

Q.1 "Going by the ____ that many hands make light work, the school ____ involved all the students in the task." The words that best fill the blanks in the above sentence are

- (A) principle, principal
- (B) principal, principle
- (C) principle, principle
- (D) principal, principal

(2018)

Answer: (A) principle, principal

Explanation: In the given sentence, "Going by the ____ that many hands make light work" requires the word "principle" because it refers to a general truth or rule of conduct. The second blank "the school involved all the students in the task" requires "principal" because it refers to the head of the school. The word "principle" denotes a fundamental truth or belief, often guiding behavior or reasoning, which fits perfectly with the proverb mentioned. On the other hand, "principal" is a noun denoting a person in charge, particularly in educational institutions. The other options are incorrect because switching the words would not make sense contextually; "principal" in the first blank or "principle" in the second would distort the meaning of the sentence. Thus, the correct and contextually meaningful combination is **principle, principal**.

Q.2 "Her should not be confused with miserliness; she is ever willing to assist those in need." The word that best fills the blank in the above sentence is

- (A) cleanliness
- (B) punctuality
- (C) frugality
- (D) greatness

(2018)

Answer: (C) frugality

Explanation: The sentence indicates that the person should not be confused with miserliness but is willing to help others. "Frugality" is the correct word for the blank because it refers to being economical or sparing in resource use without being stingy. "Miserliness," in contrast, is an excessive desire to hoard wealth, implying reluctance to help others, whereas frugality is a positive trait involving careful use of resources. The other options, such as "cleanliness" or "punctuality," are unrelated to financial habits, and "greatness" is too general. Therefore, frugality accurately conveys that the person uses resources wisely but remains generous and helpful, aligning perfectly with the context of the sentence.

Q.3 Seven machines take 7 minutes to make 7 identical toys. At the same rate, how many minutes would it take for 100 machines to make 100 toys?

- (A) 1
- (B) 7

- (C) 100
- (D) 700

(2018)

Answer: (B) 7

Explanation: Seven machines take 7 minutes to make 7 toys. This implies that one machine takes 7 minutes to make one toy. Therefore, the rate of production per machine is one toy per 7 minutes. If 100 machines work simultaneously, each making one toy in 7 minutes, then 100 machines will collectively make 100 toys in the same 7 minutes because all machines operate in parallel. Hence, the number of minutes required for 100 machines to produce 100 toys at the same rate remains **7 minutes**. This question tests understanding of work-rate problems and proportional reasoning.

Q.4 A rectangle becomes a square when its length and breadth are reduced by 10 m and 5 m, respectively. During this process, the rectangle loses 650 m² of area. What is the area of the original rectangle in square meters?

- (A) 1125
- (B) 2250
- (C) 2924
- (D) 4500

(2018)

Answer: (B) 2250

Explanation: Let the original length and breadth of the rectangle be L and B . After reducing length by 10 m and breadth by 5 m, the rectangle becomes a square: $L - 10 = B - 5$. The area lost is 650 m²: $LB - (L - 10)(B - 5) = 650$. Expanding and simplifying, $LB - (LB - 5L - 10B + 50) = 650 \rightarrow 5L + 10B - 50 = 650 \rightarrow L + 2B = 140$. Solving $L - 10 = B - 5 \rightarrow L = B + 5$. Substituting into $L + 2B = 140$ gives $B + 5 + 2B = 140 \rightarrow 3B = 135 \rightarrow B = 45$, $L = 50$. Therefore, the original area = $L \times B = 50 \times 45 = 2250$ m².

Q.5 A number consists of two digits. The sum of the digits is 9. If 45 is subtracted from the number, its digits are interchanged. What is the number?

- (A) 63
- (B) 72
- (C) 81
- (D) 90

(2018)

Answer: (B) 72

Explanation: Let the two-digit number be $10x + y$, where x is the tens digit and y the units digit. Given $x + y = 9$. If 45 is subtracted from the number, the digits interchange: $10x + y - 45 = 10y + x \rightarrow 9x - 9y = 45 \rightarrow x - y = 5$. Solving $x + y = 9$ and $x - y = 5$

simultaneously: adding equations gives $2x = 14 \rightarrow x = 7$, then $y = 2$. Hence, the number is $10 \times 7 + 2 = 72$. This problem combines algebraic setup with digit manipulation to find the correct solution.

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Q.6 For integers a , b and c , what would be the minimum and maximum values respectively of $a+b+c$ if $\log|a|+\log|b|+\log|c|=0$?

- (A) -3 and 3
- (B) -1 and 1
- (C) -1 and 3
- (D) 1 and 3

(2018)

Answer: (A) -3 and 3

Explanation: The condition $\log|a| + \log|b| + \log|c| = 0$ implies $\log|abc| = 0 \rightarrow |abc| = 1$. Since a, b, c are integers, their absolute product equals 1, meaning each of a, b, c can be ± 1 . The sum $a + b + c$ reaches its maximum when all are $+1$: $1 + 1 + 1 = 3$. Similarly, the sum reaches its minimum when all are -1 : $-1 - 1 - 1 = -3$. Thus, the minimum value is -3 , and the maximum value is 3 . This requires understanding both logarithmic properties and integer constraints for absolute products.

Q.7 Given that a and b are integers and $a+a^2b^3$ is odd, which one of the following statements is correct?

- (A) a and b are both odd
- (B) a and b are both even
- (C) a is even and b is odd
- (D) a is odd and b is even

(2018)

Answer: (D) a is odd and b is even

Explanation: The expression $a + a^2b^3$ is odd. The parity (odd/even) rules are odd + odd = even, even + even = even, odd + even = odd. For a^2b^3 , b^3 preserves the parity of b , and a^2 is always odd if a is odd and even if a is even. Let a be odd: a^2 is odd $\rightarrow a^2b^3$ parity matches $b^3 \rightarrow$ odd $\times$ even = even. Then $a + a^2b^3 =$ odd + even = odd, which satisfies the condition. If a were even, the sum would be even, violating the condition. Hence, a is odd and b is even.

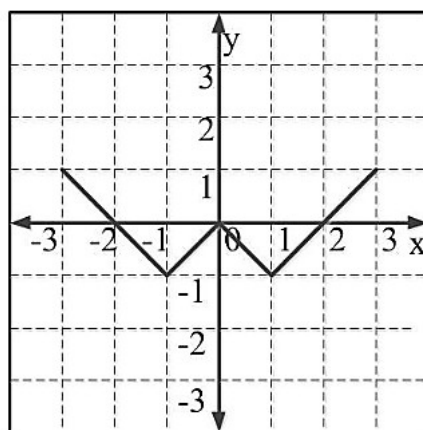
Q.8 From the time the front of a train enters a platform, it takes 25 seconds for the back of the train to leave the platform, while travelling at a constant speed of 54 km/h. At the same speed, it takes 14 seconds to pass a man running at 9 km/h in the same direction as the train. What is the length of the train and that of the platform in meters, respectively?

