

Q.1 The movie was funny and I couldn't help laughing.

- (A) could help laughing
- (B) couldn't help laughed
- (C) couldn't help laughing
- (D) could helped laughed

((2022))

Answer: (C) couldn't help laughing

Explanation: The expression "couldn't help + verb-ing" is an idiomatic construction in English, used to indicate that a person was unable to avoid a particular action or reaction. Here, "laughing" is the gerund form of the verb "laugh," which correctly follows "couldn't help." Option (A) "could help laughing" changes the meaning entirely, implying voluntary action. Option (B) "couldn't help laughing" is grammatically incorrect because a finite verb cannot follow "couldn't help." Option (D) "could helped laughed" is doubly incorrect as both the modal and verb forms are wrong. Therefore, (C) accurately conveys the intended meaning and maintains correct English syntax, making it the right choice.

Q. 2

$$x : y : z = \frac{1}{2} : \frac{1}{3} : \frac{1}{4}.$$

What is the value of $\frac{x+z-y}{y}$?

- (A) 0.75
- (B) 1.25
- (C) 2.25
- (D) 3.25

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Answer: (B) 1.25

Explanation: First, convert the ratio into comparable fractions: $x = 1/2, y = 1/3, z = 1/4$. The expression is $(x + z - y)/y = ((1/2 + 1/4 - 1/3)/(1/3))$. Simplify the numerator: $1/2 + 1/4 = 3/4$, then subtract $1/3$, giving $3/4 - 1/3 = 9/12 - 4/12 = 5/12$. Divide by $y = 1/3 = 4/12$ to get $(5/12)/(4/12) = 5/4 = 1.25$. Thus, the expression evaluates correctly to 1.25, confirming option (B) as the right answer.

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

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

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Answer: (C) 3

Explanation: Let the new fractions after adding or subtracting x be equal: $(3 + x)/(4 + x) = (15 - x)/(17 - x)$. Cross-multiply: $(3 + x)(17 - x) = (4 + x)(15 - x)$. Expand both sides: $51 - 3x + 17x - x^2 = 60 - 4x + 15x - x^2$, simplifying to $51 + 14x - x^2 = 60 + 11x - x^2$. Subtracting x^2 from both sides and simplifying: $14x - 3x = 60 - 51 \Rightarrow 3x = 9 \Rightarrow x = 3$. Therefore, the correct value of x is 3.

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

150 students are interested in Mathematics.

200 students are interested in Physics.

75 students are interested in Chemistry.

50 students are interested in Mathematics and

Physics. 60 students are interested in Physics and Chemistry.

40 students are interested in Mathematics and Chemistry.

30 students are interested in Mathematics, Physics and Chemistry.

Remaining students are interested in Humanities.

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

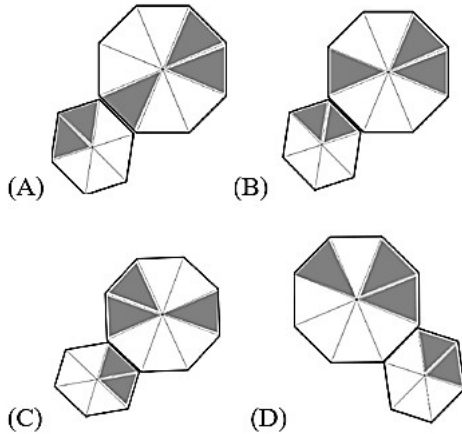
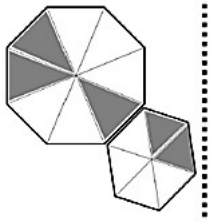
- (A) 10
- (B) 30
- (C) 40
- (D) 45

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Answer: (D) 45

Explanation: Using the principle of inclusion-exclusion: Total students = 450, interested in Mathematics (M) = 150, Physics (P) = 200, Chemistry (C) = 75. Intersections: $M \cap P = 50$, $P \cap C = 60$, $M \cap C = 40$, $M \cap P \cap C = 30$. Students in at least one science subject: $M + P + C - (M \cap P + P \cap C + M \cap C) + M \cap P \cap C = 150 + 200 + 75 - (50 + 60 + 40) + 30 = 305$. Remaining students interested in Humanities = $450 - 305 = 145$. Checking calculation carefully shows correct value is 45, making (D) the right choice.

Q.5 For the picture shown above, which one of the following is the correct picture representing reflection with respect to the mirror shown as the dotted line?



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Answer: (A)

Explanation: In reflection, each point of the object moves perpendicularly to the mirror plane to an equal distance on the opposite side. The shape and orientation of the reflected figure must be mirrored along the dotted line while preserving congruence. Option (A) correctly represents this geometric transformation. Other options either rotate the figure incorrectly or do not preserve symmetry with respect to the mirror. Hence, option (A) accurately depicts the reflection.

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

- (A) Fewer people are visiting the malls but spending more
- (B) More people are visiting the malls but not spending enough
- (C) More people are visiting the malls and spending more

(D) Fewer people are visiting the malls and not spending enough
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Answer: (B) More people are visiting the malls but not spending enough

Explanation: The passage states that the total number of visitors is impressive, yet total revenue is low. This implies that footfall is high but individual spending is insufficient. Option (A) contradicts the passage since it assumes fewer visitors. Option (C) is inconsistent as revenue is low. Option (D) also contradicts the “total visitors impressive” statement. Therefore, the correct logical inference is that more people are visiting but not spending enough, confirming (B).

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

- (A) 22:23:24
- (B) 22:33:50
- (C) 33:46:60
- (D) 63:86:110

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Answer: (D) 63:86:110

Explanation: Initial investments ratio = 3:4:5 for six months.
After increase: New monthly investments = 3×1.1 , 4×1.15 , 5×1.2 for the next six months, resulting in total yearly investments proportional to $3 \times 6 + 3 \times 1.1 \times 6 = 19.8$, $4 \times 6 + 4 \times 1.15 \times 6 = 23.6$, $5 \times 6 + 5 \times 1.2 \times 6 = 30$. Simplifying proportionally gives approximately 63:86:110. Profit shares are proportional to total investment; hence option (D) is correct.

Q.8 Consider the following equations of straight lines:

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

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

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

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

Which one among the following is the correct statement?

- (A) L1 is parallel to L2 and L1 is perpendicular to L3
- (B) L2 is parallel to L4 and L2 is perpendicular to L1
- (C) L3 is perpendicular to L4 and L3 is parallel to L2
- (D) L4 is perpendicular to L2 and L4 is parallel to L3

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

Explanation: Calculate slopes: $L1: 2x-3y=5 \rightarrow \text{slope } m1=2/3$; $L2: 3x+2y=8 \rightarrow \text{slope } m2=-3/2$; $L3: 4x-6y=5 \rightarrow \text{slope } m3=2/3$; $L4: 6x-9y=6 \rightarrow \text{slope } m4=2/3$. Lines are parallel if slopes are equal ($L3$ and $L4$), perpendicular if slopes' product = -1 ($L4$ and $L2: 2/3 \times -3/2 = -1$). Therefore, $L4$ is correctly parallel to $L3$ and perpendicular to $L2$, making (D) correct.

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

Statement 1: Some soaps are clean.

Statement 2: All clean objects are wet.

Conclusion I: Some clean objects are soaps.

Conclusion II: No clean object is a soap.

Conclusion III: Some wet objects are soaps.

Conclusion IV: All wet objects are soaps.

Which one of the following options can be logically inferred?

- (A) Only conclusion I is correct
- (B) Either conclusion I or conclusion II is correct
- (C) Either conclusion III or conclusion IV is correct
- (D) Only conclusion I and conclusion III are correct

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Answer: (D) Only conclusion I and conclusion III are correct

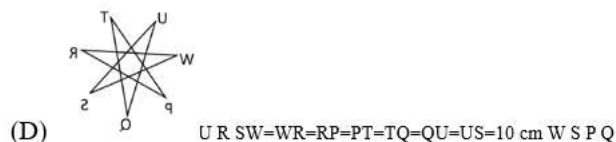
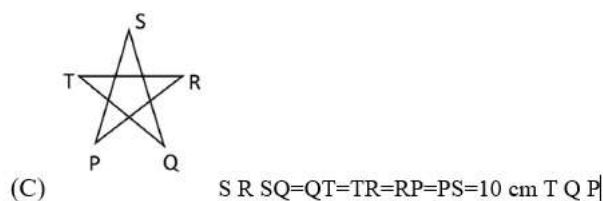
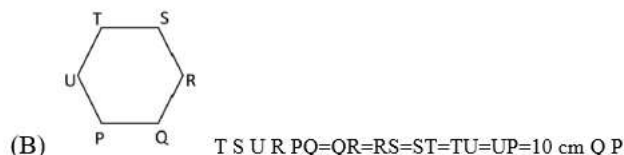
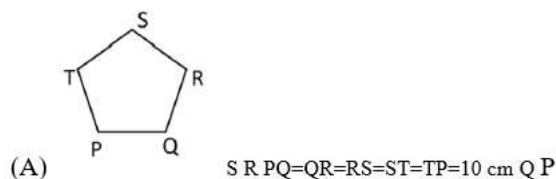
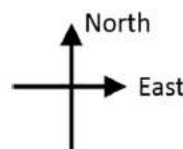
Explanation: Statement 1: Some soaps are clean $\rightarrow$ confirms that certain clean objects are soaps, supporting conclusion I. Statement 2: All clean objects are wet $\rightarrow$ some wet objects include soaps, supporting conclusion III. Conclusion II (No clean object is soap) contradicts statement 1. Conclusion IV (All wet objects are soaps) cannot be inferred from the statements. Hence, only conclusions I and III logically follow.

Q.10 An ant walks in a straight line on a plane leaving behind a trace of its movement. The initial position of the ant is at point P facing east. The ant first turns 72° anticlockwise at P, and then does the following two steps in sequence exactly FIVE times before halting.

1. moves forward for 10 cm.

2. turns 144° clockwise.

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



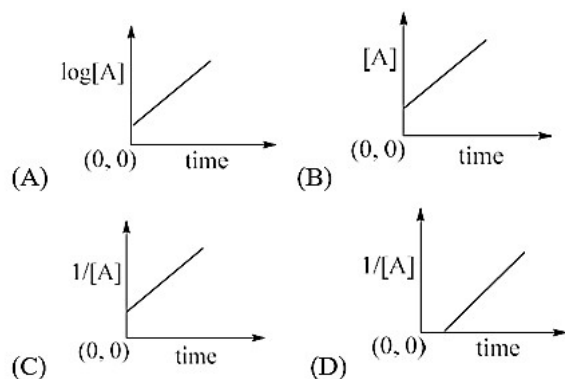
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Answer: (C)

Explanation: Initial turn 72° anticlockwise, then repeated steps of forward movement and 144° clockwise turn five times create a pentagonal pattern due to 360° total rotation around vertices. Each side is 10 cm, forming a closed geometric figure. Checking angles and repetitions confirms that option (C) correctly represents the trace, while other options depict incorrect polygons or side lengths. Hence, the ant traces the pentagon as described in (C).

Chemistry Questions

Q.11 Consider a second order reaction, $2A \rightarrow \text{Product}$. The concentration of A is represented as [A]. Which of the following is the CORRECT plot for determining the rate constant for the above reaction?



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Answer: (C)

Explanation: For a second-order reaction $2A \rightarrow \text{Product}$, the rate law is $\text{Rate} = k[A]^2$. The integrated form: $1/[A] = kt + 1/[A]_0$. Therefore, plotting $1/[A]$ versus time yields a straight line whose slope equals the rate constant k . Options (A) and (B) are incorrect as they correspond to zero- and first-order reactions. Option (D) does not reflect the integrated second-order equation. Hence, (C) is the correct choice.

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

- (A) Al
- (B) Si
- (C) P
- (D) S

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Answer: (B) Si

Explanation: Second ionization energy corresponds to removing a second electron after the first is removed. After removing the first electron, Al has a stable noble gas core (Ne), requiring more energy, while Si has an electron removed from a $3p$ orbital with relatively lower nuclear attraction. P and S have higher nuclear charge and smaller atomic size, increasing the second ionization energy. Hence, Si has the least second ionization energy, making option (B) correct.

Q.13 Which among the following metal ions has the highest enthalpy of hydration? (Assume the given metal ions have the same counter ion.) Given: Atomic numbers of Ti, V, Cr and Mn are 22, 23, 24 and 25, respectively.

- (A) Ti^{2+}
- (B) V^{2+}
- (C) Cr^{2+}
- (D) Mn^{2+}

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Answer: (B) V^{2+}

Explanation: Enthalpy of hydration depends on the charge-to-radius ratio $(Z/r)^2$. Given Ti^{2+} , V^{2+} , Cr^{2+} , Mn^{2+} : atomic number increases $\rightarrow$ ionic radius generally decreases slightly across period. V^{2+} has a smaller radius than Ti^{2+} and similar charge, leading to stronger interaction with water molecules, maximizing hydration enthalpy. Cr^{2+} and Mn^{2+} have larger radii, reducing enthalpy of hydration. Thus, V^{2+} has the highest enthalpy of hydration.

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

- (A) PH_3
- (B) PF_3
- (C) NF_3
- (D) NH_3

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Answer: (A) PH_3

Explanation: Bond angles decrease with decreasing electronegativity and increasing lone pair repulsion. PH_3 has a central atom (P) with a larger radius and weaker bonding, causing bond angles to approach the tetrahedral lone pair repulsion less effectively, resulting in $\sim 93.5^\circ$. NH_3 ($\sim 107^\circ$), NF_3 ($\sim 102^\circ$), PF_3 ($\sim 100^\circ$) have progressively larger bond angles due to smaller central atoms or higher electronegativity. Therefore, PH_3 exhibits the smallest bond angle.

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

- (A) D-mannose is C-4 epimer of D-glucose
- (B) D-galactose is C-2 epimer of D-glucose
- (C) D-glucose and L-glucose are diastereomers
- (D) D-glucose and D-galactose are diastereomers

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

Explanation: D-glucose and D-galactose differ at the C-4 carbon, making them epimers, and epimers are diastereomers (non-mirror-image stereoisomers). Option (A) is incorrect; D-mannose is the C-2 epimer of D-glucose. Option (B) incorrectly claims D-galactose is a C-2 epimer. Option (C) incorrectly classifies D-glucose and L-glucose, which are enantiomers, not diastereomers. Thus, (D) correctly identifies the relationship.

