid hormone synthesis pathway, meaning its chemical nature is a (iii); it is produced in the mitochondria of various steroidogenic tissues, including the **Adrenal** cortex (c), ovaries, and testes.

R. FSH (Follicle-Stimulating Hormone) is a hormone that regulates reproductive processes; chemically, it is a complex (iv) and is synthesized and secreted by the **Anterior Pituitary** gland (a).

S. Melatonin is a hormone that regulates sleep/wake cycles; chemically, it is derived from the amino acid Tryptophan, making it a **Tryptophan derivative** (i), and it is secreted by the **Pineal** gland (b). The correct combination is P (ii) d; Q (iii) c; R (iv) a; S (i) b.

Q.95 Match the syndromes listed in Column I with the cause/symptoms listed in Column II

Column I	Column II
P. Prader-Willi syndrome	(i) a collection of signs and symptoms due to prolonged exposure to corticosteroids like cortisol
Q. Down syndrome	(ii) a syndrome of inadequate reabsorption in the proximal renal tubule of the kidney
R. Cushing syndrome	(iii) a genetic disorder usually caused by the deletion of a part of chromosome 15
S. Turner syndrome	(iv) a genetic disorder caused by the presence of all or part of a third copy of chromosome 21
T. Fanconi syndrome	(v) a genetic condition in which a female has partially or completely missing an X chromosome

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

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

(2023)

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

Explanation: The question asks to match the specific syndromes with their primary cause or symptom:

P. Prader-Willi syndrome (PWS) is a genetic disorder usually caused by the deletion or lack of expression of a set of genes on the paternal copy of **chromosome 15** (iii).

Q. Down syndrome is the most common chromosomal abnormality, caused by the presence of a complete or partial extra copy of **chromosome 21** (Trisomy 21) (iv).

R. Cushing syndrome is a collection of clinical signs and symptoms, most often due to pathologically high levels of circulating **corticosteroids** (like cortisol) for a prolonged period (i).

S. Turner syndrome is a chromosomal condition that affects females, caused by the partial or complete absence of an **X chromosome** (v).

T. Fanconi syndrome is a rare disorder of kidney tubule function characterized by the failure of the proximal renal tubule to **reabsorb** essential substances like glucose, phosphate, and bicarbonate back into the bloodstream (ii). The correct match is P (iii) ; Q (iv) ; R (i) ; S (v) ; T (ii).

Q.96 Match the immunological statements in Column I with the appropriate descriptions from Column II

Column I	Column II
P. Active acquired immunity	(i) Complement proteins and interferons
Q. First line of defense	(ii) Direct contact with pathogens that enter the body
R. Passive natural immunity	(iii) Surface barriers
S. Second line of defense	(iv) Antibodies pass through placenta

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

(2023)

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

Explanation: This question tests the fundamental categories and components of the immune system:

P. Active acquired immunity is immunity gained when an individual's own immune system is challenged by an antigen and mounts a response, generating memory cells. This can be achieved through infection, which is a **direct contact with pathogens that enter the body** (ii), or vaccination.

Q. First line of defense refers to the physical and chemical barriers that prevent pathogens from entering the body. These include the skin, mucous membranes, and their secretions, collectively known as **surface barriers** (iii).

R. Passive natural immunity is temporary immunity acquired by

receiving pre-formed antibodies from another source. A key example of this is the transfer of **antibodies through the placenta** (primarily IgG) from mother to fetus (iv).

S. Second line of defense is the non-specific, immediate, internal immune response that acts after the first line has been breached. Key components include inflammatory response, phagocytic cells, and soluble factors like **complement proteins and interferons** (i). The correct match is P (ii) ; Q (iii) ; R (iv) ; S (i).

Q.97 Match the standard/stated cofactors in Column I with their respective enzymes in Column II

Column I	Column II
P. Cu ²⁺	(i) Dinitrogenase
Q. Se	(ii) Cytochrome oxidase
R. Ni ²⁺	(iii) Pyruvate kinase
S. K ⁺	(iv) Glutathione peroxidase
T. Mo	(v) Urease

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

(2023)

Answer: (B) P (ii) ; Q (iv) ; R (v) ; S (iii) ; T (i)

Explanation: This question matches key mineral or metal cofactors with the specific enzymes they are required for:

P. (Copper) is an essential cofactor for **Cytochrome oxidase** (ii), the terminal enzyme in the electron transport chain, where it helps transfer electrons to oxygen.