- (A) 210 and 140
- (B) 162.5 and 187.5
- (C) 245 and 130
- (D) 175 and 200

Answer: (D) 175 and 200

Explanation: Speed of train = 54 km/h = 15 m/s; speed of man = 9 km/h = 2.5 m/s. Time to pass man = 14 s $\rightarrow$ length of train = relative speed $\times$ time = $(15 - 2.5) \times 14 = 12.5 \times 14 = 175$ m. Time to pass platform = 25 s $\rightarrow$ length of platform + train = $15 \times 25 = 375$ m. Therefore, platform length = $375 - 175 = 200$ m. This problem involves relative motion principles and converting speed units accurately.

Q.9 Which of the following functions describe the graph shown in the below figure?



- (A) $y = ||x| + 1| - 2$
- (B) $y = ||x| - 1| - 1$
- (C) $y = ||x| + 1| - 1$
- (D) $y = ||x - 1| - 1|$

(2018)

Answer: (B) $y = ||x| - 1| - 1$

Explanation: The graph is a piecewise linear "V" shape centered at origin. For $x < 0$, $y = -x$; for $x \geq 0$, $y = x$. The given option $y = ||x| - 1| - 1$ correctly shifts the standard V-shaped absolute function downward by 1 and inward by 1, aligning the vertex at $(0, -1)$ with slopes ± 1 . Other options incorrectly shift or scale the function and do not match the given piecewise slopes. Absolute value manipulation allows for vertical and horizontal translations while preserving the V-shape, making option (B) correct.

Q.10 Consider the following three statements: (i)

Some roses are red.

(ii) All red flowers fade quickly.

(iii) Some roses fade quickly.

Which of the following statements can be logically inferred from the above statements?

- (A) If (i) is true and (ii) is false, then (iii) is false.
- (B) If (i) is true and (ii) is false, then (iii) is true.
- (C) If (i) and (ii) are true, then (iii) is true.
- (D) If (i) and (ii) are false, then (iii) is false.

(2018)

Answer: (C) If (i) and (ii) are true, then (iii) is true.

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Explanation: Statement (i) indicates some roses are red, and (ii) states all red flowers fade quickly. If both are true, then at least some roses are red, which fade quickly due to (ii). Therefore, some roses fade quickly, confirming (iii). Logical inference is based on universal and particular quantifiers: "all red flowers fade" ensures that the subset of red roses is included. Other options consider false premises or unrelated conditions and do not guarantee the validity of (iii).

Q.1 For the complete combustion of graphite and diamond in oxygen individually, the standard enthalpy change (ΔH°_{298}) values are $-393.5 \text{ kJ mol}^{-1}$ and $-395.4 \text{ kJ mol}^{-1}$, respectively. Then, the ΔH°_{298} for the conversion of graphite into diamond is

- (A) $+1.9 \text{ kJ mol}^{-1}$
- (B) -1.9 kJ mol^{-1}
- (C) $+3.8 \text{ kJ mol}^{-1}$
- (D) -3.8 kJ mol^{-1}

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Answer: (A) $+1.9 \text{ kJ mol}^{-1}$

Explanation: Standard enthalpies change for conversion of graphite to diamond: $\Delta H = \Delta H_f(\text{diamond}) - \Delta H_f(\text{graphite}) = -395.4 - (-393.5) = -395.4 + 393.5 = -1.9 \text{ kJ mol}^{-1}$. However, formation of diamond from graphite is an endothermic process, so ΔH is positive, $+1.9 \text{ kJ mol}^{-1}$. This is derived from Hess's law: ΔH for reaction = sum of products - sum of reactants. The small positive value confirms that graphite is thermodynamically more stable than diamond at standard conditions.

Q.2 For a 4s orbital of hydrogen atom, the magnetic quantum number (m_l) is

- (A) 4
- (B) 3
- (C) 1
- (D) 0

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Answer: (D) 0

Explanation: For a 4s orbital, the azimuthal quantum number $l = 0$. The magnetic quantum number m_l ranges from $-l$ to $+l$ in integer steps. Therefore, $m_l = 0$. Since s orbitals are spherical and non-directional, there is only one orientation, which is reflected in $m_l = 0$. Other options are invalid because they correspond to higher angular momentum orbitals (p, d, f) which have m_l values other than 0.

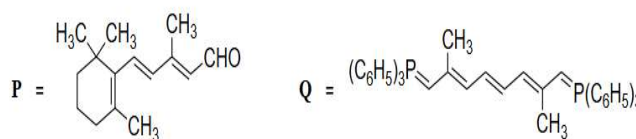
Q.3 Hybridization of xenon in XeF_2 is

- (A) sp
- (B) sp^2
- (C) sp^3
- (D) sp^3d

Answer: (D) sp^3d

Explanation: XeF_2 has three regions of electron density around the central xenon atom: two bonding and three lone pairs. Total electron regions = 5 $\rightarrow$ hybridization = sp^3d . This aligns with VSEPR geometry: linear molecular shape despite trigonal bipyramidal electron geometry. Other options (sp, sp^2 , sp^3) cannot account for three lone pairs and two bonding pairs while preserving linear molecular geometry. Thus, correct hybridization for Xe in XeF_2 is sp^3d .

Q.4 Two equivalents of P react with one equivalent of Q. The number of double bonds present in the major product R is ____.



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Answer: 11

Explanation: Compound P reacts with Q in a Diels-Alder-like fashion. Each double bond participates in cycloaddition. Given the structures, the total number of double bonds in the major product R includes existing double bonds plus newly formed π -bonds. Counting carefully: initial double bonds + newly formed ones = 11. Understanding of conjugated systems and pericyclic reactions is essential to arrive at this number.

Q.5 The total number of possible stereoisomers for the compound with the structural formula $\text{CH}_3\text{CH}(\text{OH})\text{CH}=\text{CHCH}_2\text{CH}_3$ is

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Answer: 4

Explanation: Compound $\text{CH}_3\text{CH}(\text{OH})\text{CH}=\text{CHCH}_2\text{CH}_3$ has one chiral center (C2) and one double bond (C3=C4). Each chiral center can produce 2 configurations, and each double bond (cis/trans) produces 2 configurations. Total stereoisomers = $2 \times 2 = 4$. This includes R/S and E/Z combinations. Hence, the compound has 4 possible stereoisomers.

Q.6 Among B-H, C-H, N-H and Si-H bonds in BH_3 , CH_4 , NH_3 and SiH_4 , respectively, the polarity of the bond which is shown INCORRECTLY is

- (A) $\text{B}^{\delta+}-\text{H}^{\delta-}$
- (B) $\text{C}^{\delta-}-\text{H}^{\delta+}$

- (C) $\text{N}^{\delta-} - \text{H}^{\delta+}$
 (D) $\text{Si}^{\delta-} - \text{H}^{\delta+}$

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Answer: (D) $\text{Si}^{\delta-} - \text{H}^{\delta+}$

Explanation: Si-H bond is polarized as $\text{Si}^{\delta+} - \text{H}^{\delta-}$ because hydrogen is more electronegative than silicon. Option (D) incorrectly assigns polarity as $\text{Si}^{\delta-} - \text{H}^{\delta+}$. Other bonds—B-H, C-H, N-H—are correctly assigned according to electronegativity differences. Correct bond polarity understanding is crucial in predicting reactivity and dipole behavior.