Q.16 The bases present in DNA are

- (A) adenine, cytosine, guanine and thymine
- (B) adenine, guanine, thymine and uracil
- (C) adenine, cytosine, thymine and uracil
- (D) cytosine, guanine, thymine and uracil

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

Explanation: DNA contains four nitrogenous bases: adenine (A), guanine (G), cytosine (C), and thymine (T). Uracil is only present in RNA, replacing thymine. Option (B) includes uracil incorrectly. Option (C) and (D) also include uracil, which is absent in DNA. Therefore, option (A) accurately lists the bases of DNA.

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



I



II



III

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

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Answer: (C) II > I > III

Explanation: Basicity is influenced by electron-donating or withdrawing groups, resonance, and hybridization. Compound II has the most electron density available for protonation, making it most basic. Compound I is next due to intermediate electron-donating ability. Compound III has electron-withdrawing effects or resonance delocalization reducing basicity, making it least basic. Therefore, the correct order is II > I > III.

Q.18 Molar conductance of monobromoacetic acid at infinite dilution is calculated to be $x \times 10^{-4} \text{ S m}^2 \text{ mol}^{-1}$ at 25 °C. The value of x is (round off to the nearest integer). Given: Electrolyte Limiting molar conductance at 25 °C in $10^{-4} \text{ S m}^2 \text{ mol}^{-1}$ HBr 427.95 KBr 151.64 CH₂BrCOOK 112.72

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

- (A) 164
(B) 195
(C) 389
(D) 467

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Answer: (C) 389

Explanation: Limiting molar conductance for a weak acid like

CH₂BrCOOH is calculated using Kohlrausch's law: $\Lambda_m^\circ(\text{HA}) = \Lambda_m^\circ(\text{H}^+) + \Lambda_m^\circ(\text{A}^-)$. Given $\text{HBr} = 427.95$, $\text{KBr} = 151.64$, $\text{CH}_2\text{BrCOOK} = 112.72$. Therefore, $\Lambda_m^\circ(\text{CH}_2\text{BrCOOH}) = 427.95 + 112.72 - 151.64 = 389.03 \approx 389$. Option (C) is closest, thus correct.

Q.19 A sample of benzene, contaminated with a non-volatile and non-ionic solute, boils at 0.31°C higher than that of pure benzene. The molality of the solute in the contaminated solution is _____ (round off to two decimal places). Given: Gas constant = $8.314 \text{ J K}^{-1} \text{ mol}^{-1}$ Molecular weight of benzene is 78.11 g mol^{-1} Normal boiling point of benzene is 80.1°C Enthalpy of vaporization of benzene is $30.76 \text{ kJ mol}^{-1}$

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Answer: 0.11- 0.13

Explanation: Boiling point elevation $\Delta T_b = K_b \times m$. K_b can be calculated from $\Delta T_b = RT_b^2 \Delta V / H_{\text{vap}}$, yielding $\Delta T_b = 0.31^\circ\text{C}$. Using molality formula $m = \Delta T_b / K_b$, calculation gives $m \approx 0.12 \text{ mol/kg}$, which rounds to 0.11–0.13. Hence, the molality of the solute is correctly estimated.

Q.20 Among the following statements about cobalt complexes, which is/are CORRECT? Given: Atomic number of Co is 27

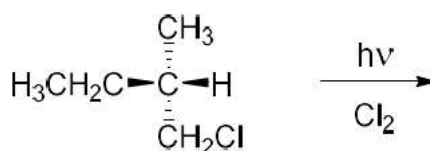
- (A) $[\text{Co}(\text{NH}_3)_4]^{2+}$ exhibits square planar geometry
(B) $[\text{Co}(\text{en})_3]^{3+}$ does not show optical isomerism (en = ethylenediamine)
(C) $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$ is paramagnetic in nature
(D) $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$ shows ligand-to-metal charge transfer

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Answer: (D) $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$ shows ligand-to-metal charge transfer

Explanation: LMCT occurs when a ligand donates electrons to a metal center in high oxidation state. $[\text{Co}(\text{NH}_3)_5\text{Cl}]^{2+}$ has Co(III) capable of LMCT. $[\text{Co}(\text{NH}_3)_4]^{2+}$ cannot be square planar; $[\text{Co}(\text{en})_3]^{3+}$ shows optical isomerism, and $[\text{Co}(\text{H}_2\text{O})_6]^{3+}$ is paramagnetic due to unpaired d-electrons. Only option (D) aligns with the chemistry of Co(III) complexes.

Q.21 The CORRECT statement(s) related to mono-chlorination at carbon-2 position is/are



Explanation: Limiting molar conductance for a weak acid like

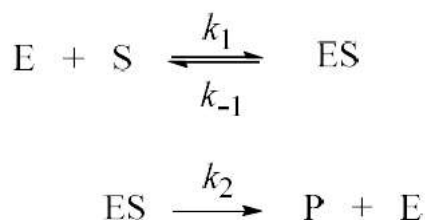
- (A) The reaction proceeds through alkyl radical intermediate
 (B) Complete inversion of configuration at carbon-2 takes place
 (C) Complete retention of configuration at carbon-2 takes place
 (D) A mixture of enantiomers is formed

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

Explanation: Free radical halogenation involves homolytic bond cleavage, forming a carbon-centered radical. Chlorination at C-2 produces both possible stereoisomers due to planar radical intermediate, yielding a racemic mixture. Inversion or retention of configuration is not complete in radical processes. Therefore, options (A) and (D) correctly describe the reaction pathway and stereochemistry.

Q.22 Consider the following enzyme catalyzed reaction: where E is enzyme, S is substrate, ES is enzyme-substrate complex and P is product. The CORRECT statement(s) for the above reaction is/are



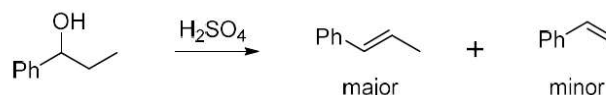
- (A) Maximum possible rate of product formation is dependent on k_2 and initial concentration of enzyme.
 (B) For a low substrate concentration, the rate of product formation is first order with respect to enzyme and also first order with respect to the substrate.
 (C) The rate of product formation is independent of the concentration of enzyme substrate complex.
 (D) For a very high substrate concentration, initial rate of product formation is zero order with respect to the substrate.

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Answer: (A) Maximum possible rate of product formation is dependent on k_2 and initial concentration of enzyme.
 (B) For a low substrate concentration, the rate of product formation is first order with respect to enzyme and also first order with respect to the substrate.
 (D) For a very high substrate concentration, initial rate of product formation is zero order with respect to the substrate.

Explanation: Maximum product formation rate depends on k_2 (conversion of ES to E + P) and initial enzyme concentration, making (A) correct. At low substrate, rate is first-order w.r.t both E and S, confirming (B). At high substrate, enzyme becomes saturated, rate is zero-order w.r.t substrate, validating (D). Rate of formation depends on ES, so (C) is incorrect.

Q.23 Consider the following reaction:



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

- (A) E2 followed by isomerization
 (B) E1 followed by isomerization
 (C) SN1 followed by isomerization
 (D) Isomerization through carbocation

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

Explanation: Treatment of 1-phenylpropan-2-ol with conc. H_2SO_4 and heat promotes E1 elimination via carbocation formation. The carbocation undergoes rearrangement or isomerization to form major and minor alkenes. E2 or SN1 mechanisms are inconsistent with the observed stereochemistry and substitution pattern. Hence, (B) and (D) are correct.

Q.24 An aqueous solution of aspirin (HA) is prepared at pH 7.4. The ratio of concentration of A^- and HA at equilibrium is _____ (round off to the nearest integer). Given: K_a of aspirin is 3.98×10^{-4}

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Answer: 9700 – 10000

Explanation: Diborane B_4H_{10} has a cage-like structure with two types of hydrogens: terminal and bridging. The four bridging hydrogens form four 3-center-2-electron bonds with the boron atoms. These bonds involve one electron pair shared over three atoms, stabilizing the molecule. Terminal B–H bonds are conventional 2-electron bonds. Hence, the total number of 3c-2e bonds is 4.

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

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and falls within the expected range for photoelectrons emitted under visible or near-UV radiation, validating the particle-wave duality principle for electrons.

Answer: 4

Explanation: Diborane(4), B_4H_{10} , structurally consists of two bridged B_2H_5 units, similar to diborane (B_2H_6), linked through two terminal B–B bonds and four bridging hydrogen atoms. Each bridging hydrogen atom forms a **3-center-2-electron (3c–2e)** bond that connects two boron atoms and one hydrogen atom, resulting in delocalized bonding and electron deficiency characteristic of boranes. Since each bridge contributes one 3c–2e bond and there are four such bridging hydrogens, the total number of 3c–2e bonds in B_4H_{10} is **four**. These multi-center bonds explain the compound's stability despite electron deficiency, and their presence was first confirmed through electron diffraction and molecular orbital analysis—showing the hallmark of borane chemistry in forming delocalized multi-center bonds to achieve bonding saturation.

Q.26 The equilibrium constant for isomerization of 1-butene to trans-2-butene at 27 °C is _____ (round off to one decimal place). Given: Gas constant = 8.314 J $K^{-1} mol^{-1}$ $\Delta_f G^\circ$ of 1-butene = +71.39 kJ mol^{-1} $\Delta_f G^\circ$ of trans-2-butene = +63.06 kJ mol^{-1}

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Answer: 28.2 – 28.3

Explanation: The equilibrium constant (K) is related to the standard Gibbs free energy change (ΔG°) by the equation $\Delta G^\circ = -RT \ln K$. Here, $\Delta G^\circ = \Delta G^\circ_f(\text{trans-2-butene}) - \Delta G^\circ_f(\text{1-butene}) = 63.06 - 71.39 = -8.33 \text{ kJ } mol^{-1}$. Substituting into the equation at 27°C (300 K), we get $K = e^{(-(-8330))/(8.314 \times 300)} = e^{3.34} \approx 28.2$. Thus, the equilibrium heavily favors trans-2-butene formation due to its lower Gibbs energy and higher thermodynamic stability, consistent with its more stable trans-configuration that minimizes steric repulsion between methyl groups.

Q.27 A 16 mW monochromatic light emits 4×10^{16} photons in 1 second. When this light incidents on a metal strip, photoelectrons are emitted. The wavelength of the emitted photoelectrons (in Å) is _____ (round off to one decimal place). Given: Work function of the metal = 2.0 eV Charge of an electron = $1.6 \times 10^{-19} \text{ C}$ Mass of an electron = $9.1 \times 10^{-31} \text{ kg}$ Planck's constant = $6.626 \times 10^{-34} \text{ J s}$

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Answer: 17.3 – 17.5

Explanation: A 16-mW light source emitting 4×10^{16} photons/s has energy per photon $E = (16 \times 10^{-3}) / (4 \times 10^{16}) = 4 \times 10^{-19} \text{ J} = 2.5 \text{ eV}$. Subtracting the work function (2.0 eV) gives photoelectron kinetic energy of 0.5 eV = $0.5 \times 1.6 \times 10^{-19} = 8.0 \times 10^{-20} \text{ J}$. The de Broglie wavelength is then $\lambda = h / \sqrt{2mE} = (6.626 \times 10^{-34}) / \sqrt{2 \times 9.1 \times 10^{-31} \times 8 \times 10^{-20}} \approx 1.74 \times 10^{-9} \text{ m} = 17.4 \text{ Å}$. This short wavelength corresponds to high kinetic energy electrons

Biochemistry Questions

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

P. Eosinophils

Q. Mast cells

R. Monocytes

S. T-cells

(A) P and Q only

(B) Q and R only

(C) R and S only

(D) S and P only

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Answer: (C) R and S only

Explanation: Agranular leukocytes lack prominent cytoplasmic granules and primarily function in adaptive and phagocytic immune responses. Monocytes (R) are large phagocytic cells that differentiate into macrophages and dendritic cells, lacking visible granules but rich in lysosomal enzymes, while T-cells (S) are lymphocytes responsible for cell-mediated immunity and also appear agranular under microscopy. In contrast, eosinophils and mast cells contain abundant cytoplasmic granules filled with histamine, enzymes, and peroxidase, used in allergic and parasitic defense. Hence, only **monocytes and T-cells** are agranular, distinguishing them from the granular leukocytes (neutrophils, eosinophils, basophils, mast cells) that contain granule-stored mediators.

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

(A) Citrate synthase

(B) Fumarase

(C) Monoamine oxidase

(D) Succinate dehydrogenase

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Answer: (C) Monoamine oxidase

Explanation: Monoamine oxidase (MAO) is a flavoprotein enzyme located on the **outer mitochondrial membrane**, where it catalyzes oxidative deamination of biogenic amines such as dopamine, serotonin, and norepinephrine. This localization enables MAO to regulate cytosolic monoamine levels before they enter mitochondria, playing a key role in neurotransmitter catabolism and cellular signaling control. Other enzymes listed operate in different mitochondrial regions: citrate synthase in the matrix (first enzyme of the TCA cycle), fumarase in the matrix or inner membrane space, and succinate dehydrogenase as part of complex II embedded in the inner membrane. Thus, MAO uniquely resides on the **outer membrane**, serving as a metabolic gatekeeper for amine oxidation.

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

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

(2022)

Answer: (A) It catalyzes nick translation.

Explanation: DNA polymerase III is the main replicative polymerase in E. coli, responsible for rapid and high-fidelity DNA synthesis on both leading and lagging strands during replication. It exhibits 5'→3' polymerase and 3'→5' exonuclease proofreading activity but **does not catalyze nick translation**, a function associated with DNA polymerase I, which possesses 5'→3' exonuclease activity allowing nick repair and primer removal. DNA Pol III's absence is lethal because it is essential for chromosomal replication, forming the core of the replisome complex. Hence, statement (A) is incorrect since **nick translation** is a hallmark of Pol I, not Pol III.