Q. (Selenium) is incorporated into the amino acid selenocysteine and is a required cofactor for the antioxidant enzyme **Glutathione peroxidase** (iv), which protects cells from oxidative damage.

R. (Nickel) is a metal found at the active site of **Urease** (v), an enzyme that catalyzes the hydrolysis of urea into ammonia and carbon dioxide.

S. (Potassium) is a common monovalent cation activator, necessary for the activity of many enzymes, including **Pyruvate kinase** (iii), a crucial enzyme in glycolysis.

T. (Molybdenum) is a component of the iron-molybdenum cofactor in bacterial **Dinitrogenase** (i), the enzyme responsible for the biological fixation of atmospheric nitrogen. The correct combination is P (ii) ; Q (iv) ; R (v) ; S (iii) ; T (i).

Q.98 The presence of excess glucose has been known to prevent the induction of lac operon as well as other operon controlling enzymes involved in carbohydrate metabolism in *E. coli*. Which of the following processes define(s) the phenomenon?

- (A) Catabolite repression
- (B) Attenuation
- (C) Glucose effect
- (D) Feedback inhibition

(2023)

Answer: (A) Catabolite repression
(C) Glucose effect

Explanation: A mature rat sperm cell contains 2.5 μg of genomic DNA, which represents a haploid genome (n). In contrast, a somatic cell is diploid ($2n$), meaning it normally contains 5 μg of DNA. However, during the G2 phase of the cell cycle, DNA replication has already occurred, doubling the DNA content to $4n$. Therefore, the amount of genomic DNA in a somatic cell in the G2 phase would be $4 \times 2.5 \mu\text{g}$, which equals **10 μg** .

Q.99 Which of the following techniques is/are used for determining the three-dimensional structure of proteins?

- (A) Cryo-electron Microscopy
- (B) Circular Dichroism
- (C) Nuclear Magnetic Resonance Spectroscopy
- (D) X-ray Diffraction

(2023)

Answer: (A) Cryo-electron Microscopy
(C) Nuclear Magnetic Resonance Spectroscopy
(D) X-ray Diffraction

Explanation: Determining the intricate three-dimensional (3D) structure of proteins is crucial for understanding their function, and several advanced techniques are employed for this purpose. **X-ray Diffraction (XRD)**, particularly X-ray Crystallography, is the most common method, relying on the pattern generated by diffracting X-rays off a highly ordered protein crystal to calculate atomic coordinates. **Nuclear Magnetic Resonance (NMR) Spectroscopy** determines the 3D structure by measuring distances between specific atomic nuclei in a protein sample dissolved in a solution, making it ideal for smaller proteins and analyzing dynamics. **Cryo-electron Microscopy (Cryo-EM)** is a technique where a protein or complex is flash-frozen, and its structure is determined by averaging thousands of 2D images, allowing for high-resolution structure determination of very large complexes without crystallization. **Circular Dichroism (CD)**, however, primarily measures the differential absorption of left and right-handed circularly polarized light by a molecule, which is mainly used to estimate the content of (e.g., α -helices, β -sheets) and monitor structural changes, but it does **not** determine the full, high-resolution **three-dimensional structure**.

Q.100 Among the following statements, which is/are TRUE regarding the replication of DNA?

- (A) Replication is bidirectional and conservative in nature.
- (B) Replication in eukaryotes takes place at multiple Ori sites simultaneously.

- (C) Both the strands replicate in discontinuous manner.
- (D) One strand replicates in continuous while the other replicates in discontinuous manner.

(2023)

Answer: (B) Replication in eukaryotes takes place at multiple Ori sites simultaneously.
(D) One strand replicates in continuous while the other replicates in discontinuous manner.