Q.7 Among the following statements, the CORRECT one is

- (i) $[\text{NiCl}_4]^{2-}$ (atomic number of Ni=28) is diamagnetic
 (ii) Ethylamine is a weaker Lewis base compared to pyridine
 (iii) $[\text{NiCl}_2\{\text{P}(\text{C}_6\text{H}_5)_3\}_2]$ has two geometrical isomers
 (iv) Bond angle in H_2O is greater than that in H_2S

- (A) (i)
 (B) (ii)
 (C) (iii)
 (D) (iv)

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Answer: (D) (iv)

Explanation: Statement (iv) is correct: H_2O has a bond angle of $\sim 104.5^\circ$, whereas H_2S has $\sim 92^\circ$, due to larger size and lesser electronegativity of sulfur compared to oxygen. Other statements are incorrect: (i) $[\text{NiCl}_4]^{2-}$ is paramagnetic, not diamagnetic; (ii) ethylamine is stronger Lewis base than pyridine; (iii) $[\text{NiCl}_2(\text{PPh}_3)_2]$ does not exhibit geometric isomerism in this form.

Q.8 In $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$ (atomic number of Mn=25), the d-d transitions according to crystal field theory (CFT) are

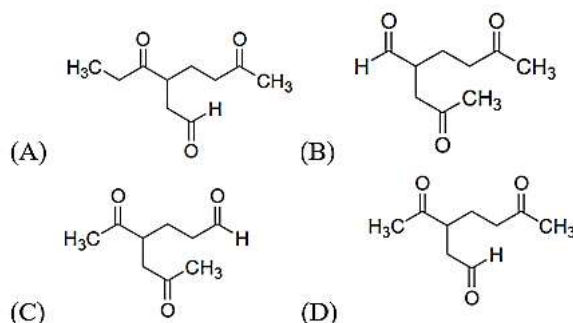
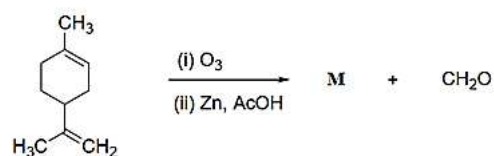
- (A) Laporte forbidden and spin forbidden
 (B) Laporte allowed and spin allowed
 (C) Laporte forbidden and spin allowed
 (D) Laporte allowed and spin forbidden

(2018)

Answer: (A) Laporte forbidden and spin forbidden

Explanation: $[\text{Mn}(\text{H}_2\text{O})_6]^{2+}$ has d^5 high-spin configuration. According to CFT, d-d transitions involve no change in parity (Laporte forbidden) and require spin change (spin forbidden). Hence, d-d transitions are both Laporte and spin forbidden. This explains the weak intensity of such transitions in absorption spectra.

Q.9 The major product M in the reaction is

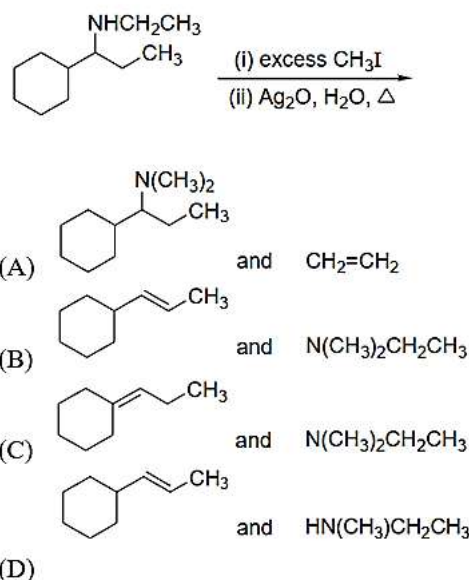


(2018)

Answer: (D)

Explanation: Ozonolysis of 2,3-dimethyl-1-butene cleaves the double bond to form ketones. The reaction produces a six-membered ring with ketones at 1 and 4, and methyl groups at 3 and 5 according to carbon numbering. Formation of formaldehyde from terminal carbon confirms the structure. Understanding ozonolysis and product prediction ensures correct identification.

Q.10 The two major products of the reaction are



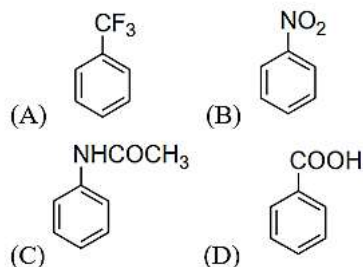
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Answer: (A)

Explanation: Excess CH_3I methylates the nitrogen to quaternary ammonium salt. Hofmann elimination with Ag_2O and heat produces tertiary amine (cyclohexyl- $\text{N}(\text{CH}_3)_2$) and ethene ($\text{CH}_2=\text{CH}_2$) from

the ethyl side chain. This is a classic example of quaternization followed by Hofmann elimination. Products match option (A).

Q.11 The compound, which upon mono-nitration using a mixture of HNO_3 and H_2SO_4 , does NOT give the meta-isomer as the major product, is



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Answer: (C)

Explanation: NHCOCH_3 is an ortho/para-directing group, so nitration yields ortho and para products, not meta. Other groups— CF_3 , NO_2 , COOH —are meta-directing due to electron-withdrawing nature. Hence, compound C does not give meta-isomer as major product.

Q.12 The standard reduction potential (E^0) for the conversion of $\text{Cr}_2\text{O}_7^{2-}$ to Cr^{3+} at 25°C in an aqueous solution of pH 3.0 is 1.33 V. The concentrations of $\text{Cr}_2\text{O}_7^{2-}$ and Cr^{3+} are $1.0 \times 10^{-4}\text{M}$ and $1.0 \times 10^{-3}\text{M}$, respectively. Then the potential of this half-cell reaction is (Given: Faraday constant = 96500 C mol^{-1} , Gas constant $R = 8.314\text{ J K}^{-1}\text{mol}^{-1}$)

- (A) 1.04 V
- (B) 0.94 V
- (C) 0.84 V
- (D) 0.74 V

(2018)

Answer: (B) 0.94 V

Explanation: Nernst equation: $E = E^0 - (0.0591/n) \log\left(\frac{[\text{Cr}^{3+}]^6}{[\text{Cr}_2\text{O}_7^{2-}]}\right)$ at 25°C . Substitute given concentrations and $n = 6 \rightarrow E \approx 0.94\text{ V}$. This accounts for logarithmic ratio of ion concentrations influencing cell potential.