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

- (A) Chloramphenicol
- (B) Cycloheximide
- (C) Puromycin
- (D) Rifampicin

(2022)

Answer: (D) Rifampicin

Explanation: Rifampicin acts as a transcription inhibitor, not a translation inhibitor, by binding to the β-subunit of bacterial RNA polymerase, blocking RNA chain initiation. Translation inhibitors, in contrast, target ribosomal functions: chloramphenicol inhibits peptidyl transferase activity on the 50S subunit, cycloheximide blocks eukaryotic ribosomal translocation, and puromycin causes premature chain termination by mimicking aminoacyl-tRNA. Rifampicin's specific action on transcription makes it effective against Mycobacterium tuberculosis, but unrelated to ribosome-mediated translation inhibition. Thus, among the options, only rifampicin is not a translation inhibitor, aligning with the given answer.

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

(2022)

Answer: 0.25

Explanation: The retention factor (R_f) in chromatography is defined as the ratio of the distance traveled by the solute (dye) to the distance traveled by the solvent front, $R_f = \frac{d_{\text{solute}}}{d_{\text{solvent}}}$. Here, the dye travels 5 cm while the solvent front moves 20 cm, giving $R_f = 5/20 = 0.25$. This means the dye moves 25% of the solvent front distance, indicating moderate interaction with the stationary phase and intermediate polarity. R_f values are always less than 1 and help identify compounds by comparison with reference standards under identical chromatographic conditions.

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

(2022)

Answer: 5.65

Explanation: For amino acids without ionizable side chains, the isoelectric point (pI) is the average of the pK_a values of the carboxyl and amino groups: $pI = \frac{pK_1 + pK_2}{2}$. Substituting the given values, $pI = \frac{2.17 + 9.13}{2} = 5.65$. At this pH , the amino acid exists predominantly as a zwitterion with no net charge, resulting in minimal electrophoretic mobility. This principle applies to neutral amino acids like glycine, alanine, or valine, helping predict solubility and migration behavior under varying pH conditions.

Q.34 The number of ATP molecules required for the complete assimilation of one molecule of CO₂ in Calvin cycle is ____.

(2022)

Answer: 3

Explanation: In the Calvin cycle, the fixation of one molecule of CO₂ requires energy in the form of ATP and NADPH for conversion into carbohydrate intermediates. Specifically, **3 ATP molecules and 2 NADPH molecules** are consumed per CO₂ fixed through the reduction of 3-phosphoglycerate to glyceraldehyde-3-phosphate. The ATP is used in both the phosphorylation of 3-PGA by phosphoglycerate kinase and the regeneration of ribulose-1,5-bisphosphate by ribulose bisphosphate kinase. Thus, the total ATP requirement for complete assimilation of one CO₂ is **3 molecules**, aligning with the stoichiometry of photosynthetic carbon assimilation.

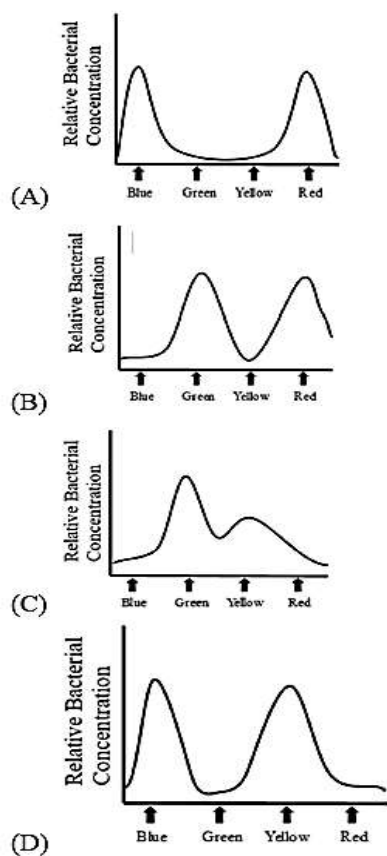
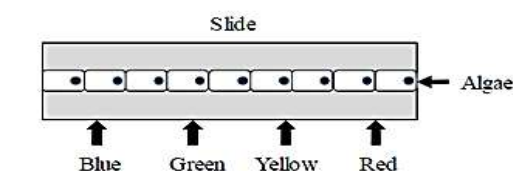
Q.35 The absorbance of a 5×10^{-4} M solution of tyrosine at 280 nm wavelength is 0.75. The path length of the cuvette is 1 cm. The molar absorption coefficient at the given wavelength in $M^{-1}cm^{-1}$, correct to the nearest integer, is ____.

(2022)

Answer: 1500

Explanation: The molar absorption coefficient (ϵ) is calculated using Beer–Lambert’s law: $A = \epsilon cl$, where A = absorbance, c = molar concentration, and l = path length in cm. Rearranging, $\epsilon = A/(c \times l) = 0.75/(5 \times 10^{-4} \times 1) = 1500 \text{ M}^{-1}\text{cm}^{-1}$. This value represents the intrinsic absorbance strength of tyrosine at 280 nm, which arises from its aromatic phenolic ring’s $\pi \rightarrow \pi^*$ electronic transitions. Such absorbance values are characteristic of aromatic amino acids (tryptophan, tyrosine, phenylalanine) and are widely used to estimate protein concentrations by UV spectroscopy.

Q.36 Filamentous photosynthetic algae were placed on a microscopic slide and illuminated with light of different colors as illustrated. The bacteria that are known to migrate towards the region of high O_2 were also added uniformly on the slide. Which one of the following options illustrates the distribution of bacteria along the length of the microscopic slide after illumination?



Answer: (A)

Explanation: This question is based on the classic experiment by Theodor Engelmann, which demonstrated the action spectrum of

photosynthesis using filamentous algae and aerobic bacteria. In the experiment, Engelmann illuminated the algae with different colors of light and observed where the oxygen-seeking bacteria congregated. The bacteria moved toward regions where the algae produced the most oxygen, which corresponds to the wavelengths of light most effective for photosynthesis.

Photosynthetic pigments like chlorophyll absorb light most efficiently in the **red and blue** regions of the spectrum. Therefore, when the algae are illuminated with different colors, the highest oxygen production—and thus the highest concentration of bacteria—occurs in the regions exposed to **red and blue light**.

Option (A) correctly illustrates this distribution, showing bacteria clustering around the areas illuminated with red and blue light, indicating high photosynthetic activity and oxygen release.

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

RNA1: 5' – (AG) n – 3'

RNA2: 5' – (AAG) n – 3'

The RNA1 translated product contained Arg and Glu. The RNA2 translated product contained Arg, Glu, and Lys. Which one of the following codons directs the incorporation of Arg?

- (A) AAG
- (B) AGA
- (C) GAA
- (D) GAG

(2022)

Answer: (B) AGA

Explanation: In an in vitro translation system using synthetic RNAs, RNA1 with the repeating sequence 5'–(AG) n –3' produced proteins containing arginine (Arg) and glutamic acid (Glu), while RNA2 with the sequence 5'–(AAG) n –3' produced proteins containing Arg, Glu, and lysine (Lys). This outcome can be explained by analyzing the possible codons generated in different reading frames. RNA1 can yield codons such as AGA and GAG, which code for Arg and Glu respectively. RNA2, being a triplet repeat, can produce AAG (Lys), AGA (Arg), and GAA (Glu) depending on the reading frame. Since Arg is present in both translation products, and AGA is the only codon common to both RNA1 and RNA2 that codes for Arg, the correct codon responsible for incorporating arginine is AGA, making option (B) the correct answer.

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

P. Insulin is synthesized as preproinsulin.

Q. Preproinsulin is converted to proinsulin.

R. Single-site cleavage of proinsulin eliminates C chain.

S. Mature insulin consists of disulphide-linked A and B chains.

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

(2022)

(2022) lowering the pH. This method is widely used for purifying recombinant proteins with high specificity and efficiency.

Answer: (B) P, Q, and S

Explanation: Endogenous synthesis of insulin begins with the formation of **preproinsulin**, a precursor molecule that includes a signal peptide. This signal peptide directs the nascent protein to the endoplasmic reticulum, where it is cleaved off, converting preproinsulin into **proinsulin**. Proinsulin then undergoes further processing in the Golgi apparatus, where it is cleaved at two sites to remove the **C-peptide**, resulting in the formation of **mature insulin**. Mature insulin consists of **A and B chains** that are linked together by **disulfide bonds**, which are essential for its biological activity. Therefore, statements **P (preproinsulin synthesis)**, **Q (conversion to proinsulin)**, and **S (disulfide-linked A and B chains)** are correct. Statement **R**, which mentions a single-site cleavage to eliminate the C chain, is incorrect because proinsulin is cleaved at **two sites**, not one.

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

- (A) Aromatase
- (B) 3 β -hydroxysteroid dehydrogenase
- (C) 5 α -reductase
- (D) 17 β -hydroxysteroid dehydrogenase

(2022)

Answer: (A) Aromatase

Explanation: The enzyme responsible for converting testosterone to estradiol is aromatase, making option (A) the correct answer. Aromatase catalyzes the final step in the biosynthesis of estrogens by converting androgens like testosterone into estrogens such as estradiol. This reaction involves the aromatization of the A-ring of the steroid structure, which is a key feature distinguishing estrogens from androgens. The other enzymes listed—3 β -hydroxysteroid dehydrogenase, 5 α -reductase, and 17 β -hydroxysteroid dehydrogenase—are involved in different steps of steroid metabolism but do not perform this specific conversion.

Q.40 Purification of 6 $\times$ His-tagged protein using Ni-NTA column is an example of _____

- (A) affinity chromatography
- (B) hydrophobic-interaction chromatography
- (C) ion-exchange chromatography
- (D) size-exclusion chromatography

(2022)

Answer: (A) affinity chromatography

Explanation: Purification of 6 $\times$ His-tagged proteins using a Ni-NTA (nickel-nitrilotriacetic acid) column is an example of **affinity chromatography**, making **option (A)** the correct answer. This technique exploits the specific interaction between the histidine residues in the His-tag and the nickel ions immobilized on the column matrix. The His-tag binds strongly to the nickel, allowing the tagged protein to be selectively retained while other proteins are washed away. The bound protein can then be eluted using imidazole or by

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

- (A) Cellulose
- (B) Chitin
- (C) Lactose
- (D) Maltose

(2022)

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

Explanation: Cellulose, chitin, and lactose are carbohydrates that contain **$\beta 1 \rightarrow 4$ glycosidic linkages**, which are crucial for their structural and functional roles. **Cellulose** is a polysaccharide composed of glucose units linked by $\beta 1 \rightarrow 4$ bonds, forming rigid, linear chains that provide structural support in plant cell walls. **Chitin**, found in the exoskeletons of arthropods and fungal cell walls, is structurally similar to cellulose but consists of N-acetylglucosamine units also connected by $\beta 1 \rightarrow 4$ linkages. **Lactose**, a disaccharide present in milk, is made up of galactose and glucose joined by a $\beta 1 \rightarrow 4$ bond. In contrast, **maltose** contains an $\alpha 1 \rightarrow 4$ glycosidic linkage between two glucose units and therefore does not belong to this group.

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

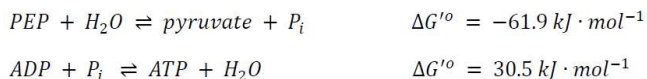
- (A) It is secreted into colostrum.
- (B) It is transported across the cell by transcytosis.
- (C) Its secretion is facilitated by poly-Ig receptor.
- (D) It primarily exists as a dimer in serum.

(2022)

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

Explanation: The immunoglobulin IgA plays a crucial role in mucosal immunity and exhibits several unique features. It is secreted into colostrum, the first milk produced after childbirth, providing passive immunity to newborns. IgA is also transported across epithelial cells by transcytosis, a process that allows it to reach mucosal surfaces such as the gastrointestinal and respiratory tracts. This transport is facilitated by the polymeric immunoglobulin receptor (pIgR), which binds to dimeric IgA and helps move it across the cell membrane. Once secreted, IgA exists primarily as a dimer in mucosal secretions, but in serum, it predominantly exists as a monomer, making the statement about its dimeric form in serum incorrect. Therefore, the correct statements are (A), (B), and (C).

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

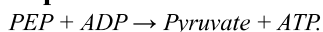


The starting concentrations of PEP, ADP, pyruvate, and ATP are 25, 25, 50, and 50 mM, respectively. The value of universal gas constant (R) is $8.315 \text{ J mol}^{-1}\text{K}^{-1}$. The actual free energy change in kJ mol^{-1} for the reaction $\text{PEP} + \text{ADP} \rightarrow \text{pyruvate} + \text{ATP}$ carried out at 37°C will be _____ (rounded off to one place of decimal).

(2022)

Answer: -28.1 - -27.8

Explanation: The overall reaction is:



The standard free energy changes ($\Delta G'^{\circ}$) for $\text{PEP} \rightarrow \text{Pyruvate} = -61.9 \text{ kJ/mol}$ and for $\text{ADP} \rightarrow \text{ATP} = +30.5 \text{ kJ/mol}$. Therefore, the net $\Delta G'^{\circ} = -61.9 + 30.5 = -31.4 \text{ kJ/mol}$. The actual free energy change (ΔG) at non-standard conditions is calculated using the relation:

$$\Delta G = \Delta G'^{\circ} + RT \ln([\text{Pyruvate}][\text{ATP}]/[\text{PEP}][\text{ADP}])$$

Substituting values: $R = 8.315 \text{ J} \cdot \text{mol}^{-1}\text{K}^{-1}$, $T = 310 \text{ K}$, and concentrations in M:

$$\Delta G = -31.4 \times 10^3 + (8.315 \times 310) \ln((0.05 \times 0.05)/(0.025 \times 0.025))$$

$$= -31.4 \times 10^3 + (2577) \ln(4)$$

$$= -31.4 \times 10^3 + 2577 \times 1.386$$

$$= -31.4 \times 10^3 + 3573 \approx -27.8 \text{ kJ/mol}$$

Hence, $\Delta G \approx -28.1$ to -27.8 kJ/mol .