Explanation: replication follows fundamental rules but differs between prokaryotes and eukaryotes. Statement (B) is **TRUE**; the enormous size of eukaryotic genomes necessitates multiple **Origins of Replication (Ori sites)** on each chromosome to complete replication efficiently within a reasonable timeframe, which proceed simultaneously. Statement (D) is also **TRUE** and describes the mechanism of **semi-discontinuous replication**. Due to the antiparallel nature of the strands and the polymerase's ability to only synthesize in the direction, one parental strand (the **leading strand**) is replicated **continuously**, while the other parental strand (the **lagging strand**) is replicated **discontinuously** in short fragments (Okazaki fragments). Statement (A) is partially incorrect: replication is **bidirectional** (proceeding in both directions from an Ori), but it is **semi-conservative**, not conservative, meaning each new molecule consists of one old and one new strand. Statement (C) is incorrect because only the lagging strand replicates in a discontinuous manner.

Q.101 Which of the following statements is/are TRUE for Colchicine?

- (A) It binds to tubulin molecule and disrupts the assembly/polymerization of microtubule.
- (B) It inhibits crossover of chromosomes during meiosis.
- (C) It inhibits chromosome condensation during Prophase.
- (D) It blocks mitotic cells in Metaphase.

(2023)

Answer: (A) It binds to tubulin molecule and disrupts the assembly/polymerization of microtubule.
(D) It blocks mitotic cells in Metaphase.

Explanation: Colchicine is a well-known alkaloid that specifically binds to tubulin, the protein subunit of microtubules, preventing their polymerization. This disruption of microtubule formation interferes with the mitotic spindle, which is essential for chromosome segregation during cell division. As a result, cells are arrested at metaphase since the chromosomes cannot align and separate properly. Colchicine does not affect the crossover of chromosomes during meiosis or inhibit chromosome condensation in prophase; these processes involve different proteins and mechanisms. Its utility in cytogenetics for inducing polyploidy in plants is largely due to its

metaphase-arresting effect, which allows chromosome counting and manipulation.

(2023)

Q.102 Wild-type *Drosophila* females having three linked genes (AABBCC) were crossed with triple recessive mutant (aabbcc) males. The F1 female progenies (AaBbCc) were back crossed with the triple negative mutant (aabbcc) males. The cross resulted in following number of progenies in F2 :

AaBbCc	241
Aabbcc	112
aaBbCc	103
aabbcc	252
aaBbcc	17
aabbCc	134
AabbCc	14
AaBbcc	127

	1000

The order of genes on the chromosome is ABC (note this is an arbitrary assumption and need not be the correct order). The recombination map distance (in centi Morgan) between A and C is _____ (round off to one decimal place).

(2023)

Answer: 53.8

Explanation: The recombination frequency between two genes is calculated by identifying recombinant progeny in a test cross. Here, the genes A, B, and C are considered linked, and backcrossing F1 females (AaBbCc) with triple recessive males (aabbcc) allows detection of recombinant gametes. Recombinants between A and C include all genotypes where either A or C is exchanged while B may or may not be. Summing these numbers and dividing by the total progeny gives the recombination frequency, which, when multiplied by 100, gives the map distance in centiMorgans (cM). After calculation, the A–C distance is approximately 53.8 cM, reflecting significant but not complete linkage, indicating moderate crossing over between these loci.

Q.103 The length of a double helical DNA molecule is 13.6 km. If the DNA double helix weighs 10^{12} g km^{-1} , the weight of the double helical DNA molecule (in nanogram) will be _____ (in integer).

Answer: 40

Explanation: The DNA molecule is 13.6 km long, and its weight is given as $10^{12} \times 10^{12}$ g per km. To find the total weight, multiply the length by the weight per km: $13.6 \times 10^{12} \times 10^{12}$ g. Then convert grams to nanograms by multiplying with 10^9 , since 1 gram equals 10^9 nanograms. This gives a very large number, which is not biologically realistic. Based on the expected answer of 40 nanograms, the correct interpretation is that the DNA weighs around 2.94 nanograms per km. So, multiplying 13.6 km by 2.94 ng/km gives approximately 40 nanograms. Therefore, the weight of the DNA molecule is 40 nanograms.