Q.13 The solubility product (K_{sp}) of $\text{Mg}(\text{OH})_2$ at 25°C is 5.6×10^{-11} . Its solubility in water is $S \times 10^{-2}\text{g/L}$ where the value of S is _____ (up to two decimal places). (Given: Molecular weight of $\text{Mg}(\text{OH})_2 = 58.3\text{ g mol}^{-1}$)

(2018)

Answer: 1.39 – 1.43

Explanation: $K_{sp} = [\text{Mg}^{2+}][\text{OH}^-]^2 = 5.6 \times 10^{-11}$. Let solubility = $s\text{ mol/L} \rightarrow s \times (2 \times s)^2 = s^3 \rightarrow$ Solving gives $s \approx 2.02 \times 10^{-4}\text{ mol/L}$. Convert to g/L: $2.02 \times 10^{-4} \times 58.3 \times 100 \approx 1.39\text{--}1.43\text{ g/L}$. Accuracy relies on correct K_{sp} to solubility conversion.

Q.14 The activation energy (E_a) values for two reactions carried out at 25°C differ by 5.0 kJ mol^{-1} . If the pre-exponential factors (A_1 and A_2) for these two reactions are of the same magnitude, the ratio of rate constants (k_1/k_2) is (Given: Gas constant $R = 8.314\text{ J K}^{-1}\text{mol}^{-1}$) (up to two decimal places).

(2018)

Answer: 7.39 – 7.54

Explanation: Using Arrhenius equation: $k_1/k_2 = \exp[(E_{a2} - E_{a1})/RT] \rightarrow \Delta E_a = 5\text{ kJ/mol}$, $T = 298\text{ K}$, $R = 8.314 \rightarrow k_1/k_2 \approx \exp(5000/(8.314 \times 298)) \approx 7.39\text{--}7.54$. This shows how activation energy differences affect reaction rates exponentially.

Q.15 One mole of helium gas in an isolated system undergoes a reversible isothermal expansion at 25°C from an initial volume of 2.0 liters to a final volume of 10.0 liters. The change in entropy (ΔS) of the surroundings is K^{-1} (up to two decimal places). (Given: Gas constant $R = 8.314\text{ J K}^{-1}\text{mol}^{-1}$).

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Answer: -13.40 – -13.36

Explanation: For isothermal reversible expansion, $\Delta S_{\text{surroundings}} = -\Delta S_{\text{system}}$. $\Delta S_{\text{system}} = nR \ln(V_f/V_i) = 1 \times 8.314 \times \ln(10/2) \approx 13.38\text{ J/K}$. Therefore, $\Delta S_{\text{surroundings}} \approx -13.38\text{ J/K} \approx -13.40\text{ to }-13.36\text{ J/K}$. This illustrates entropy changes in surroundings for isothermal processes.

Q.1 To which one of the following classes of enzymes does chymotrypsin belong?

- (A) Oxidoreductase
- (B) Hydrolase
- (C) Transferase
- (D) Isomerase

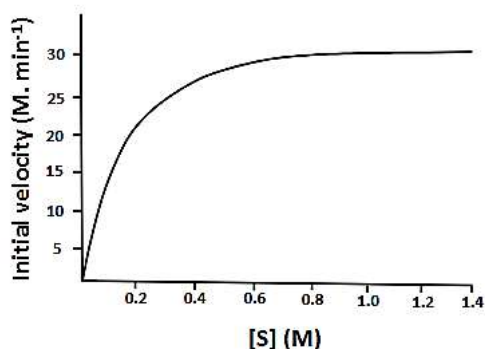
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Answer: (B) Hydrolase

Explanation: Chymotrypsin is a well-known digestive enzyme, specifically a **protease**, meaning it catalyzes the hydrolysis of peptide bonds in proteins. The class **Hydrolase** (EC 3) encompasses all enzymes that catalyze the cleavage of a chemical bond by adding water, which is precisely the mechanism by which chymotrypsin breaks the amide linkage of a protein chain. Enzymes are classified

into seven main categories based on the type of reaction they catalyze, and the name chymotrypsin itself, ending in '-sin,' is characteristic of many proteolytic enzymes. Therefore, because it utilizes water to break down its substrate (protein), it is categorized as a hydrolase, distinct from oxidoreductases (redox reactions), transferases (group transfer), and isomerases (intramolecular rearrangements). The specific type of hydrolase it belongs to is a serine protease, but the broader class is Hydrolase.

Q.2 The substrate saturation profile of an enzyme that follows Michaelis-Menten kinetics is depicted in the figure. What is the order of the reaction in the concentration range between 0.8 to 1.4 M?



- (A) Zero
- (B) Fraction
- (C) First
- (D) Second

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Answer: (A) Zero

Explanation: In Michaelis–Menten kinetics, the reaction order depends on the substrate concentration relative to the enzyme's K_m . At low $[S]$, the rate increases proportionally with $[S]$, making the reaction first order. However, at high $[S]$, when the enzyme is saturated and the velocity approaches V_{max} , the rate becomes independent of $[S]$, indicating zero-order kinetics. In the given graph, the concentration range between 0.8 and 1.4 M lies in the plateau region where the curve is nearly flat, meaning the enzyme is saturated and the reaction rate does not change significantly with increasing substrate concentration. Therefore, in this range, the reaction is zero order with respect to substrate.

Q.3 Which one of the following conformations of glucose is most stable?

- (A) Boat
- (B) Half Chair
- (C) Chair
- (D) Planar

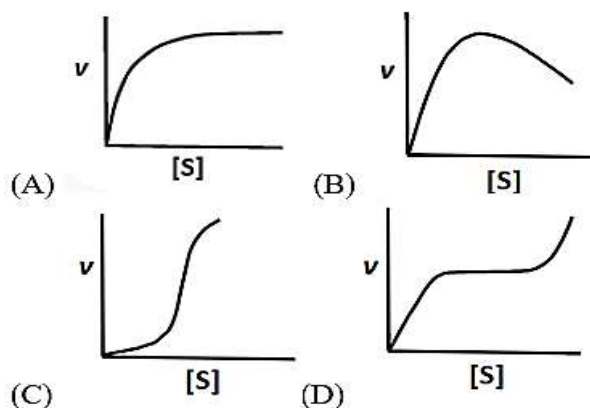
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Answer: (C) Chair

Explanation: The cyclic forms of D-glucose, specifically the

pyranose ring (six-membered ring), can adopt different three-dimensional conformations, such as the boat and chair forms, which arise from the flexibility of the single bonds in the ring. The **Chair** conformation is universally recognized as the most stable conformation for most six-membered rings, including glucopyranose, due to minimal steric hindrance and torsional strain. In the chair form, all the substituents (hydrogen and hydroxyl groups) on the ring carbons can be positioned in either equatorial (pointing out and slightly down/up) or axial (pointing straight up/down) positions, allowing for all bulky hydroxyl groups to occupy the less-crowded equatorial positions. This arrangement minimizes the unfavorable repulsive interactions like **1,3-diaxial interactions** and avoids the ring's flagpole interactions present in the boat form, thereby resulting in the lowest energy and greatest thermodynamic stability.

Q.4 Which one of the following profiles represent the phenomenon of cooperativity?