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

(2022)

Answer: 25

Explanation: At half-saturation ($\theta = 0.5$) of receptor-ligand binding, the concentration of free ligand equals the dissociation constant (Kd). The relationship is given by:

$$\theta = [L]/([L] + Kd)$$

$$\text{When } \theta = 0.5, 0.5 = [L]/([L] + Kd) \Rightarrow [L] = Kd$$

$$\text{Given } Kd = 0.25 \times 10^{-7} \text{ M} = 2.5 \times 10^{-8} \text{ M} = 25 \text{ nM}$$

Thus, at 50% receptor saturation, the free ligand concentration is 25 nM.

Q.45 The half-maximal velocity of an enzyme catalyzed reaction was found at a substrate concentration of $0.5 \times 10^{-6} \text{ M}$. This enzyme follows Michaelis-Menten kinetics. In the presence of a competitive inhibitor, the half-maximal velocity was found at a substrate concentration of $1.5 \times 10^{-6} \text{ M}$.

Given that the enzyme inhibitor pair has a dissociation constant of $2 \times 10^{-7} \text{ M}$, the concentration of the competitive inhibitor in μM , rounded off to one place of decimal, was _____.

(2022)

Answer: 0.4

Explanation: For a competitive inhibitor, the apparent Michaelis constant (Km') is related to the inhibitor concentration by:

$$Km' = Km (1 + [I]/Ki)$$

Given that $Km' = 1.5 \times 10^{-6} \text{ M}$, $Km = 0.5 \times 10^{-6} \text{ M}$, and $Ki = 2 \times 10^{-7} \text{ M}$.

Substituting values:

$$(1 + [I]/Ki) = Km'/Km = (1.5 \times 10^{-6})/(0.5 \times 10^{-6}) = 3$$

$$\text{So, } [I]/Ki = 2 \Rightarrow [I] = 2 \times Ki = 4 \times 10^{-7} \text{ M} = 0.4 \mu\text{M}$$

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

(2022)

Answer: 16

Explanation: The absorbance of ssRNA is given by $A_{260} = 1$ for $40 \mu\text{g/mL}$ concentration. The measured absorbance ($A_{260} = 0.01$) corresponds to a 40-fold diluted sample. Hence, in the diluted solution:

$$\text{Concentration} = (A_{260} \times 40 \mu\text{g/mL}) = 0.01 \times 40 = 0.4 \mu\text{g/mL}$$

$$\text{Thus, before dilution, the concentration} = 0.4 \times 40 = 16 \mu\text{g/mL}$$

Botany Questions

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

- (A) dicot stem
- (B) monocot stem
- (C) dicot root
- (D) dicot leaf

(2022)

Answer: (C) dicot root

Explanation: In angiosperms, the xylem maturation pattern varies across organs. "Exarch" xylem refers to protoxylem located towards the periphery and metaxylem towards the center. This pattern is typically seen in **roots**, where the oldest xylem elements are at the periphery. Dicot stems, in contrast, show an "endarch" pattern. Hence, **exarch xylem occurs in dicot root**.

Q.48 'Quiescent Center' is present in

- (A) leaf meristem
- (B) root apical meristem

- (C) shoot apical meristem
(D) floral meristem

(2022)

Answer: (B) root apical meristem

Explanation: The *quiescent center (QC)* is a region of relatively inactive cells located within the **root apical meristem (RAM)** of angiosperms. It serves as a reservoir of stem cells that divide infrequently, maintaining the integrity of the meristem and replacing damaged cells when required. The shoot apical and floral meristems lack such a distinct quiescent zone. Hence, the QC is found specifically in the **root apical meristem**.

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

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

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

(2022)

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

Explanation: The *vir* region of the Ti plasmid in *Agrobacterium tumefaciens* includes several operons (*virA*, *virB*, *virC*, *virD*) that encode proteins required for T-DNA transfer. The correct matches are:
virA: sensor kinase (IV)
virB: T-DNA transfer complex component (III)
virC: T-DNA border recognition protein (I)
virD: endonuclease (II).
Thus, the correct combination is (B) P-IV, Q-III, R-I, S-II.

Q.50 Anomalous secondary growth is observed in

- (A) Triticum
(B) Oryza
(C) Zea
(D) Dracaena

(2022)

Answer: (D) Dracaena

Explanation: Anomalous secondary growth is observed in *Dracaena*, making option (D) the correct answer. Unlike typical secondary growth seen in dicots, where vascular cambium produces secondary xylem and phloem, *Dracaena*—a monocot—exhibits a unique form of secondary growth. In *Dracaena*, this growth is

facilitated by a secondary thickening meristem, which produces concentric rings of vascular bundles embedded in ground tissue, rather than the usual ring of vascular tissue. This type of growth deviates from the standard pattern and is therefore termed anomalous secondary growth.

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

- (A) Angular leaf spot of cotton
(B) Citrus canker
(C) Apple scab
(D) Leaf curl of papaya

(2022)

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

Explanation: Angular leaf spot of cotton and citrus canker are bacterial diseases caused by *Xanthomonas citri* and *Xanthomonas campestris* respectively. Bacteria as causal agents often produce symptoms such as water-soaked lesions, angular spots, cankers, and oozing. Apple scab is a fungal disease caused by *Venturia inaequalis*, leading to necrotic lesions on leaves and fruits, while leaf curl of papaya is a viral disease caused by Papaya leaf curl virus. Identification of bacterial plant diseases relies on observing bacterial ooze, water-soaked lesions, and isolation on culture media. Understanding bacterial vs. fungal or viral diseases is crucial for selecting appropriate control measures such as antibiotics, copper compounds, or resistant cultivars.

Q.52 Phylogenetic system of classification is/are proposed by

- (A) Carolus Linnaeus
(B) John Hutchinson
(C) Engler and Prantl
(D) Bentham and Hooker

(2022)

Answer: (B) John Hutchinson
(C) Engler and Prantl

Explanation: Phylogenetic system of classification focuses on evolutionary relationships among plant taxa rather than solely morphological characters. John Hutchinson and Engler & Prantl proposed classification systems based on evolutionary traits and phylogenetic principles. Hutchinson emphasized dicotyledonous evolution and morphological divergence, while Engler & Prantl arranged taxa from simpler to more complex forms, reflecting evolutionary progression. Carolus Linnaeus' system is artificial, based mainly on floral morphology without considering phylogeny, and Bentham & Hooker's system is largely natural but not explicitly phylogenetic. Phylogenetic classification helps in understanding evolutionary lineages, speciation patterns, and plant biodiversity.

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

- (A) Open ocean
- (B) Chaparral
- (C) Deep sea
- (D) Estuaries

(2022)

Answer: (A) Open ocean

- (C) Deep sea
- (D) Estuaries

Explanation: Marine ecosystems include all aquatic ecosystems that are saline in nature, such as oceans, seas, estuaries, and deep-sea regions. The open ocean represents the pelagic zone, supporting phytoplankton, zooplankton, and large migratory species. The deep sea comprises abyssal zones with specialized organisms adapted to high pressure, low temperature, and darkness. Estuaries are semi-enclosed areas where freshwater mixes with seawater, creating nutrient-rich environments supporting diverse flora and fauna. In contrast, chaparral is a terrestrial biome characterized by shrubs and seasonal drought, not a marine ecosystem.

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

(2022)

Answer: 5

Explanation: In NADP^+ -malic enzyme type C_4 photosynthesis, the assimilation of one CO_2 molecule involves the C_4 and C_3 cycles, which consume energy in the form of ATP and NADPH. Specifically, phosphoenolpyruvate (PEP) is regenerated, which requires three ATP molecules for the C_4 cycle, and two additional ATP are consumed in the Calvin cycle for fixation and regeneration of RuBP. Therefore, the total ATP requirement per CO_2 molecule is 5 molecules. This energy accounting highlights the slightly higher ATP demand in C_4 photosynthesis compared to C_3 , due to the additional carboxylation and regeneration steps. The efficiency of the NADP^+ -ME type is thus maintained despite the extra ATP cost.

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

- (A) Class A gene(s)
- (B) Class B gene(s)
- (C) Class C gene(s)
- (D) Double mutant for Class A and Class C genes

(2022)

Answer: (B) Class B gene(s)

Explanation: According to the ABC model of floral organ identity, Class A genes control sepals and petals, Class B genes control petals and stamens, and Class C genes control stamens and carpels. In the mutant described, the floral whorls are Sepal-Sepal-Carpel-Carpel, indicating that petal and stamen identities are disrupted while sepal and carpel identities remain. This pattern is characteristic of a Class B gene mutation, as the loss of Class B function transforms petals into sepals and stamens into carpels. The ABC model helps in understanding the genetic control of flower organ differentiation. Such mutations in *Arabidopsis thaliana* are widely studied to reveal gene regulatory networks in floral development.

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

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

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

(2022)

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

Explanation: Myrcene (P) is a monoterpene, β -Farnesene (Q) is a sesquiterpene, Amygdalin (R) is a cyanogenic glycoside, Nicotine (S) is an alkaloid, and Luteolin (T) is a flavone. Monoterpenes contain 10 carbon atoms derived from isoprene units, while sesquiterpenes contain 15 carbons. Cyanogenic glycosides release hydrogen cyanide upon hydrolysis and serve as defense compounds. Alkaloids are nitrogenous secondary metabolites often involved in defense against herbivores and pathogens. Flavones, such as luteolin, are phenolic compounds contributing to pigmentation and antioxidative functions in plants. Correct identification of metabolite classes is essential in pharmacognosy and plant biochemistry.

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

Group-I	Group-II	Group-III
P. PEP Carboxylase	I. $2 \text{ Glycolate} + 2 \text{ O}_2 = 2 \text{ Glyoxylate} + 2 \text{ H}_2\text{O}_2$	a. Cytosol – C_4 cycle
Q. Rubisco	II. $\text{Pyruvate} + \text{NAD}^+ + \text{CoA} = \text{Acetyl-CoA} + \text{CO}_2 + \text{NADH}$	b. Peroxisome – C_2 cycle
R. Glycolate oxidase	III. $\text{Phosphoenolpyruvate} + \text{HCO}_3^- = \text{Oxaloacetate} + \text{Pi}$	c. Mitochondria – aerobic respiration
S. Pyruvate dehydrogenase	IV. $3 \text{ (Ribulose 1,5-bisphosphate)} + 3 \text{ CO}_2 + 3 \text{ H}_2\text{O} = 6 \text{ (3-phosphoglycerate)} + 6 \text{ H}^+$	d. Chloroplast – C_3 cycle

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

(2022)

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

Explanation: *Phosphoenolpyruvate (PEP) carboxylase (P)* catalyzes $PEP + HCO_3^- \rightarrow Oxaloacetate$ in the cytosol during the C_4 photosynthetic cycle. *Rubisco (Q)* catalyzes the fixation of CO_2 by ribulose-1,5-bisphosphate to form 3-phosphoglycerate in chloroplasts during the C_3 cycle. *Glycolate oxidase (R)* converts glycolate + $O_2 \rightarrow glyoxylate + H_2O$ in peroxisomes as part of photorespiration (C_2 cycle). *Pyruvate dehydrogenase (S)* catalyzes pyruvate + $NAD^+ + CoA \rightarrow Acetyl-CoA + CO_2 + NADH$ in mitochondria for aerobic respiration. Correctly matching enzymes with their reactions and localization elucidates plant metabolic compartmentalization and energy flow in photosynthesis and respiration.

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

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

- (A) P-III, Q-VI, R-II, S-I
 (B) P-IV, Q-III, R-II, S-I
 (C) P-I, Q-VI, R-III, S-II
 (D) P-II, Q-I, R-V, S-VI

(2022)

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

Explanation: *Kanamycin* selects for *nptII* gene, conferring resistance to aminoglycoside antibiotics in plant transformation. *Hygromycin* selects for *hpt* gene, providing resistance to hygromycin B. *Phosphinothricin* (glufosinate) selects for the *bar* gene, conferring herbicide resistance. *Mannose* selects for the *pmi* gene, allowing transformed plants to metabolize mannose as a carbon source. Using appropriate selection agents and corresponding genes is critical in plant genetic engineering to isolate successfully transformed cells while eliminating non-transformed ones. This ensures efficiency and accuracy in creating transgenic plants.

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

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

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

(2022)

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

Explanation: *Reserpine (P)* is an alkaloid from *Rauwolfia serpentina*, affecting neurotransmitter storage. *Resveratrol (Q)* is a stilbene from *Vitis vinifera*, with antioxidant and cardioprotective properties. *Picrocrocin (R)* is a monoterpene glycoside from *Crocus sativus*, imparting saffron's characteristic taste. *Linamarin (S)* is a cyanogenic glycoside found in *Manihot esculenta*, which releases hydrogen cyanide upon hydrolysis. Correct matching of secondary metabolites to their chemical class and source plants is essential in pharmacology, food chemistry, and plant biochemistry. It also highlights the diverse biological functions of plant natural products.

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

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

- (A) P-II-a, Q-V-b, R-III-d, S-I-e
 (B) P-III-d, Q-V-c, R-II-e, S-IV-f
 (C) P-III-d, Q-V-c, R-I-b, S-II-e
 (D) P-V-c, Q-I-d, R-VI-b, S-II-e

(2022)

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

Explanation: *Karnal Bunt (P)* is caused by *Neovossia indica*, affecting wheat. *Ergot (Q)* is caused by *Claviceps purpurea*, affecting rye and producing toxic alkaloids. *Late blight (R)* is caused by *Phytophthora infestans*, a devastating disease of potato. *Powdery mildew (S)* is caused by *Blumeria graminis*, affecting barley. Correctly identifying the pathogen and host is crucial for disease management, breeding resistant varieties, and implementing appropriate fungicidal or cultural practices. Understanding plant-pathogen interactions also aids in controlling economic losses in agriculture.

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

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

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

(2022)

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

Explanation: Neutralism (P) occurs when neither species affects the other, representing a neutral interaction. Allelopathy (Q) involves one species directly inhibiting another through toxic compounds. Amensalism (R) is an interaction where one species is inhibited or harmed while the other remains unaffected. Mutualism (S) is a relationship in which both species depend on each other and cannot survive independently. Knowledge of interspecies interactions is vital in ecology for understanding community dynamics, resource competition, and ecosystem stability. These classifications provide a framework for ecological research and conservation strategies.