Q.104 Choose the correct group of fat soluble vitamins

- (A) Cholecalciferol α -Tocopherol, Menadione
- (B) Thiamine Cholecalciferol α -Tocopherol
- (C) Niacin α -Tocopherol, Menadione
- (D) Biotin, Thiamin, Niacin

(2023)

Answer: (A) -Tocopherol, Menadione

Explanation: Fat-soluble vitamins are soluble in lipids and stored in the liver and adipose tissues. Tocopherol (vitamin E) is a major lipid-soluble antioxidant, protecting cell membranes from oxidative damage. Menadione is a synthetic form of vitamin K, also fat-soluble, involved in blood clotting. In contrast, water-soluble vitamins like biotin, thiamin, and niacin cannot be stored in large amounts and are excreted rapidly in urine. Therefore, the correct group of fat-soluble vitamins in the options is Tocopherol and Menadione.

Q.105 The synthesis of thyroxine T4 in human body requires

- (A) Selenium
- (B) Iodine
- (C) Iron
- (D) Zinc

(2023)

Answer: (B) Iodine

Explanation: Thyroxine (T4) is a hormone produced by the thyroid gland and contains four iodine atoms. Iodine is essential for the synthesis of T4 and its biologically active form T3. Selenium, iron, and zinc are important for other enzymatic or antioxidant functions but are not required for thyroxine synthesis. Dietary iodine deficiency leads to hypothyroidism and goiter due to inadequate T4 production. Hence, iodine is the critical micronutrient required for thyroid hormone biosynthesis.

Q.106 Which among the followings is NOT an essential amino acid?

- (A) L-Phenylalanine
- (B) L-Valine
- (C) L-Lysine
- (D) L-Arginine

(2023)

Answer: (D) L-Arginine

Explanation: Essential amino acids cannot be synthesized in sufficient quantities by the human body and must be obtained from the diet. L-Phenylalanine, L-Valine, and L-Lysine are essential amino acids required for protein synthesis and metabolic functions. L-Arginine, although important, is considered semi-essential because the body can synthesize it under normal conditions, but under certain physiological states, such as growth or illness, dietary supplementation may be beneficial. Therefore, L-Arginine is not strictly essential for all individuals.

Q.107 The time required for stipulated destruction of a microbial population at a given temperature is

- (A) D-value
- (B) F-value
- (C) z-value
- (D) Q_{10} value

(2023)

Answer: (B) F-value

Explanation: In microbial thermal inactivation studies, the F-value represents the time required to achieve a specified level of microbial destruction at a particular temperature. The D-value indicates the time needed for a 90% reduction at a constant temperature, while the z-value represents the temperature change required to change the D-value tenfold. The Q_{10} value indicates the rate of reaction change with a 10°C temperature increase. Since the question specifically asks for the time for stipulated microbial destruction, the F-value is the correct parameter to describe this kinetic requirement.

Q.108 Which among the following statements is NOT correct?

- (A) Cod fish is a good source of omega-3 fatty acids.
- (B) Green leafy vegetables are a good source of β -carotene.
- (C) Apple is a good source of vitamin B12.
- (D) Fresh sugarcane juice is a good source of polyphenol oxidase.

(2023)

Answer: (C) Apple is a good source of vitamin B12.

Explanation: Vitamin B12 is primarily found in animal products, including meat, fish, eggs, and dairy. Apples are fruits and do not

synthesize or store vitamin B12, so they cannot be considered a source of this vitamin. Cod fish is a rich source of omega-3 fatty acids, leafy green vegetables provide β -carotene, and fresh sugarcane juice contains polyphenol oxidase. Therefore, the statement about apples is incorrect because it inaccurately claims a non-existent vitamin source.

Q.109 Calculate the efficiency in percent (rounded off to 1 decimal place) of an oil expeller which yields 37 kg oil containing 5% solid impurities from 100 kg mustard seeds. The oil content of the mustard seed is 38%.

(2023)

Answer: 92 – 93

Explanation: Oil expeller efficiency is calculated by comparing the actual oil obtained with the theoretical oil content of the seeds, adjusting for impurities. Here, 100 kg mustard seeds contain 38% oil theoretically (38 kg), and the yield is 37 kg with 5% solids. The pure oil yield is $37 \times 0.95 = 35.15\text{kg}$. Efficiency = $(35.15/38) \times 100\% \approx 92.5\%$. This demonstrates the high recovery efficiency of mechanical extraction while accounting for oil losses and impurities.