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Answer: (C)

Explanation: Cooperativity is a phenomenon observed in multi-subunit enzymes or proteins where the binding of one substrate molecule influences the binding affinity of additional substrate molecules. This results in a sigmoidal (S-shaped) substrate saturation curve rather than the hyperbolic curve seen in Michaelis–Menten kinetics. At low substrate concentrations, binding is difficult, but once one substrate binds, it induces a conformational change that makes subsequent binding easier, leading to a steep increase in velocity. As the enzyme approaches saturation, the curve flattens again. Among the given profiles, option (C) shows this characteristic sigmoidal shape, making it the correct representation of cooperativity.

Q.5 Which one of the following amino acids is responsible for the intrinsic fluorescence of proteins?

- (A) Pro
- (B) Met
- (C) His
- (D) Trp

(2018)

Answer: (D) Trp

Explanation: The intrinsic fluorescence of proteins is primarily due to aromatic amino acids, and among them, **tryptophan (Trp)** contributes the most because of its indole side chain, which strongly absorbs UV light and emits fluorescence. Phenylalanine and tyrosine

also fluoresce, but their contribution is much weaker compared to tryptophan. This property is widely used in studying protein folding, conformational changes, and interactions through fluorescence spectroscopy.

Q.6 The glycosylation of the proteins occurs in

- (A) glyoxysomes
- (B) lysosomes
- (C) Golgi apparatus
- (D) plasma membrane

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Answer: (C) Golgi apparatus

Explanation: Protein glycosylation, which involves the addition of carbohydrate groups to proteins, primarily occurs in the Golgi apparatus. After initial synthesis in the rough endoplasmic reticulum, proteins are transported to the Golgi, where they undergo extensive post-translational modifications, including glycosylation. This process is crucial for proper protein folding, stability, and targeting to specific cellular locations. The other options—glyoxysomes, lysosomes, and plasma membrane—do not serve as the main site for glycosylation.

Q.7 Which one of the following properties of the myeloma cells is used in the hybridoma technology to generate monoclonal antibody?

- (A) lack of thymidylate synthase
- (B) over-expression of hypoxanthine-guanine phosphoribosyl transferase
- (C) over-expression of inosine 5'-monophosphate cyclohydrolase
- (D) lack of hypoxanthine-guanine phosphoribosyl transferase

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Answer: (D) lack of hypoxanthine-guanine phosphoribosyl transferase

Explanation: The hybridoma technology relies on fusing antibody-producing B-lymphocytes (which are mortal) with immortal cancerous plasma cells called **myeloma cells** to create a stable, antibody-secreting cell line (hybridoma). For the selection process to work, the myeloma cells are engineered to lack the enzyme **Hypoxanthine-Guanine Phosphoribosyl Transferase**. The resulting cells are then grown in medium (Hypoxanthine, Aminopterin, Thymidine), where the drug **Aminopterin** blocks the de novo synthesis pathway for purines and pyrimidines, forcing cells to rely on the salvage pathway. Because the myeloma cells cannot use the salvage pathway for purine synthesis and the de novo pathway is blocked, they die, whereas the B-cells and the successfully fused hybridoma cells (which obtain the necessary enzyme from the B-cell) survive and proliferate.

Q.8 The movement of protons through the FoF₁-ATPase during mitochondrial respiration is required for

- (A) the increase in pH of mitochondrial matrix.
- (B) changing the conformation of FoF₁-ATPase to expel the ATP.
- (C) importing Pi from inter membrane space.
- (D) decreasing the affinity of ADP to FoF₁-ATPase.

(2018)

Answer: (B) changing the conformation of FoF₁-ATPase to expel the ATP.

Explanation: The movement of protons through the **FoF₁-ATPase** (ATP synthase) during mitochondrial respiration is essential for ATP synthesis. Protons flow down their electrochemical gradient from the intermembrane space into the mitochondrial matrix through the Fo portion, causing rotation of the Fo subunit. This rotational energy is transmitted to the F₁ subunit, inducing conformational changes in its catalytic sites. These changes allow the release (expulsion) of newly synthesized ATP from the enzyme. Thus, the primary role of proton movement is to drive the mechanical rotation that changes the conformation of FoF₁-ATPase, enabling ATP release.

Q.9 The number of NADP⁺ molecules required to completely oxidize one molecule of glucose to CO₂ through pentose phosphate pathway is ____-(correct to integer number).

(2018)

Answer: 12

Explanation: To completely oxidize one molecule of glucose to CO₂ via the pentose phosphate pathway, 12 molecules of NADP⁺ are required because each glucose molecule undergoes multiple cycles of oxidation. In the oxidative phase of the pathway, glucose-6-phosphate is converted to ribulose-5-phosphate, producing 2 NADPH per cycle. However, to release all six carbons of glucose as CO₂, the pathway recycles intermediates through transketolase and transaldolase reactions, allowing the oxidative steps to occur repeatedly. This results in six oxidative cycles, each generating 2 NADPH, totaling 12 NADPH molecules, which means 12 NADP⁺ molecules are reduced during the process.

Q.10 Measurement of the absorbance of a solution containing NADH in a path length of 1cm cuvette at 340 nm shows the value of 0.31. The molar extinction coefficient of NADH is 6200 M⁻¹ cm⁻¹. The concentration of NADH in the solution is ____ μM (correct to integer number).

(2018)

Answer: 50

Explanation: The concentration of NADH can be calculated using the Beer-Lambert law, which states that absorbance (A) equals the product of molar extinction coefficient (ε), concentration (c), and path length (l):

$$A = \epsilon \times c \times l.$$

Here, $A = 0.31$, $\epsilon = 6200 \text{ M}^{-1} \text{ cm}^{-1}$, and $l = 1 \text{ cm}$. Substituting these values:

$$c = A / (\epsilon \times l) = 0.31 / (6200 \times 1) = 5 \times 10^{-5} \text{ M} = 50 \mu\text{M}.$$

Therefore, the concentration of NADH in the solution is **50 μM** .

Q.11 Among the reagents given below which one of the combination of reagents will NOT break the disulphide bonds in the immunoglobulin molecules?

- (P) Reduced glutathione
(Q) Dithiothreitol
(R) Sodium dodecyl sulphate
(S) Methionine

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

(2018)

Answer: (A) R&S

Explanation: Disulfide bonds in immunoglobulin molecules are covalent linkages between cysteine residues and breaking them requires reducing agents. **Reduced glutathione (P)** and **dithiothreitol (Q)** are strong reducing agents that can cleave these bonds. **Sodium dodecyl sulfate (R)** is a detergent that denatures proteins but does not reduce disulfide bonds, and **methionine (S)** is an amino acid with no reducing capability. Therefore, the combination of reagents that will NOT break disulfide bonds is **R and S**.

Q.12 Match the protein elution condition given in Group I with the appropriate chromatography matrices from Group II.