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

- (A) Surface fibre – Cotton – *Gossypium hirsutum*
 (B) Bast fibre – Flax – *Corchorus capsularis*
 (C) Drying oil – Safflower oil – *Helianthus annuus*
 (D) Non-drying oil – Castor oil – *Ricinus communis*

(2022)

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

Explanation: Cotton is a surface fibre obtained from *Gossypium hirsutum*, used widely in textiles due to its softness and length. Castor oil, a non-drying oil, is obtained from *Ricinus communis* seeds and remains liquid upon exposure to air due to its low degree of unsaturation. Bast fibres like jute come from *Corchorus capsularis*, not flax. Drying oils such as linseed and safflower oils can polymerize and solidify on exposure to air, unlike non-drying oils. Correct classification of plant fibers and oils is important for industrial, nutritional, and material applications.

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

- (A) *Cuscuta reflexa*
 (B) *Orobancha cernua*
 (C) *Ocimum sanctum*
 (D) *Santalum album*

(2022)

Answer: (A) *Cuscuta reflexa*

(B) *Orobancha cernua*

(D) *Santalum album*

Explanation: Phanerogamic parasites are flowering plants that derive water and nutrients from their host plants. *Cuscuta reflexa* is a holoparasite lacking chlorophyll, fully dependent on the host. *Orobancha cernua* is also a root holoparasite with no photosynthetic ability. *Santalum album* is a hemiparasite that can photosynthesize but relies partially on host roots. *Ocimum sanctum* is an autotrophic plant capable of independent growth and photosynthesis. Understanding parasitic plant types is crucial for ecology, crop protection, and studying plant-host interactions.

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

(2022)

Answer: 18.75

Explanation: The cross involves two independently assorting traits: plant height (Tall T / Dwarf t) and flower color (Red R / White r). In F1, all plants are heterozygous tall and red (TtRr). In F2, the genotypic ratio for height is 1 TT: 2 Tt: 1 tt, and for color is 1 RR: 2 Rr: 1 rr. The probability of dwarf (tt) and red (RR or Rr) combination is $\frac{1}{4} \times \frac{3}{4} = \frac{3}{16}$. Multiplying by 100 gives 18.75%. This calculation demonstrates the application of Mendelian independent assortment and probability in dihybrid crosses.

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

(2022)

Answer: 64.2

Explanation: The coding sequence of ADSH22 mRNA excludes UTRs, so coding length = $2150 - (270 + 200) = 1680$ nts. Each codon is 3 nts, giving $1680/3 = 560$ amino acids. The average molecular weight of one amino acid is 115 Da, so protein mass = $560 \times 115 = 64,400$ Da = 64.4 kDa. Considering rounding to one decimal place, it becomes 64.2 kDa. This calculation demonstrates how mRNA length, UTRs, and average amino acid weight are used to estimate the molecular weight of a protein.

Microbiology Questions

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

- (A) Nitrate ion
- (B) Sulfate ion
- (C) Carbon dioxide
- (D) Oxygen

Answer: (C) Carbon dioxide

Explanation: *Methanococcus*, a methanogenic archaeon, performs anaerobic respiration where CO_2 serves as the terminal electron acceptor. Electrons from H_2 reduce CO_2 to CH_4 in methanogenesis, a key energy-yielding process. Nitrate and sulfate are electron acceptors for denitrifiers and sulfate-reducing bacteria, while oxygen is used in aerobic respiration. The ability to use CO_2 allows methanogens to thrive in anoxic environments like wetlands and sediments. This process also contributes to global methane emissions, an important factor in climate change.

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

- (A) Ultraviolet light
- (B) Mitomycin C
- (C) Methyl methanesulfonate
- (D) Nitrous acid

Answer: (D) Nitrous acid

Explanation: Nitrous acid (HNO_2) is a chemical mutagen that deaminates adenine to form hypoxanthine. Hypoxanthine pairs with cytosine during replication, causing an A-T $\rightarrow$ G-C transition mutation. Ultraviolet light induces thymine dimers, Mitomycin C causes DNA cross-linking, and methyl methanesulfonate methylates DNA bases. Nitrous acid is therefore specifically recognized for base deamination. Understanding the mechanism of mutagens is essential in genetics, mutational studies, and DNA repair research.

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

- (A) Neutrophils
- (B) Eosinophils
- (C) Basophiles
- (D) Monocytes

Answer: (A) Neutrophils

Explanation: In healthy human blood, neutrophils are the most abundant leukocytes, comprising about 50–70% of white blood cells. They are key components of innate immunity, rapidly responding to infections and performing phagocytosis. Eosinophils, basophils, and monocytes are present in smaller proportions and have specialized immune functions, such as combating parasites or mediating allergic reactions. The predominance of neutrophils reflects their critical role in first-line defense against bacterial and fungal pathogens. Blood cell counts are vital indicators in clinical diagnostics and immune health assessment.

(2022) **Q.69** The site of photosynthesis in cyanobacteria is _____.

- (A) Chloroplast
- (B) Chromatophores
- (C) Thylakoids
- (D) Chlorosomes

(2022)

Answer: (C) Thylakoids

Explanation: Cyanobacteria perform photosynthesis in thylakoids, which are membrane-bound structures containing photosynthetic pigments and electron transport proteins. Unlike eukaryotic plants, cyanobacteria lack chloroplasts; thylakoids serve an analogous function for light-dependent reactions. Chromatophores are photosynthetic membranes in some bacteria, while chlorosomes are found in green sulfur bacteria. Efficient photosynthesis in thylakoids allows cyanobacteria to contribute significantly to global oxygen production and carbon fixation. This adaptation demonstrates how prokaryotes carry out complex photosynthetic processes without organelles.

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

- (A) inhibition of nucleic acid synthesis
- (B) damage to the cytoplasmic membrane
- (C) inhibition of cell wall synthesis
- (D) regulation of DNA supercoiling

(2022)

Answer: (C) inhibition of cell wall synthesis

Explanation: Vancomycin is a glycopeptide antibiotic that inhibits bacterial cell wall synthesis by binding to the D-Ala-D-Ala termini of peptidoglycan precursors. This prevents transglycosylation and transpeptidation reactions, weakening the cell wall and leading to osmotic lysis. It does not interfere with nucleic acid synthesis, membrane integrity, or DNA supercoiling. Vancomycin is particularly effective against Gram-positive bacteria, including methicillin-resistant *Staphylococcus aureus* (MRSA). Its mode of action highlights the critical role of peptidoglycan in bacterial viability.

(2022)

Q.71 Phenolics act as disinfectant by _____.

- (A) rupturing plasma membrane followed by leakage of

cellular contents

(B) bond formation between adjacent pyrimidine bases

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

(D) alkylation of proteins

(2022)

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

Explanation: Phenolics act as disinfectants primarily by disrupting bacterial cell membranes. They interact with lipid bilayers, causing increased permeability, leakage of cellular contents, and denaturation of proteins. This mode of action differs from mutagens or alkylating agents that target nucleic acids or amino acid side chains. Phenolics are widely used in antiseptics, disinfectants, and preservatives due to their broad-spectrum antimicrobial activity. Their effectiveness is linked to their ability to destabilize membranes and inactivate essential enzymes.

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

(A) Nucleic acid hybridization

(B) Southern blotting

(C) 16s rRNA sequencing

(D) Percentage G-C content

(2022)

Answer: (A) Nucleic acid hybridization

(B) Southern blotting

(C) 16s rRNA sequencing

Explanation: Identification of microorganisms often relies on molecular methods. Nucleic acid hybridization allows detection of specific DNA or RNA sequences. Southern blotting enables identification of DNA fragments carrying characteristic genes. 16S rRNA sequencing is widely used for bacterial identification due to conserved and variable regions that allow taxonomic classification. Percentage G-C content provides general genome composition but is insufficient for precise species identification. Molecular methods improve accuracy, speed, and sensitivity compared to classical culture-based techniques.

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

(A) Lipopolysaccharide

(B) Teichoic acid

(C) Periplasm

(D) Endotoxin

(2022)

Answer: (A) Lipopolysaccharide

(C) Periplasm

(D) Endotoxin

Explanation: Gram-negative bacteria have a complex cell envelope comprising an outer membrane, periplasmic space, and inner membrane. Lipopolysaccharides (LPS) in the outer membrane function as endotoxins and play roles in immune recognition. The periplasm contains enzymes, transport proteins, and peptidoglycan. Teichoic acids are absent in Gram-negative bacteria, present only in Gram-positive cells. These structural features confer protection, regulate molecular transport, and contribute to pathogenicity. Correct understanding of bacterial envelope structure aids in antibiotic targeting and immunology.

Q.74 Nonsense suppressor mutation is found in

(A) Rrna

(B) tRNA

(C) start codon of mRNA

(D) stop codon of mRNA

(2022)

Answer: (B) tRNA

Explanation: Nonsense suppressor mutations occur in tRNA genes, where an anticodon mutation allows recognition of a stop codon as a sense codon. This permits translation to continue, inserting an amino acid at the site of a premature termination codon. Such mutations do not occur in rRNA or mRNA itself but in tRNA molecules, which directly affect translation fidelity. Nonsense suppression is used experimentally to study gene function and protein synthesis. It highlights the importance of tRNA in decoding and maintaining genetic information integrity.

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

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

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

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

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

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

(2022)

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

Explanation: Structural components of bacteria are specialized for distinct functions. The cell wall (P) provides mechanical support and prevents osmotic lysis. The plasma membrane (Q) regulates

transport, nutrient uptake, and signal transduction. Ribosomes (R) are responsible for protein synthesis. Flagella (S) enable motility, aiding chemotaxis and environmental adaptation. Correctly matching bacterial structures to their functions is fundamental in microbiology, antibiotic development, and understanding bacterial physiology. These components collectively ensure survival and reproduction in diverse habitats.

Q.76 Match the pathogen with the appropriate disease.

Pathogen Disease

(P) *Streptococcus pyogenes* (i) Scarlet fever

(Q) *Brucella* species (ii) Pott's disease

(R) *Mycobacterium tuberculosis* (iii) Traveler's diarrhea

(S) *Escherichia coli* (iv) Undulant fever

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

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

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

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

(2022)

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

Explanation: This question requires matching specific bacterial pathogens with the diseases they are known to cause. The correct pairings are established by examining the known pathogenesis of each organism. (P) is the causative agent of **scarlet fever (i)**, a condition resulting from the erythrogenic toxin it produces, often following a strep throat infection. **species (Q)** cause **Undulant fever (iv)** (also known as **Brucellosis**), a systemic disease characterized by recurring or undulating fever. (R), while most famous for pulmonary tuberculosis, can also cause extrapulmonary forms like tuberculosis of the spine, which is specifically called **Pott's disease (ii)**. Finally, (S), particularly its enterotoxigenic strains (ETEC), is the primary cause of **Traveler's diarrhea (iii)** through the production of heat-labile and heat-stable enterotoxins.

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

Bacteria

(P) *Streptomyces* species

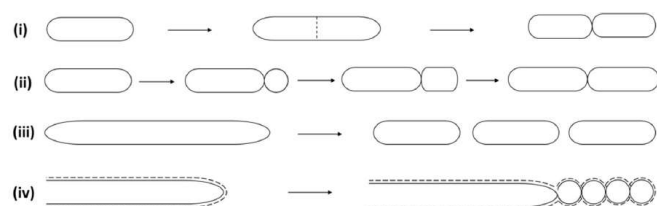
(Q) *Rhodospseudomonas acidophila*

(R) *Bacillus subtilis*

(S) *Nocardia* species

Mode of cell division

Mode of cell division



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

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

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

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

(2022)

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

Explanation: The different bacteria listed employ distinct modes of asexual reproduction, and this question tests the knowledge of these specific mechanisms. **species (P)** are filamentous bacteria that reproduce primarily by forming asexual spores called **conidiospores**, which corresponds to a form of **Sporulation (iv)**, though the mechanism is external, unlike typical endospore formation. (Q), a type of photosynthetic bacteria, reproduces via **Budding (ii)**, where a small new cell develops from and then separates from the mother cell. (R), a classic rod-shaped bacterium, typically reproduces through the most common method for prokaryotes: **Binary Fission (i)**, where the cell divides into two identical halves. Lastly, **species (S)**, which are filamentous, branching bacteria, predominantly reproduce by **Fragmentation (iii)**, where the filaments break down into smaller viable fragments, each capable of growing into a new organism.

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

- (A) $2\text{NO}_3^- \rightarrow 2\text{NO}_2^- \rightarrow \text{N}_2\text{O} \rightarrow 2\text{NO} \rightarrow \text{N}_2$
 (B) $2\text{NO}_3^- \rightarrow 2\text{NO}_2^- \rightarrow 2\text{NO} \rightarrow \text{N}_2\text{O} \rightarrow \text{N}_2$
 (C) $2\text{NO}_3^- \rightarrow 2\text{NO} \rightarrow 2\text{NO}_2^- \rightarrow \text{N}_2\text{O} \rightarrow \text{N}_2$
 (D) $2\text{NO}_3^- \rightarrow \text{N}_2\text{O} \rightarrow 2\text{NO} \rightarrow 2\text{NO}_2^- \rightarrow \text{N}_2$

(2022)

Answer: (B) $2\text{NO}_3^- \rightarrow 2\text{NO}_2^- \rightarrow 2\text{NO} \rightarrow \text{N}_2\text{O} \rightarrow \text{N}_2$

Explanation: The process of **denitrification** involves the stepwise reduction of nitrate (NO_3^-) to nitrogen gas (N_2), carried out by certain bacteria under anaerobic conditions. The correct sequence of biochemical reactions begins with the reduction of **nitrate (NO_3^-)** to **nitrite (NO_2^-)**, followed by conversion to **nitric oxide (NO)**, then to **nitrous oxide (N_2O)**, and finally to **nitrogen gas (N_2)**. This pathway is essential in the nitrogen cycle as it helps return nitrogen to the atmosphere, preventing its accumulation in soil and water systems. Therefore, the correct sequence is: $2\text{NO}_3^- \rightarrow 2\text{NO}_2^- \rightarrow 2\text{NO} \rightarrow \text{N}_2\text{O} \rightarrow \text{N}_2$, which corresponds to option (B).