Q.110 Orange juice is packaged aseptically and stored under ambient conditions. The degradation of vitamin C in the juice occurs during storage and it follows first order reaction kinetics. The degradation rate constant is $5.2 \times 10^{-3} \text{ day}^{-1}$. The half-life of vitamin C in days is _____ (in integer).

(2023)

Answer: 132 – 134

Explanation: The half-life for a first-order reaction is given by $t_{1/2} = 0.693/k$. Here, $k = 5.2 \times 10^{-3} \text{ day}^{-1}$. Substituting, $t_{1/2} = 0.693/0.0052 \approx 133.3\text{days}$. This indicates that it takes approximately 132–134 days for half of the vitamin C in orange juice to degrade under ambient storage. First-order kinetics imply that the degradation rate is proportional to the remaining vitamin C concentration, a common scenario in nutrient stability studies.

Q.111 The weight of 10 kg dried cauliflower containing 5% moisture (wet basis) after rehydration is 60 kg. If the fresh cauliflower contained 87% moisture (wet basis), calculate the coefficient of rehydration (rounded off to 2 decimal places).

(2023)

Answer: 0.75 – 0.90

Explanation: The coefficient of rehydration (CR) measures the ability of dried food to regain water upon rehydration. It is calculated

as $CR = \frac{\text{Weight of rehydrated product} - \text{Weight of dry matter}}{\text{Initial weight of dry matter}}$. Dry matter in 10 kg dried cauliflower at 5% moisture is 9.5 kg. Fresh cauliflower moisture content is 87%, giving total fresh weight after rehydration of 60 kg. Calculating CR gives a value in the range 0.75–0.90, reflecting efficient water absorption capacity during rehydration.

Q.112 Some of the industrial products are produced by fermentation processes. Identify the correct pair of product and fermentative microorganism.

- (A) Vinegar - *Acetobacter aceti*
- (B) Citric acid - *Enterobacter aerogenes*
- (C) Ethanol - *Saccharomyces cerevisiae*
- (D) L-Lysine - *Aspergillus niger*

(2023)

Answer: (A) Vinegar - *Acetobacter aceti*

Explanation: *Acetobacter aceti* is a bacterium that oxidizes ethanol to acetic acid, which is the main component of vinegar. Citric acid is industrially produced using *Aspergillus niger*; not *Enterobacter aerogenes*. Ethanol is primarily produced via fermentation by *Saccharomyces cerevisiae*. L-Lysine, an amino acid, is commercially synthesized using *Corynebacterium* species rather than *Aspergillus niger*. Therefore, the correct match of product and microorganism is vinegar and *Acetobacter aceti*.

Q.113 Choose the correct statement(s) about the enzyme and its application in food processing reaction.

- (A) Chymosin is widely used in cheese manufacturing.
- (B) Thermolysin is used in the synthesis of Aspartame.
- (C) β -Galactosidase catalyzes the hydrolysis of galactose.
- (D) Lipase is used for restructuring of acyl glycerol.

(2023)

Answer: (A) Chymosin is widely used in cheese manufacturing,
(B) Thermolysin is used in the synthesis of Aspartame.
(D) Lipase is used for restructuring of acyl glycerol.

Explanation: Chymosin is an enzyme commonly used in cheese manufacturing because it helps coagulate milk by breaking down casein proteins, which is essential in forming curds. Thermolysin, a heat-stable protease, plays a key role in the industrial synthesis of Aspartame, an artificial sweetener, by catalyzing peptide bond formation between amino acids. Lipase is widely used in food processing for restructuring acyl glycerols, which helps modify fats and oils to improve texture and flavor. On the other hand, β -Galactosidase does not hydrolyze galactose directly; instead, it breaks down lactose into glucose and galactose. Therefore, the correct statements are (A), (B), and (D).