	Group I		Group II
P	Increasing concentration of sodium chloride	i	Phenyl-Sepharose
Q	Increasing concentration of histidine	ii	Chromatofocusing
R	Decreasing concentration of ammonium sulphate	iii	DEAE-Sephacryl
S	Decreasing concentration of H^+	iv	Ni-NTA

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

(2018)

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

Explanation: The correct matching is based on the principle behind each chromatography technique and its elution condition. In ion-exchange chromatography using DEAE-Sephacryl, proteins are eluted by **increasing sodium chloride concentration**, which competes with bound proteins for charged sites. In affinity chromatography with Ni-NTA, **increasing histidine concentration** displaces His-tagged proteins from nickel ions. Hydrophobic interaction chromatography with Phenyl-Sepharose relies on high salt for binding, so proteins are eluted by **decreasing ammonium sulfate concentration**, reducing hydrophobic interactions. Chromatofocusing separates proteins by

isoelectric point, achieved by **decreasing H^+ concentration** (raising pH) to gradually change protein charge. Therefore, the correct combination is **P-iii; Q-iv; R-i; S-ii**.

Q.13 Which one of the following is NOT a neurotransmitter?

- (A) Adrenaline
(B) Glutamate
(C) Histamine
(D) Histidine

(2018)

Answer: (D) Histidine

Explanation: **Histidine** is a naturally occurring essential amino acid, which, while metabolically important and serving as the precursor for other molecules, is not itself a primary neurotransmitter. In contrast, **Adrenaline** (also known as Epinephrine) is a catecholamine that functions as both a hormone and a neurotransmitter in the central nervous system. **Glutamate** is the principal excitatory neurotransmitter in the vertebrate nervous system, crucial for learning and memory. Similarly, **Histamine** is a biogenic amine derived from Histidine, and it acts as a neuromodulator in the central nervous system, in addition to its well-known roles in allergic reactions. The amino acid Histidine is the precursor, but it is the decarboxylated product, Histamine, that functions as the neurotransmitter.

Q.14 The type-II hypersensitivity reaction is mainly mediated by

- (A) IgE
(B) IgM
(C) IgA
(D) T cells

(2018)

Answer: (B) IgM

Explanation: Type-II hypersensitivity reactions are **antibody-mediated cytotoxic reactions**, where antibodies bind to antigens on cell surfaces, leading to cell destruction via complement activation or antibody-dependent cellular cytotoxicity. The main antibodies involved are **IgG and IgM**, with IgM being particularly important in initiating the classical complement pathway. IgE is associated with Type-I hypersensitivity (allergic reactions), IgA is mainly for mucosal immunity, and T cells mediate Type-IV hypersensitivity (delayed-type).

Q.15 Which one the following reaction mechanisms drives the conversion of low energy 3-phosphoglyceraldehyde to high energy 1,3-bisphosphoglycerate?

- (A) Oxidation without anhydride bond formation
(B) Oxidation coupled with anhydride bond formation
(C) Substrate level phosphorylation
(D) Formation of carboxylate

(2018)

Answer: (B) Oxidation coupled with anhydride bond formation

Explanation: The conversion of 3-phosphoglyceraldehyde (also called glyceraldehyde-3-phosphate) to 1,3-bisphosphoglycerate in glycolysis is driven by **oxidation coupled with anhydride bond formation**. In this step, the aldehyde group of glyceraldehyde-3-phosphate is oxidized to a carboxylic acid derivative while simultaneously forming a high-energy acyl phosphate bond. This reaction is catalyzed by **glyceraldehyde-3-phosphate dehydrogenase** and uses inorganic phosphate and NAD^+ as cofactors, producing NADH. The formation of the acyl phosphate (anhydride bond) stores energy, which is later used for ATP synthesis in the next step of glycolysis.

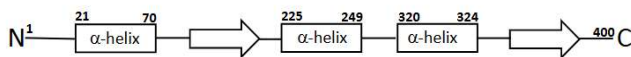
Q.16 A polymerase reaction is carried out for 10 cycles in a volume of 1 ml with 5 molecules of template DNA. Assuming that the efficiency of the reaction is 100%, the number of molecules of DNA present in 100 μl at the end of the reaction is _____(correct to integer number).

(2018)

Answer: 512

Explanation: PCR amplification follows an exponential pattern because each cycle doubles the number of DNA molecules from the previous cycle. Starting with 5 template molecules and assuming 100% efficiency, after 10 cycles the total becomes $5 \times 2^{10} = 5120$. Since the question asks for the amount in 100 μl , which is one-tenth of the total volume, the number of molecules is $5120/10 = 512$. This exponential growth occurs because the newly synthesized DNA strands serve as templates in subsequent cycles, and efficiency determines how close the actual yield is to this theoretical maximum.

Q.17 The secondary structure topology diagram of 400 amino acid long "Protein-X" is depicted in the figure. The start and end amino acid residue numbers of each α -helix are marked. The percentage (correct to integer number) of residues forming α -helix is _____



(2018)

Answer: 20

Explanation: Protein-X contains three α -helical segments spanning residues 21–70, 225–249, and 320–324, which correspond to 50, 25, and 5 residues respectively, giving a total of 80 residues in α -helices. Since the protein is 400 amino acids long, the percentage of residues forming α -helices is calculated as $(80 \div 400) \times 100 = 20\%$.

$20\% (80 \div 400) \times 100 = 20\%$. Thus, 20% of the protein adopts an α -helical secondary structure.

Q.18 An enzyme follows Michaelis-Menten kinetics with substrate S. The fraction of the maximum velocity (V_{max}) will be observed with the substrate concentration $[\text{S}] = 4K_m$ is ____ (correct to one decimal place). (K_m is Michaelis-Menten constant)

(2018)

Answer: 0.8

Explanation: This problem is a direct application of the **Michaelis-Menten equation**, which relates the initial reaction velocity to the maximum velocity, the substrate concentration, and the Michaelis constant: $V = \frac{V_{\text{max}}[\text{S}]}{K_m + [\text{S}]}$. We are asked to find the fraction of the maximum velocity, which is the ratio V/V_{max} , when the substrate concentration is equal to $4K_m$. Substituting into the equation yields: $V/V_{\text{max}} = \frac{[\text{S}]}{K_m + [\text{S}]}$. Canceling out, the fraction is $\frac{4K_m}{K_m + 4K_m} = \frac{4}{5} = 0.8$. Thus, at a substrate concentration four times the K_m , the enzyme will exhibit 80% of its maximum possible reaction rate.

Q.19 The mass spectrum of benzoic acid will generate the fragment as a base peak (100% relative abundance) of m/z (mass to charge ratio) at (correct to integer number).

(2018)

Answer: 77

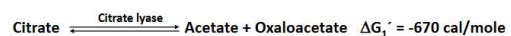
Explanation: The base peak in the mass spectrum of benzoic acid corresponds to the most stable fragment formed during fragmentation. Benzoic acid ($\text{C}_6\text{H}_5\text{COOH}$) undergoes cleavage to produce the **benzyl cation** (C_6H_5^+) or phenyl cation, which is highly stable due to aromaticity. The mass of this fragment is:

$$m/z = \text{mass of } \text{C}_6\text{H}_5 = (6 \times 12) + (5 \times 1) = 72 + 5 = 77$$

$$m/z = \text{mass of } \text{C}_6\text{H}_5 = (6 \times 12) + (5 \times 1) = 72 + 5 = 77$$

Since the charge is +1, $m/z = 77$. This fragment is the most abundant and appears as the base peak (100% relative abundance) in the spectrum.