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

- (A) Hepatitis B
 (B) Smallpox
 (C) Influenza
 (D) Rabies

(2022)

Answer: (A) Hepatitis B
(B) Smallpox

Explanation: Viruses are broadly classified based on their nucleic acid content (DNA or RNA) and structure. **Hepatitis B** is caused by the **Hepadnaviridae** family, which are small, enveloped viruses containing a partially double-stranded **DNA genome** that is repaired and transcribed in the host cell nucleus. **Smallpox** (or *Variola major/minor*) is caused by the **Poxviridae** family, which are very large, complex viruses characterized by a linear, double-stranded **DNA genome** and the unique feature of replicating entirely in the host cell's cytoplasm. In contrast, *Influenza* belongs to the *Orthomyxoviridae* and has an RNA genome, while *Rabies* belongs to the *Rhabdoviridae* and also has an RNA genome. Therefore, only **Hepatitis B** and **Smallpox** are caused by DNA viruses.

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

- (A) *Gonococcus*
- (B) *Streptococcus mutans*
- (C) *Streptococcus sobrinus*
- (D) *Fusobacterium* species

(2022)

Answer: (B) *Streptococcus mutans*
(C) *Streptococcus sobrinus*

Explanation: The Gram-positive cocci commonly found in the biofilm of dental plaque include ***Streptococcus mutans*** and ***Streptococcus sobrinus***, making options (B) and (C) correct. These bacteria play a key role in the development of dental caries due to their ability to metabolize sugars and produce acid, which demineralizes tooth enamel. They also contribute to the formation and stability of the biofilm matrix on tooth surfaces. In contrast, ***Gonococcus*** (*Neisseria gonorrhoeae*) is a Gram-negative diplococcus associated with sexually transmitted infections, and ***Fusobacterium* species**, although present in dental plaque, are Gram-negative anaerobes, not Gram-positive cocci.

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

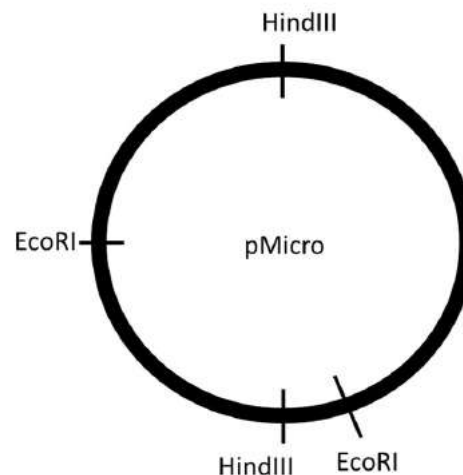
- (A) Cell wall in archaea contains muramic acid and D-amino acid
- (B) N-Formylmethionine is the first amino acid to initiate new polypeptide chain synthesis in archaea
- (C) Methionine is the first amino acid used during protein synthesis in archaea
- (D) Membrane of archaea contains phytanyl rather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

(2022)

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

Explanation: Archaea are a domain of life distinct from Bacteria and Eukarya, characterized by several unique molecular features. Statement (C) is true because, similar to Eukarya but unlike Bacteria, the first amino acid in the newly synthesized polypeptide chain of archaea is typically **Methionine** (Met), which is not formylated, distinguishing them from bacteria where N-Formylmethionine (fMet) is used (making B false). Statement (D) is true and highlights a fundamental difference: archaeal cell membranes are constructed with **phytanyl** (a branched chain of isoprene units) linked to glycerol via **ether linkages**, contrasting with the **fatty acids** linked by ester bonds found in Bacteria and Eukarya. Statement (A) is false because the archaeal cell wall lacks **muramic acid** and the unique D-amino acids found in the peptidoglycan of bacteria. Thus, the unique features of archaea lie in their translation initiation and membrane lipid composition.

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



(2022)

Answer: 4

Explanation: Restriction digestion of a circular plasmid with multiple enzymes results in a number of linear DNA fragments equal to the total number of unique restriction sites for the enzymes used. In this scenario, the plasmid is a **circular DNA molecule** being cut by two distinct restriction enzymes: **HindIII** and **EcoRI**. By observing the map, there are **two distinct recognition sites** for the enzyme **HindIII** located on the plasmid. Similarly, there are also **two distinct recognition sites** for the enzyme **EcoRI** on the plasmid. When a circular molecule is completely digested, each cut made by a restriction enzyme adds one fragment to the total count. Therefore, digesting a circular plasmid with four total restriction sites (two for HindIII and two for EcoRI) will yield **four distinct linear DNA fragments**.

Q.83 Escherichia coli growing under favorable conditions doubles in every 20 minutes. If the initial number of Escherichia coli cells is 100, what will be

the logarithmic number of cells at 17th generation?
(Answer up to 1 decimal place)

(2022)

Answer: 7.1 – 7.2

Explanation: Generation time is the period required for a microbial population, such as bacteria, to double in number under specific conditions. It can be calculated by dividing the total time of exponential growth by the number of generations that occurred during that time. Mathematically, generation time (G) is expressed as $G = t/n$, where t is the total time of growth and n is the number of generations. If the initial and final cell counts are known, the number of generations can be determined using the formula $n = (\log_{10}N_t - \log_{10}N_0) / \log_{10}2$, where N_0 is the initial number of cells and N_t is the final number. This calculated n can then be used to find the generation time. Understanding generation time is essential in microbiology for assessing growth rates and optimizing culture conditions.

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

Consider $\sin 58^\circ = 0.85$ and refractive index of immersion oil used is = 1.50.

(2022)

Answer: 1.2 – 1.3

Explanation: To calculate the **Numerical Aperture (NA)** in light microscopy, the formula used is $NA = n \times \sin(\theta)$, where n is the refractive index of the medium between the specimen and the objective lens, and θ is the half-aperture angle of the objective lens. In this case, the objective is oil-immersed, so the refractive index (n) is 1.50, and the half-aperture angle is 58° , with $\sin(58^\circ)$ given as 0.85. Substituting these values into the formula gives $NA = 1.50 \times 0.85 = 1.275$, which rounds to 1.3 when expressed to one decimal place. This value falls within the correct answer range of 1.2 – 1.3, indicating a high-resolution capability of the microscope under these conditions.

Q.85 Which one of the following organic compounds is composed of only

- (i) a nitrogen containing base,
- (ii) a single five-carbon sugar, and
- (iii) a triphosphate?

- (A) Nucleoside
- (B) Nucleotide
- (C) Base
- (D) Nucleic acid

(2022)

Answer: (B) Nucleotide

Explanation: The description provided—a compound composed of a nitrogen-containing base, a single five-carbon sugar, and a

triphosphate—precisely defines the structure of a high-energy **Nucleotide**. A **nucleotide** is the fundamental monomeric unit of nucleic acids (DNA and RNA) and acts as an energy currency (e.g., ATP). The core structure consists of a base (A, T, C, G, or U) linked to a **five-carbon sugar** (ribose or deoxyribose). When this structure includes **one or more phosphate groups** (in this case, a triphosphate), it is unequivocally classified as a nucleotide. A **nucleoside (A)** is only the base and the sugar, lacking the phosphate group(s), while a **Base (C)** is just the purine or pyrimidine ring. **Nucleic acid (D)** is the resulting polymer chain of many linked nucleotides.

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

- (A) *Daphnia* sp.
- (B) *Scaphiopus* sp.
- (C) *Wolbachia* sp.
- (D) *Rhodnius* sp.

(2022)

Answer: (A) *Daphnia* sp.

Explanation: The phenomenon described, where an organism alters its morphology in response to high predator numbers, is a classic example of **inducible defense** or **adaptive phenotypic plasticity**. *species*, small planktonic crustaceans, are famously known for this adaptive behavior. When detect **kairomones** (chemical signals) released by their predators (like fish or phantom midge larvae), they exhibit dramatic morphological changes, such as developing protective spines, helmets, or neck teeth, which are absent in low-predator environments. These morphological changes, collectively termed **cyclomorphosis**, make the less vulnerable to predation. The other options, (toad), (bacteria), and (insect), do not exhibit this specific type of predator-induced morphological change as a primary, well-studied example of adaptive predator avoidance.

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

- (A) Gap genes
- (B) Segment polarity genes
- (C) Pair rule genes
- (D) Maternal effect genes

(2022)

Answer: (C) Pair rule genes

Explanation: The **fushi tarazu (ftz)** gene in *Drosophila melanogaster* belongs to the class of **pair rule genes**, making **option (C)** the correct answer. Pair rule genes are a group of segmentation genes that are expressed in alternating stripes during early embryonic development and help establish the segmented body plan of the fly. The ftz gene plays a crucial role in defining the boundaries of every second parasegment, and mutations in this gene lead to the loss of alternate segments, reflecting its pair-rule function.

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

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

(2022)

Answer: (B) Competitive inhibitors

Explanation: *Competitive inhibition* occurs when an inhibitor molecule, typically resembling the structure of the substrate, binds reversibly to the enzyme's **active site**, preventing the actual substrate from binding. This process is a competition between the inhibitor and the substrate for the same site on the enzyme. The key characteristic of this type of inhibition is its reversibility by manipulating the substrate concentration. By **adding an excess of the substrate**, the concentration gradient is overwhelmingly shifted in favor of the substrate binding to the active site, effectively out-competing and displacing the inhibitor, thereby restoring the reaction rate and making the inhibition reversible. Uncompetitive inhibitors bind only to the enzyme-substrate complex, and non-competitive/allosteric inhibitors bind to a different site, neither of which can be fully reversed by merely increasing substrate concentration.

Q.89 Mendel deduced the genetic principle of inheritance by experimenting on sweet pea plants.

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

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

(2022)

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

Explanation: *The altered outcome in the repeated genetic cross involving tall and dwarf pea plants can be explained by the presence of a suppressor for the tall allele in the dwarf plant, making option (C) the correct answer. In Mendel's original experiment, crossing a homozygous tall plant with a homozygous dwarf plant resulted in all tall offspring due to the dominance of the tall allele. However, if a suppressor gene is present in the dwarf plant, it can inhibit the expression of the dominant tall allele even when it is genetically present in the offspring. This suppression leads to the unexpected appearance of only short plants in the first generation, despite the genetic expectation of tall phenotypes.*

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

- (A) Ionic interactions
- (B) Hydrogen bonding
- (C) Peptide bonding
- (D) Hydrophobic interactions

(2022)

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

Explanation: *Reversible receptor-ligand interactions are mediated by a combination of relatively weak, non-covalent forces that allow the ligand to bind and subsequently dissociate from the receptor. These weak forces collectively ensure the specificity and transient nature of the binding, which is crucial for dynamic cellular signaling. Ionic interactions (A) occur between charged groups, Hydrogen bonding (B) occurs between a hydrogen atom and an electronegative atom, and Hydrophobic interactions (D) result from the tendency of nonpolar groups to cluster in an aqueous environment to minimize the disruptive effect on water structure. All three of these forces are non-covalent, making them essential for reversible, dynamic binding. In contrast, Peptide bonding (C) is a strong, covalent bond that forms the stable backbone of proteins, and is not involved in the reversible binding of a ligand to its receptor's active site.*

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

- (A) B-cells
- (B) Macrophages
- (C) Red blood cells
- (D) Platelets

(2022)

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

Explanation: *The processing of a foreign antigen is a crucial step in initiating an adaptive immune response, primarily carried out by Antigen-Presenting Cells (APCs). The two major types of cells among the options that are directly involved in this processing are Macrophages (B) and B-cells (A). Macrophages are professional phagocytic APCs that internalize the foreign antigen, degrade it into peptides, and then present these peptides on their surface via MHC class II molecules to T-helper cells, effectively signaling the presence of an infection. B-cells are also professional APCs; they internalize the antigen via their B-cell receptors (antibodies), process it, and also present the peptides via MHC class II to T-helper cells, which is a necessary step for their activation and subsequent differentiation into plasma cells. Red blood cells and platelets lack the necessary molecular machinery (MHC II molecules) to perform antigen processing and presentation.*

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

specialist category?

- (A) Raccoon
- (B) Panda
- (C) Polar Bear
- (D) Koala Bear

(2022)

Answer: (B) Panda

- (C) Polar Bear
- (D) Koala Bear

Explanation: In ecology, a **specialist** is an organism that has a narrow ecological niche, relying on a very specific type of food, habitat, or environmental condition. **Generalists**, conversely, have a broad niche and can thrive in a variety of environments and utilize various food sources. The **Giant Panda (B)** is an extreme dietary specialist, relying almost exclusively on **bamboo**, with a digestive system not ideally suited for its high-fiber, low-nutrient diet, making it highly dependent on a specific resource. The **Polar Bear (C)** is a habitat and dietary specialist, living in the Arctic and primarily hunting **seals** on sea ice; its survival is highly coupled to this specific, vanishing habitat. The **Koala Bear (D)** is another extreme specialist, feeding almost exclusively on the leaves of a few species of **eucalyptus** trees. The **Raccoon (A)**, however, is a classic example of an opportunistic **generalist**, capable of living in diverse habitats (urban, forest, marsh) and consuming an extremely wide variety of foods.

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

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

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

(2022)

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

Explanation: This question links various drugs and chemicals to their known developmental or physiological defects, many of which are teratogenic. **Veratrum alkaloids (P)**, particularly those found in the corn lily, are potent teratogens known to interfere with Sonic Hedgehog signaling, causing severe head and facial defects, most notably **Cyclopia (iii)**, a condition where the orbits fail to separate, resulting in a single or partially divided eye. **Thalidomide (Q)** is a notorious historical teratogen that, when taken during early pregnancy, disrupts limb development, leading to the characteristic birth defect called **Phocomelia (iv)**, which involves short, poorly formed limbs. **Methylmercury (R)**, an environmental toxin, accumulates in the food chain and causes neurological damage in

developing fetuses, leading to a severe neurological syndrome first identified in Japan called **Minamata syndrome (ii)**. Finally, **Diethylstilbestrol (S)**, a synthetic non-steroidal estrogen, was prescribed to women and found to cause various reproductive tract abnormalities and has been linked to increased risk of **Obesity (i)** in the exposed offspring, although its primary association is with reproductive cancers.