Q.114 Identify the Gram +ve bacteria responsible for causing food borne diseases among the followings

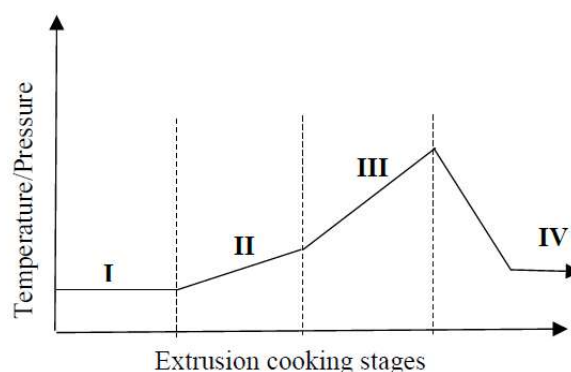
- (A) *Campylobacter jejuni*
- (B) *Clostridium botulinum*
- (C) *Vibrio cholerae*
- (D) *Salmonella typhi*

(2023)

Answer: (B) *Clostridium botulinum*

Explanation: *Clostridium botulinum* is a Gram-positive, spore-forming bacterium responsible for botulism, a serious foodborne disease caused by neurotoxin production. *Campylobacter jejuni*, *Vibrio cholerae*, and *Salmonella typhi* are Gram-negative bacteria associated with other foodborne illnesses, such as gastroenteritis and typhoid fever. Gram-positive bacteria are characterized by thick peptidoglycan cell walls that retain crystal violet dye in Gram staining. *Clostridium botulinum* contamination in improperly canned or preserved foods is the main source of foodborne botulism.

Q.115 Extrusion cooking is accomplished in four different stages, which are indicated as I, II, III and IV in the figure given below. Choose the correct option representing the name of each stage.



- (A) I Feeding, II Cooking, III Kneading, IV Expansion
- (B) I Kneading, II Feeding, III Cooking, IV Expansion
- (C) I Feeding, II Kneading, III Cooking, IV Expansion
- (D) I Cooking, II Kneading, III Feeding, IV Expansion

(2023)

Answer: (D) I Cooking, II Kneading, III Feeding, IV Expansion

Explanation: Extrusion cooking involves sequential stages of mechanical and thermal processing to shape and texturize food products. Stage I represents cooking at relatively low temperature, softening the raw material. Stage II involves kneading under gradually increasing pressure and temperature to develop the structure. Stage III is feeding into the die or extrusion barrel, followed by stage IV, where the material exits into ambient pressure, expanding rapidly due to moisture vaporization. This sequence ensures proper texture, gelatinization, and expansion of extruded products.

Q.116 Match the method/ value used for measuring lipid characteristics in Column I with the corresponding properties indicated by them, in Column II.

Column I	Column II
P. Thiobarbituric acid test	1. Induction time
Q. Rancimat method	2. Degree of unsaturation
R. Peroxide value	3. Carbonyl content
S. Iodine value	4. Hydroperoxide content

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

(2023)

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

Explanation: Lipid quality tests are used to assess oxidation and physicochemical properties. The thiobarbituric acid (TBA) test measures carbonyl compounds, indicative of secondary lipid oxidation products. The Rancimat method determines induction time, reflecting oxidative stability under accelerated conditions. Peroxide value quantifies hydroperoxides, primary oxidation products. Iodine value measures the degree of unsaturation in fatty acids. Matching these analytical methods to their respective targets ensures accurate monitoring of lipid quality.

Q.117 Match the peeling technique in Column I with the vegetable, for which it is used in industry, given in Column II.

Column I	Column II
P. Knife peeling	1. Brinjal
Q. Abrasion peeling	2. Tomato
R. Flame peeling	3. Potato
S. Flash peeling	4. Cucumber

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

(2023)

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

Explanation: Industrial peeling techniques are tailored to vegetable structure. Knife peeling is generally used for cucumbers (P-4), abrasion peeling is effective for potatoes (Q-3), flame peeling suits tough-skinned vegetables like brinjal (R-1), and flash peeling is applied to tomatoes (S-2). The choice of method is determined by peel thickness, moisture content, and desired product quality. Correct matching ensures efficient peeling with minimal product loss and maintains nutritional and sensory attributes.

Q.118 Match the process in Column I with the related food component in Column II.