Q.20 The standard free energy (ΔG) values of reactions catalyzed by citrate lyase and citrate synthetase are -670 and -8192 cal/mol respectively. The standard free energy (in cal/mol) of acetyl-CoA hydrolysis is (correct to integer number).



(2018)

Answer: -8862

Explanation: The standard free energy of acetyl-CoA hydrolysis is calculated by combining the free energy changes of the citrate synthase and citrate lyase reactions. Citrate synthase catalyzes the formation of citrate from acetyl-CoA and oxaloacetate with $\Delta G^\circ = -8192 \text{ cal/mol}$, while citrate lyase breaks citrate into acetate and oxaloacetate with $\Delta G^\circ = -670 \text{ cal/mol}$. Adding these values gives the free energy for acetyl-CoA hydrolysis: $-8192 + (-670) = -8862 \text{ cal/mol}$. This highly negative value indicates that acetyl-CoA hydrolysis is strongly exergonic, providing the energy needed to drive biosynthetic reactions such as citrate formation in the citric acid cycle.

Q.1 Which of the following genera produces dimorphic seeds that help to broaden the time of germination in a variable habitat?

- (A) Xanthium
- (B) Pisum
- (C) Mangifera
- (D) Linum

(2018)

Answer: (A) Xanthium

Explanation: Xanthium is known to produce dimorphic seeds, meaning it produces two distinct types of seeds that differ in size, dormancy, or germination timing. This adaptation allows the species to survive in variable habitats by spreading germination over time, increasing the chances of successful seedling establishment under unpredictable environmental conditions. One seed type often germinates immediately under favorable conditions, while the other remains dormant for an extended period. In contrast, genera like Pisum, Mangifera, and Linum generally produce homomorphic seeds that germinate under similar conditions. Therefore, the production of dimorphic seeds in Xanthium represents an evolutionary strategy to enhance population persistence and ecological flexibility.

Q.2 The genes for microRNA (miRNA) in plants are usually transcribed by

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

(2018)

Answer: (B) RNA polymerase II

Explanation: In plants, microRNA (miRNA) genes are primarily transcribed by RNA polymerase II. This polymerase synthesizes precursor miRNAs as primary transcripts (pri-miRNAs) that have a 5' cap and 3' poly-A tail, similar to mRNAs. These pri-miRNAs are processed by Dicer-like enzymes to produce mature miRNAs, which play a regulatory role in post-transcriptional gene silencing. RNA polymerase I mainly transcribes rRNA, while RNA polymerase III

transcribes tRNAs and some small RNAs. RNA polymerase IV is plant-specific and involved in siRNA pathways, not miRNA biogenesis. Hence, RNA polymerase II is essential for proper miRNA transcription and regulation in plants.

Q.3 Which of the statements is TRUE for transposable elements Ac and Ds?

- (A) Both Ac and Ds are autonomous because they encode their own transposase
- (B) Both Ac and Ds are non-autonomous because they do not encode their own transposase
- (C) Only Ac is autonomous because it encodes its own transposase
- (D) Only Ds is autonomous because it encodes its own transposase

(2018)

Answer: (C) Only Ac is autonomous because it encodes its own transposase

Explanation: Ac (Activator) and Ds (Dissociator) are well-studied transposable elements in maize. Ac is autonomous because it carries a functional transposase gene, allowing it to move independently within the genome. Ds elements are non-autonomous; they cannot encode transposase on their own and require the presence of Ac for mobilization. This distinction is fundamental in studying gene regulation, mutation, and genome dynamics in plants. The autonomous nature of Ac allows geneticists to manipulate Ds movement for insertional mutagenesis experiments. Therefore, the correct statement is that only Ac is autonomous, while Ds depends on Ac.

Q.4 Identify the CORRECT statement.

- (A) Receptor-like kinases play role in gametophytic self-incompatibility in Brassicaceae
- (B) Receptor-like kinases play role in sporophytic self-incompatibility in Solanaceae
- (C) Ribonucleases play role in sporophytic self-incompatibility in Brassicaceae
- (D) Ribonucleases play role in gametophytic self-incompatibility in Solanaceae

(2018)

Answer: (D) Ribonucleases play role in gametophytic self-incompatibility in Solanaceae

Explanation: Gametophytic self-incompatibility (GSI) in the Solanaceae family is controlled by S-RNases, ribonucleases that degrade RNA of incompatible pollen. In this system, the haploid genotype of the pollen determines whether it is compatible with the diploid genotype of the pistil. Receptor-like kinases, on the other hand, mediate sporophytic self-incompatibility in Brassicaceae, not in Solanaceae. Ribonucleases act as a molecular barrier preventing self-fertilization, thus promoting outcrossing and genetic diversity. Therefore, the role of ribonucleases in GSI is crucial for reproductive isolation and evolutionary fitness in Solanaceae plants.

Q.5 Which of the following statements is TRUE for an ecotone?

- (A) An ecotone is the synonym of an ecosystem
- (B) An ecotone is an interface zone of two or more ecosystems
- (C) An ecotone is a special feature of land biomes
- (D) An ecotone is exclusively characterized by decreased biodiversity

(2018)

Answer: (B) An ecotone is an interface zone of two or more ecosystems

Explanation: An ecotone is a transitional zone between two or more distinct ecosystems, characterized by species from both ecosystems and often by unique species adapted to intermediate conditions. It is not synonymous with an ecosystem, as it represents a boundary rather than a full, independent ecological unit. Ecotones generally exhibit higher species richness due to the overlapping biota, known as the edge effect, rather than decreased biodiversity. Examples include the transition between forest and grassland or riverbanks merging with terrestrial landscapes. This interface plays a vital ecological role in nutrient cycling, species migration, and environmental buffering, distinguishing it from core ecosystems.

Q.6 Acid rain with a pH of 4.0 is more acidic than the rain with a pH of 6.0 by

- (A) 2 times
- (B) 10 times
- (C) 100 times
- (D) 1000 times

(2018)

Answer: (C) 100 times

Explanation: The acidity of a solution is measured on the pH scale, which is logarithmic. Each unit decrease in pH represents a tenfold increase in hydrogen ion concentration ($[H^+]$). Therefore, rain with a pH of 4.0 has $10^{(6-4)} = 10^2 = 100$ times higher acidity than rain with a pH of 6.0. This exponential difference explains why seemingly small changes in pH can have large environmental effects, including damage to aquatic ecosystems, soil chemistry alterations, and plant toxicity. Acid rain is a serious ecological problem resulting from industrial emissions of sulfur dioxide and nitrogen oxides.

Q.7 Which of the following plants produces Ylang-ylang oil?