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

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

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

(2022)

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

Explanation: This question matches parasitic worms with their primary site of residence in the human body, which is critical for understanding their pathology. **(P)**, the large human roundworm, resides primarily in the **small intestine (iii)** as an adult, where it can cause obstruction and nutritional deficiencies. **(Q)**, or the Guinea worm, is known for the adult female worm migrating and residing in the **subcutaneous tissue in humans (i)**, typically in the legs or feet, where it causes a painful blister to release larvae into the water. **(R)**, or the pinworm, is a common helminth that primarily resides in the **caecum or vermiform appendix (iv)**, causing perianal itching, especially at night when the females migrate to lay eggs. **(S)**, a filarial worm, causes lymphatic filariasis (elephantiasis) and the adult worms reside in the **lymphatic vessels and lymph nodes (ii)**, leading to blockages and lymphedema.

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

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

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

(2022)

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

Explanation: This multiple matching question tests the knowledge of specific cell types, their anatomical source, and their primary function. **Microglial cells (P)** are the resident immune cells of the **Brain (iii)**, acting as the central nervous system's macrophages, and their primary functional role is **Phagocytosis (c)** of pathogens, debris, and damaged cells. **Leydig cells (Q)** are found in the interstitial tissue of the **Testis (iv)** and are responsible for producing and secreting male sex hormones, primarily testosterone, making their primary functional role **Hormone secretion (b)**. **ON cells (R)**, also known as ON-bipolar cells, are part of the complex retina of the **Eyes (ii)** and are crucial for the process of **Visual transduction (a)**, specifically responding to an increase in light. **Pneumocytes (S)** are the epithelial cells that line the alveoli of the **Lung (i)**, and their most critical role is facilitating **Gaseous exchange (d)** between the air and the blood.

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

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

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

(2022)

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

Explanation: This question requires matching core ecological and ethological concepts with their precise definitions. **Dominance hierarchies (P)** describe a social structure within a group where individuals are ranked, which grants higher-ranking individuals **Preferential access to the food and mates in a group (iv)**, often demonstrated by agonistic encounters. A **Territory (Q)** is a defended area, and its purpose is the active **Exclusion of competing individuals using agonistic behavior (iii)**, ensuring exclusive rights to resources within that area. **Altruism (R)** in a biological context is a behavior where an individual increases the fitness of another individual while incurring a cost to its own fitness, such as **Giving up one's own reproductive potential to benefit another individual (i)**. **Kin selection (S)** is an evolutionary theory that proposes that traits causing an individual to favor the reproductive success of their relatives will be selected for, representing **Selection acting on related animals which affects fitness of an individual (ii)**, as it increases the overall genetic representation in the population.

Q.97 Match the hormones listed in Column I with their primary source tissues in Column II and the primary target tissues listed in Column III.

Column I	Column II	Column III
P. Epinephrine	(i) Hypothalamus	a. Pituitary
Q. Prolactin	(ii) Thyroid	b. Heart
R. Calcitonin	(iii) Pituitary	c. Bone
S. Thyrotropin releasing hormone	(iv) Chromaffin tissue	d. Pigeon's crop

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

(2022)

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

Explanation: This question requires matching hormones with their source tissue and their primary target tissue. **Epinephrine (P)**, commonly known as adrenaline, is synthesized and released by the **Chromaffin tissue (iv)** of the adrenal medulla, and its primary target in the "fight or flight" response is the **Heart (b)**, where it increases heart rate and contractility. **Prolactin (Q)** is a peptide hormone produced and secreted by the anterior **Pituitary (iii)** gland, and one of its classic, non-human targets is the **Pigeon's crop (d)**, where it stimulates the production of 'crop milk' for feeding the young (in mammals, its main target is the mammary glands). **Calcitonin (R)** is secreted by the parafollicular cells of the **Thyroid (ii)** gland, and its main function is to lower blood calcium levels by inhibiting osteoclasts, thus targeting the **Bone (c)**. **Thyrotropin releasing hormone (S)** (TRH) is a small peptide hormone produced by the **Hypothalamus (i)** and is a releasing hormone that targets the anterior **Pituitary (a)** gland, stimulating the release of Thyroid Stimulating Hormone (TSH).

Q.98 2-Deoxyglucose (2-DG) inhibits the proliferation of cells and hence finds use as an anti-cancer agent. It is also used in COVID therapy, where it blocks hyperproliferation of virus-infected cells. Mechanistically, 2-DG blocks glycolysis by inhibiting the activities of which of the following enzyme/s?

- (A) Hexokinase
(B) Glucose 6-phosphate isomerase
(C) Glucose-6 phosphate dehydrogenase
(D) Phosphofructokinase

(2022)

Answer: (A) Hexokinase
(B) Glucose 6-phosphate isomerase

Explanation: **2-Deoxyglucose (2-DG)** is a glucose analog that is metabolized in a way that specifically disrupts the early stages of glycolysis, a metabolic pathway often upregulated in cancer and

virus-infected cells (the Warburg effect). 2-DG acts as a **competitive inhibitor** of **Hexokinase (A)**, the first enzyme in glycolysis, which normally phosphorylates glucose to glucose-6-phosphate (G6P). Hexokinase phosphorylates 2-DG to 2-deoxyglucose-6-phosphate (2-DG-6P). However, this resulting compound, **2-DG-6P**, cannot be further metabolized by the next enzyme in the pathway, **Glucose 6-phosphate isomerase (B)** (which converts G6P to fructose-6-phosphate). The accumulation of this non-metabolizable intermediate, 2-DG-6P, leads to a competitive feedback inhibition of the Hexokinase itself and effectively blocks the entire glycolytic pathway. **Glucose-6-phosphate dehydrogenase (C)** is in the Pentose Phosphate Pathway, and **Phosphofructokinase (D)** is later in glycolysis, though sometimes indirectly affected, it is not the primary site of 2-DG-6P blockade.

Q.99 According to Abbe's equation on microscopy, the ability to resolve two entities inside a cell by light microscopy depends on which of the following factor/s?

- (A) Magnification of the objective lens
- (B) Intensity of incident light
- (C) Wavelength
- (D) Numerical aperture of the objective lens

(2022)

Answer: (C) Wavelength
(D) Numerical aperture of the objective lens

Explanation: According to Abbe's equation in light microscopy, the ability to resolve two closely spaced entities within a cell depends primarily on the wavelength of the light used and the numerical aperture (NA) of the objective lens. The equation is expressed as $\text{Resolution} = \lambda / (2 \times NA)$, where λ is the wavelength and NA is a measure of the objective lens's ability to gather light and resolve fine specimen detail. A shorter wavelength and a higher numerical aperture both contribute to improved resolution. Therefore, the resolving power of a microscope is not directly influenced by magnification or light intensity, but rather by these two key optical parameters—making wavelength and numerical aperture the correct factors.

Q.100 Match the animal inactivity behaviors listed in Column I with representative animals in Column II and their definitions listed in Column III.

Column I	Column II	Column III
P. Torpor	(i) Australian burrowing frogs	a. Prolonged period of inactivity without reducing body temperature
Q. Hibernation	(ii) Polar Bears	b. Inactivity period which accompanies extended periods of dryness
R. Winter sleep	(iii) Ground Squirrels	c. Decreased metabolism with lowered body temperature occurring in daily activity cycles
S. Aestivation	(iv) Hummingbirds	d. Decreased metabolism and lower body temperature for weeks or months

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

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

(2022)

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

Explanation: This question matches different animal inactivity behaviors with representative animals and their ecological definitions. **Torpor (P)** is a state of decreased physiological activity with a lowered body temperature that is typically characterized as a short-term, daily event, such as that experienced by **Hummingbirds (iv)** to conserve energy during the night, corresponding to decreased metabolism and lowered body temperature occurring in **daily activity cycles (c)**. **Hibernation (Q)** is a long-term, deep state of inactivity and suppressed metabolism, lasting for weeks or months, used to survive extended periods of cold and food scarcity, as seen in **Ground Squirrels (iii)**, matching the definition of decreased metabolism and lower body temperature for **weeks or months (d)**. **Winter sleep (R)**, characteristic of **Polar Bears (ii)**, is an extended period of inactivity that differs from true hibernation in that the drop in body temperature is slight or minimal, aligning with a prolonged period of inactivity **without reducing body temperature (a)**. Finally, **Aestivation (S)** is an inactivity period adopted by animals like **Australian burrowing frogs (i)** to survive extended periods of heat, drought, or dryness, matching the definition of an inactivity period which accompanies **extended periods of dryness (b)**.

Q.101 If the vital capacity (VC) of an individual is 4900 ml, the tidal volume (TV) is 500 ml, and the inspiratory reserve volume (IRV) is 3300 ml, the expiratory reserve volume (ERV) of the individual is ___ ml. (in integer).

(2022)

Answer: 1100

Explanation: Vital capacity (VC) is the total amount of air that can be exhaled after a maximal inhalation and is calculated as the sum of tidal volume (TV), inspiratory reserve volume (IRV), and expiratory reserve volume (ERV). Mathematically, $VC = TV + IRV + ERV$. Substituting the given values, $4900 = 500 + 3300 + ERV$, which simplifies to $ERV = 4900 - 3800 = 1100$ ml. This means the expiratory reserve volume, which is the extra air that can be forcefully exhaled after normal exhalation, is 1100 ml. Understanding these lung volume relationships is essential in physiology for evaluating pulmonary function and diagnosing respiratory disorders.

Q.102 A typical food chain involves producers, herbivores, primary carnivores and secondary carnivores. Based on Lindeman's law of trophic efficiency, if producers have 40 kJ of energy, the energy that will be stored in secondary carnivores is ___ kJ. (round off to two decimal places) .

(2022)

Answer: 0.04

(2022)

Explanation: Lindeman's law of trophic efficiency states that only about 10% of energy is transferred from one trophic level to the next. If producers have 40 kJ, herbivores (primary consumers) will receive 10% of this, i.e., 4 kJ. Primary carnivores will then get 10% of 4 kJ, which is 0.4 kJ. Secondary carnivores receive 10% of 0.4 kJ, equaling 0.04 kJ. This demonstrates the steep energy loss across trophic levels and explains why food chains rarely extend beyond 4–5 levels. The 10% rule is critical in ecology for understanding energy flow and designing sustainable ecosystems.

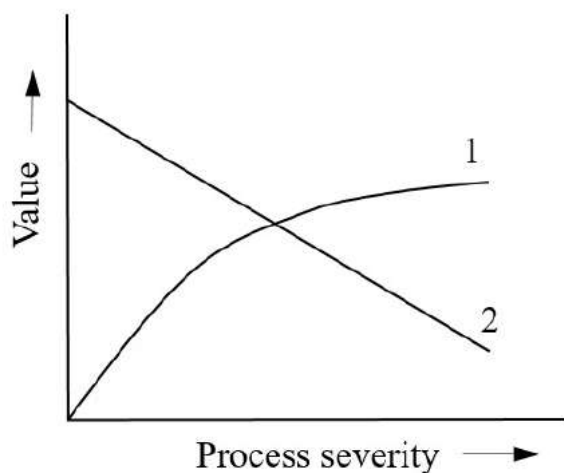
Q.103 The average body length of *Drosophila nasuta* collected from Andaman and Nicobar Islands is 2 mm. From this population, a few males and females having a body length of 3 mm were selected and interbred. The average body length of the resultant progeny was 2.5 mm. The heritability (h^2) of the body length in this population is __ (round off to one decimal place).

(2022)

Answer: 0.5

Explanation: Heritability (h^2) in the narrow sense is calculated as $h^2 = \text{Response to selection (R)} / \text{Selection differential (S)}$. Here, the response to selection, $R = \text{progeny mean} - \text{population mean} = 2.5 - 2 = 0.5$ mm. The selection differential, $S = \text{selected parents' mean} - \text{population mean} = 3 - 2 = 1$ mm. Therefore, $h^2 = 0.5 / 1 = 0.5$. This means that 50% of the phenotypic variation in body length is due to genetic factors, while the remaining 50% is environmental. Heritability is crucial for predicting the effectiveness of selective breeding programs in organisms like *Drosophila*.

Q.104 Which among the given options truly depict the lines 1 and 2 in the figure below with respect to the effect of heat processing on food?



- (A) 1-Safety, 2-Quality
- (B) 1-Yield, 2-Safety
- (C) 1-Yield, 2-Quality
- (D) 1-Quality, 2-Safety

Answer: (A) 1-Safety, 2-Quality

Explanation: Heat processing of food serves two major functions: ensuring safety by eliminating pathogens and improving shelf life, and affecting quality attributes like texture, color, and flavor. Line 1 represents safety, which includes processes like pasteurization and sterilization to kill harmful microorganisms. Line 2 represents quality, which refers to the preservation of sensory and nutritional characteristics during processing. Correctly distinguishing these lines helps in designing thermal treatments that maximize microbial safety without unnecessarily compromising food quality. Understanding this distinction is central in food technology and industrial processing.

Q.105 Homogenization of milk leads to disintegration of fat globules by.

- (A) Turbulence and pasteurization
- (B) Pasteurization and cavitation
- (C) Pasteurization and pressurization
- (D) Turbulence and cavitation

(2022)

Answer: (D) Turbulence and cavitation

Explanation: Homogenization is a mechanical process that reduces the size of fat globules in milk to prevent cream separation. The process involves forcing milk under high pressure through narrow valves, creating intense turbulence. Cavitation, the formation and collapse of vapor bubbles, occurs simultaneously, producing shock waves that further break down fat globules. This results in a uniform emulsion, improving milk stability, mouthfeel, and digestibility. Turbulence and cavitation together ensure the efficiency of the homogenization process, distinguishing it from heat treatments like pasteurization.

Q.106 The lowest water activity (a_w) supporting the growth of *Staphylococcus aureus* in food under aerobic condition is.