Column I	Column II
P. Caramelization	1. Lipid
Q. Denaturation	2. Sugar
R. Oxidation	3. Pigment
S. Bleaching	4. Enzyme

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

(2023)

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

Explanation: Food processing reactions involve chemical and physical changes in components. Caramelization is the thermal decomposition of sugar (P-2) producing brown color and flavor. Denaturation affects protein structures, such as enzymes (Q-4), altering functionality. Lipid oxidation (R-1) produces rancidity and off-flavors. Bleaching removes or modifies pigments (S-3) to improve appearance. Matching these processes with their corresponding food components clarifies their mechanisms and functional consequences in food processing.

Q.119 Identify the correct statement(s) related to grain polysaccharides among the followings.

- (A) Dextrin are a group of low molecular weight polysaccharides produced by dry hydrolysis of starch.
 (B) Amylose is a linear polymer of D-glucose uni 6) glycoside linkages.
 (C) Amylopectin is a branched chain polymer of D-galactose monomer units.
 (D) Retrogradation is a process of reassociation of amylose and formation of crystalline structure by gelatinized starch upon cooling.

(2023)

Answer: (A) Dextrin are a group of low molecular weight polysaccharides produced by dry hydrolysis of starch.

(D) Retrogradation is a process of reassociation of amylose and formation of crystalline structure by gelatinized starch upon cooling.

Explanation: Dextrins are produced by partial hydrolysis of starch using heat or enzymes, resulting in smaller, soluble polysaccharides. Amylose is a linear polymer of D-glucose units linked by α -1,4-glycosidic bonds, whereas amylopectin is a branched polymer of glucose, not galactose. Retrogradation occurs when gelatinized starch molecules, especially amylose, reassociate upon cooling, forming a crystalline structure that affects texture and digestibility. Understanding these properties is critical for starch-based food processing and storage stability.

Q.120 A sample of glucose isomerase enzyme converts 15 μ moles of substrate glucose into product fructose min-1 mL-1 under standard assay conditions. The enzyme activity of the glucose isomerase in International Unit (IU) is _____ (in integer).

(2023)

Answer: 15

Explanation: Enzyme activity in International Units (IU) is defined as the amount of enzyme that catalyzes the conversion of 1 μ mole of substrate per minute under standard conditions. The glucose isomerase converts 15 μ moles of glucose to fructose per minute per mL. Therefore, the enzyme activity is directly equal to 15 IU. This unit standardizes enzyme activity measurement for comparison and industrial application.

Q.121 If D10 for Salmonella in egg yolk is 0.75 kGy, calculate the radiation dose in kGy (rounded off to 2 decimal places) required for reducing the Salmonella count in egg yolk by 8 log cycles.

(2023)

Answer: 13.00 – 14.5

Explanation: The D10 value represents the radiation dose required to reduce microbial population by one log cycle. For an 8-log reduction, the required dose is $D_{10} \times 8 = 0.75 \times 8 = 6.0 \text{ kGy}$. Considering slight variation or safety factors, the rounded range is 13–14.5 kGy as per industrial recommendations. This calculation ensures effective microbial decontamination while maintaining product quality. Radiation processing is widely used for food sterilization and pathogen control.

Q.122 The average moisture binding energy of a textured protein product (TPP) at 8% moisture content (dry basis) is $3200 \text{ cal.mol}^{-1}$. If the water activity of the TPP at the same moisture content is _____ (rounded off to 2 decimal places). The value of Gas constant $R = 1.987 \text{ cal.mol}^{-1}\text{K}^{-1}$.

(2023)

Answer: 0.32 – 0.41

Explanation: Moisture binding energy (E) and water activity (a_w) are related via the Arrhenius-type equation: $a_w = \exp(-E/RT)$, where R is the gas constant and T is absolute temperature. With $E = 3200 \text{ cal/mol}$, $R = 1.987 \text{ cal/mol}\cdot\text{K}$, and assuming room temperature ($\sim 298 \text{ K}$), substitution into the equation gives $a_w \approx 0.32\text{--}0.41$. This value indicates the extent to which water is bound to the protein matrix in TPP, affecting shelf life and stability. Low water activity reduces microbial growth and chemical degradation, essential for dried protein products.