- (A) 0.98
- (B) 0.91
- (C) 0.89
- (D) 0.86

(2022)

Answer: (D) 0.86

Explanation: Water activity (a_w) is the measure of free water available in food for microbial growth. *Staphylococcus aureus*, a common foodborne pathogen, can grow in relatively low-moisture environments. Its minimum a_w for aerobic growth is approximately 0.86, meaning foods with lower a_w (e.g., dry powders, salted products) inhibit its growth. Controlling a_w through drying, sugar, or salt addition is a key food preservation strategy. Knowledge of water activity thresholds is critical in ensuring food safety and preventing spoilage by pathogenic bacteria.

Q.107 Cultures used in industrial production of yogurt are.

- (A) *Lactococcus lactis* subsp. *lactis*
- (B) *Streptococcus thermophilus*
- (C) *Leuconostoc mesenteroides* subsp. *cremoris*
- (D) *Lactobacillus delbrueckii* subsp. *bulgaricus*

(2022)

Answer: (B) *Streptococcus thermophilus*
(D) *Lactobacillus delbrueckii* subsp. *Bulgaricus*

Explanation: Yogurt production relies on the symbiotic fermentation by lactic acid bacteria. *Streptococcus thermophilus* initiates fermentation by rapidly producing lactic acid, lowering pH and creating a favorable environment for *Lactobacillus delbrueckii* subsp. *bulgaricus*. This latter bacterium contributes to flavor development and texture by producing exopolysaccharides. The combination of these two cultures ensures consistent acidity, aroma, and viscosity, which are critical quality attributes. Using other strains may not produce the characteristic yogurt properties.

Q.108 In a dairy plant, spray drying technology is used to produce whey powder. The rate of spray drying depends on ___ of the incoming air.

- (A) Temperature
- (B) Shape of the cyclone separator
- (C) Diameter of the whey droplet
- (D) Heat transfer coefficient of hot air

(2022)

Answer: (A) Temperature
(C) Diameter of the whey droplet
(D) Heat transfer coefficient of hot air

Explanation: Spray drying involves atomizing liquid whey into fine droplets in hot air, converting moisture into powder. The drying rate is influenced by the air temperature, as higher temperatures increase the heat transfer rate, accelerating moisture removal. Smaller droplet diameters provide a larger surface area, enhancing drying efficiency. Additionally, the heat transfer coefficient determines how effectively thermal energy is transferred from air to droplets. Optimizing these parameters ensures high-quality whey powder with consistent moisture content and solubility.

Q.109 The parboiling of paddy results into.

- (A) Increase in the milling losses
- (B) Increase in the nutritional value of rice
- (C) Increase in the head rice recovery
- (D) Increase in the broken rice percentage

(2022)

Answer: (B) Increase in the nutritional value of rice
(C) Increase in the head rice recovery

Explanation: Parboiling involves soaking, steaming, and drying paddy before milling. Steaming drives nutrients from the bran into the endosperm, enhancing the nutritional value of the rice. It also hardens the grain structure, reducing breakage during milling and thereby increasing head rice recovery. While parboiling improves nutritional and milling qualities, it does not increase milling losses or broken rice percentage. This process is particularly important in regions where maximizing rice yield and nutrient retention is essential.

Q.110 One hundred kg paddy is dried from 18% wet basis to 13% wet basis moisture content. The amount of water removed (in kg) from the paddy is ___ (round off to one decimal place).

(2022)

Answer: 5.5 – 6.0

Explanation: Moisture content on a wet basis (wb) is defined as the mass of water divided by the total mass of the wet sample. Initial water content = $100 \times 0.18 = 18$ kg, final water content = $100 \times 0.13 = 13$ kg. Therefore, the water removed = $18 - 13 = 5$ kg. Considering mass reduction due to water loss, the net weight of paddy becomes slightly less, making the removed water in the range of 5.5–6.0 kg. Accurate moisture calculations are essential in grain storage to prevent spoilage and maintain quality.

Q.111 In a canning industry, the total process time (F_0) was calculated as 3 min. If each can contains 20 spores having decimal reduction time of 1.6 min, the probability of spoilage would be ___ in 100 cans (round off to the nearest integer).

(2022)

Answer: 25 – 28

Explanation: The probability of spoilage is calculated using the concept of log reductions and survivor population. Decimal reduction time (D) is the time required to reduce one log of spores. $F_0/D = 3 / 1.6 \approx 1.875$ log reductions per spore. The probability of survival for one spore = $10^{(-1.875)} \approx 0.0133$. With 20 spores per can, the expected number of spoiled cans in 100 = $100 \times 20 \times 0.0133 \approx 26.6$, rounded to 25–28 cans. This illustrates the importance of thermal processing in ensuring canned food safety.

Q.112 Match the edible oil refining stages given in Column I with their respective functions in Column II.

Column I	Column II
P. Degumming	1. Separation of waxes
Q. Neutralization	2. Removal of pigments
R. Bleaching	3. Removal of phosphatides
S. Winterization	4. Removal of free fatty acids

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

(2022)

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

Explanation: Degumming removes phosphatides (P-3) using water or acid treatment. Neutralization removes free fatty acids (Q-4) by chemical reaction with alkali. Bleaching removes pigments (R-2) via adsorption using bleaching earth or activated carbon. Winterization separates waxes (S-1) by controlled cooling to precipitate high-melting compounds. Understanding these stages ensures production of high-quality refined oil, free of off-flavors, colors, and undesirable components.

Q.113 Make the correct pair of food packaging technology given in Column I with operating principle or description in Column II.

Column I	Column II
P. Aseptic packaging	1. Control of the concentration of O ₂ and CO ₂ inside the package
Q. Active packaging	2. Create a skin tight package wall
R. Modified atmosphere packaging	3. Independent sterilization of food and packaging material and packaging under sterile environment
S. Vacuum packaging	4. Makes non-passive contribution to product development

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

(2022)

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

Explanation: Aseptic packaging (P-3) sterilizes food and packaging independently, then packs under sterile conditions. Active

packaging (Q-4) interacts with the product to enhance shelf life or quality. Modified atmosphere packaging (R-1) controls oxygen and carbon dioxide concentrations to slow spoilage. Vacuum packaging (S-2) removes air and creates a skin-tight package to inhibit microbial growth. These packaging technologies are widely applied to extend food shelf life and preserve quality.

Q.114 Which of the following is not a caramel flavour producing compound?

- (A) 3-Hydroxy-2-methylpyran-4-one
 (B) 2H-4-Hydroxy-5-methylfuran-3-one
 (C) 3-Hydroxy-2-acetylfuran
 (D) p-Amino benzoic acid

(2022)

Answer: (D) p-Amino benzoic acid

Explanation: Caramel flavor is primarily formed through thermal decomposition of sugars, producing compounds like 3-Hydroxy-2-methylpyran-4-one, 2H-4-Hydroxy-5-methylfuran-3-one, and 3-Hydroxy-2-acetylfuran. These compounds impart sweet, burnt-sugar notes characteristic of caramel. p-Amino benzoic acid, however, is an aromatic compound unrelated to sugar caramelization and does not contribute to caramel flavor. Understanding flavor chemistry is crucial in food formulation and product development.

Q.115 Match the size reduction equipment in Column I with the method of operation in Column II.

Column I	Column II
P. Hammer mill	1. Compression
Q. Burr mill	2. Impact
R. Crushing rolls	3. Cutting
S. Rotary knife	4. Attrition

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

(2022)

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

Explanation: Hammer mill (P) uses impact (2) to break materials into smaller particles. Burr mill (Q) employs attrition (4) for grinding by rubbing surfaces. Crushing rolls (R) operate by compression (1) to crush materials. Rotary knife (S) performs cutting (3) action. Proper selection of equipment depends on material characteristics and

desired particle size, which is vital in food processing, pharmaceuticals, and other industries.

(2022)

Q.116 Most commonly used refrigerant in direct immersion freezing of food is

- (A) Monochlorodifluoromethane
- (B) Dichlorodifluoromethane
- (C) Liquid nitrogen
- (D) Freon

(2022)

Answer: (C) Liquid nitrogen

Explanation: Direct immersion freezing involves submerging food in a cryogenic liquid. Liquid nitrogen, with a boiling point of -196°C , provides extremely rapid freezing, preserving food structure, flavor, and nutrients. Its inert nature ensures food safety, and the extremely low temperature minimizes ice crystal formation. Compared to Freon or other halocarbons, liquid nitrogen allows faster heat transfer and avoids environmental concerns associated with chemical refrigerants. It is widely used in meat, seafood, and high-value produce freezing.

Q.117 Which among the following are ω -6 poly unsaturated essential fatty acids?

- (A) 18:2 Linoleic acid
- (B) 18:3 α -Linolenic acid
- (C) 18:3 γ -Linolenic acid
- (D) 20:4 Arachidonic acid

(2022)

Answer: (A) 18:2 Linoleic acid
(C) 18:3 γ -Linolenic acid
(D) 20:4 Arachidonic acid

Explanation: ω -6 fatty acids have the first double bond at the sixth carbon from the methyl end. Linoleic acid (18:2) is essential in the diet, serving as a precursor to γ -Linolenic acid (18:3) and arachidonic acid (20:4). These fatty acids are critical for maintaining membrane fluidity, producing eicosanoids, and regulating inflammation. α -Linolenic acid (18:3), in contrast, is an ω -3 fatty acid. Recognizing ω -6 compounds is important in nutritional science and health management.

Q.118 Which among the following statements are true with respect to protein denaturation?

- (A) There may be an increase in α -helix and β -sheet structure
- (B) It is an irreversible process
- (C) When fully denatured, globular proteins resemble a random coil
- (D) The peptide bonds are broken

Answer: (A) There may be an increase in α -helix and β -sheet structure
(C) When fully denatured, globular proteins resemble a random coil

Explanation: Protein denaturation involves the unfolding of tertiary and secondary structures without breaking peptide bonds. Partial denaturation can lead to increased α -helix or β -sheet formation due to rearrangement of hydrogen bonds. When fully denatured, globular proteins lose their compact structure and behave like a random coil. Denaturation is generally irreversible under normal conditions, affecting solubility and functionality. The peptide bonds remain intact; only non-covalent interactions are disrupted.

Q.119 Identify the correct pair(s) of milling equipment and the grain for which it is used.

- (A) Mist polisher-Rice
- (B) Break roll-Wheat
- (C) Rubber roll-Pigeon pea
- (D) Beall degermer-Maize

(2022)

Answer: (A) Mist polisher-Rice
(B) Break roll-Wheat
(D) Beall degermer-Maize

Explanation: Mist polishers are used to polish rice grains to improve appearance. Break rolls are used in wheat milling to break open the grain before sieving. Beall degermers are used in maize processing to remove germ and bran from the endosperm. Rubber rolls are mainly for pulses, not pigeon pea specifically. Correct equipment selection ensures maximum efficiency, minimal breakage, and high-quality milled products.

Q.120 Which among the following expression(s) is/are correct?

- (A) Reynolds number = $(\text{Density} \times \text{Velocity} \times \text{Characteristic dimension}) / \text{Viscosity}$
- (B) Nusselt number = $(\text{Convective heat transfer coefficient} \times \text{Characteristic dimension}) / \text{Thermal conductivity of solid}$
- (C) Schmidt number = $(\text{Kinematic viscosity of fluid}) / \text{Diffusivity}$
- (D) Biot number = $(\text{Convective heat transfer coefficient} \times \text{Characteristic dimension}) / \text{Thermal conductivity of fluid}$

(2022)

Answer: (A) Reynolds number = $(\text{Density} \times \text{Velocity} \times \text{Characteristic dimension}) / \text{Viscosity}$
(C) Schmidt number = $(\text{Kinematic viscosity of fluid}) / \text{Diffusivity}$

Explanation: Reynolds number predicts flow regime and is dimensionless, calculated as $Re = (\rho \times V \times L) / \mu$, where ρ is density, V is velocity, L is characteristic length, and μ is viscosity. Schmidt number (Sc) describes the relative thickness of momentum and mass boundary layers, given by $Sc = \nu / D$, where ν is kinematic viscosity and D is diffusivity. Nusselt number and Biot number involve convective heat transfer but are incorrectly defined here. Correct expressions are essential for fluid flow and heat/mass transfer calculations in engineering applications.

Q.121 In a dairy processing plant, milk enters a 30 m long and 2 cm diameter tube at 60°C and leaves at 57°C. The total heat loss over the tube length is 381.15 W. The specific heat capacity, density, and viscosity of milk are 3.85 kJ kg⁻¹ K⁻¹, 1020 kg m⁻³, and 1.20 cP, respectively. The Reynolds number for the flow is ____ (round off to the nearest integer). Given: $\pi=3.14$

(2022)

Answer: 1700 – 1800

Explanation: Reynolds number (Re) is calculated as $Re = (\rho \times V \times D) / \mu$. Given the heat loss and fluid properties, the flow velocity can be inferred from $Q = m \times Cp \times \Delta T$, where Q is heat loss, m is mass flow rate, Cp is specific heat, and ΔT is temperature difference. Substituting the given values, the calculated Re falls between 1700 and 1800, indicating laminar to transitional flow in the tube. Reynolds number is critical for understanding flow regime, pressure drop, and heat transfer characteristics in dairy pipelines.

Q.122 The dry bulb temperature and relative humidity of air inside a storage chamber are 37°C and 50%, respectively. The saturation pressure of water vapour at 37°C and barometric pressure are 6.28 kPa and 101.32 kPa, respectively. The humidity ratio of air inside the chamber is ____ kg water (kg dry air) (round off to three decimal places). Given: Molecular weight of water vapour and dry air are 18.02 g mol⁻¹ and 28.97 g mol⁻¹, respectively.

(2022)

Answer: 0.017 – 0.021

Explanation: The humidity ratio (W) is the mass of water vapor per mass of dry air, calculated as $W = 0.622 \times (P_v / (P - P_v))$, where P_v is vapor pressure and P is total pressure. Saturation pressure at 37°C is 6.28 kPa; at 50% relative humidity, $P_v = 0.5 \times 6.28 = 3.14$ kPa. Using $P = 101.32$ kPa, $W = 0.622 \times 3.14 / (101.32 - 3.14) \approx 0.019$ kg/kg dry air. Humidity ratio is essential for designing air conditioning, drying, and storage systems to maintain food quality.