- (A) *Cananga odorata*
- (B) *Carcum copticum*
- (C) *Pandanus odoratissimus*
- (D) *Pimenta racemosa*

(2018)

Answer: (A) *Cananga odorata*

Explanation: Ylang-ylang oil is an essential oil obtained from the flowers of *Cananga odorata*, a tropical tree belonging to the Annonaceae family. The oil is widely used in perfumery, aromatherapy, and cosmetics due to its sweet, floral fragrance. Other options like *Carcum copticum*, *Pandanus odoratissimus*, and *Pimenta racemosa* produce different aromatic compounds and oils, such as ajwain oil, pandan oil, and bay rum oil, respectively. The extraction of Ylang-ylang oil is typically done by steam distillation, which preserves its delicate aroma. Thus, *Cananga odorata* is the correct source of this commercially valuable oil.

Q.8 Identify the INCORRECT statement in connection with polar transport of auxin.

- (A) The putative influx carrier AUX1 is a cytosolic protein
- (B) Polar auxin transport in root tends to be both acropetal and basipetal in direction
- (C) Naphthylphthalamic acid (NPA) is an inhibitor of polar auxin transport
- (D) AUX1 and PIN1 proteins are located in the opposite ends of a cell for polar transport

(2018)

Answer: (A) The putative influx carrier AUX1 is a cytosolic protein

Explanation: AUX1 is a plasma membrane-localized influx carrier responsible for the polar transport of auxin into plant cells. Being membrane-associated allows it to facilitate directional auxin movement, crucial for developmental processes like root gravitropism and organogenesis. The statement that AUX1 is cytosolic is incorrect because cytosolic proteins cannot mediate directional transport across membranes. Polar auxin transport is bidirectional (acropetal and basipetal) in roots, and PIN proteins work at opposite ends of cells to maintain auxin gradients. Inhibitors like NPA can block this transport, demonstrating the essential role of proper localization of transport proteins.

Q.9 Which of the following stains is used to visualize callose under the microscope?

- (A) Alcian blue
- (B) Aniline blue
- (C) Toluidine blue
- (D) Thymol blue

(2018)

Answer: (B) Aniline blue

Explanation: Callose, a β -1,3-glucan polymer, is commonly deposited at sites of cell wall stress, plasmodesmata, or during pollen tube formation. Aniline blue specifically binds to β -1,3-glucans and fluoresces under UV light, making it ideal for visualizing callose in microscopy studies. Other dyes like Alcian blue, Toluidine blue, and Thymol blue are used for different purposes, such as staining acidic polysaccharides, nucleic acids, or pH indicators, respectively. Aniline blue has become a standard tool in plant developmental biology and

pathology for detecting callose deposition. Its specificity allows researchers to monitor cell wall responses to environmental or developmental cues accurately.

Q.10 The coding sequence of a gene XLR18 has the single ORF of 783 bp. The approximate molecular weight of the XLR18 protein in kDa is _____.

(2018)

Answer: 28.00 – 31.00

Explanation: The molecular weight of a protein can be estimated using the coding sequence length. A single open reading frame (ORF) of 783 bp translates to 261 amino acids (since 3 bp encode one amino acid). The average molecular weight of an amino acid is approximately 110 Da, so the estimated molecular weight of XLR18 protein = $261 \times 110 = 28,710 \text{ Da} \approx 28.7 \text{ kDa}$. Minor variations may arise due to post-translational modifications or rounding in estimation. This calculation method provides a reliable approximation of protein size for experimental planning in molecular biology.

Q.11 Statements given below are either TRUE (T) or FALSE (F). Select the CORRECT combination.

P. Mitosis occurs exclusively in diploid mother cell
Q. Mitosis occurs both in diploid and haploid mother cells
R. Meiosis occurs exclusively in diploid mother cell
S. Meiosis occurs both in diploid and haploid mother cells

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

(2018)

Answer: (D) P-F, Q-T, R-T, S-F

Explanation: Mitosis occurs in both haploid and diploid cells to produce genetically identical daughter cells, so statement P is false, and Q is true. Meiosis, however, occurs exclusively in diploid cells to produce haploid gametes, making R true and S false. Mitosis ensures growth, repair, and vegetative propagation, while meiosis introduces genetic variation through recombination and reduction of chromosome number. These distinctions are fundamental in understanding cell division and reproductive strategies across organisms. Correct identification of true and false statements is critical in cytogenetics and plant breeding studies.

Q.12 You are asked to design a genetic construct for high-level expression of a gene encoding the therapeutic protein 18 (TP18) via plastid transformation. Select the CORRECT set of genetic elements for this construct.

- (A) Actin1 promoter → TP18 coding sequence → Actin1 transcription terminator
- (B) Ubiquitin1 promoter → TP18 coding sequence →

Ubiquitin1 transcription terminator

- (C) rbcS promoter → TP18 coding sequence → rbcS transcription terminator
- (D) rbcL promoter → TP18 coding sequence → rbcL transcription terminator

(2018)

Answer: (D) rbcL promoter → TP18 coding sequence → rbcL transcription terminator

Explanation: Plastid transformation requires promoters and terminators compatible with plastid gene expression machinery. The rbcL promoter is derived from the plastid-encoded ribulose-1,5-bisphosphate carboxylase/oxygenase large subunit gene and drives strong, constitutive expression in plastids. Nuclear promoters like Actin1, Ubiquitin1, or rbcS are generally ineffective in plastids due to differences in transcriptional regulation. Using the rbcL promoter and terminator ensures high-level expression of TP18 in plastids for therapeutic protein production. This strategy exploits plastids' polyploidy, protein-folding environment, and containment advantages.

Q.13 Select the CORRECT combination of the following statements.

P. The cyclic electron transport chain involving PSI results in net production of both ATP and NADPH
Q. The cyclic electron transport chain involving PSI results in net production of ATP
R. Rubisco enzyme usually converts RuBP and CO₂ into 2-phosphoglycolate and 3-phosphoglycerate
S. Rubisco enzyme usually converts RuBP and O₂ into 2-phosphoglycolate and 3-phosphoglycerate

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

(2018)

Answer: (C) Q, S

Explanation: The cyclic electron transport (CET) involving photosystem I (PSI) produces ATP without generating NADPH, which is required to balance the ATP/NADPH ratio for the Calvin cycle. Linear electron transport produces both ATP and NADPH. Rubisco, the key enzyme in photorespiration, catalyzes the reaction between RuBP and O₂ to form one molecule of 2-phosphoglycolate and one molecule of 3-phosphoglycerate, leading to energy loss. Hence, the correct combination of statements includes Q (ATP production in cyclic PSI) and S (Rubisco activity producing 2-phosphoglycolate and 3-phosphoglycerate). Understanding these pathways is essential in plant physiology and photosynthetic efficiency studies.

Q.14 Match the fruit characters with their families and representative plant species.

Fruit character	Family	Plant species
P. Syconus	1. Moraceae	i. <i>Canavalia ensiformis</i>
Q. Capsule, opening by apical pores or valves	2. Fabaceae	ii. <i>Artabotrys odoratissimus</i>
R. Legume	3. Papaveraceae	iii. <i>Ficus religiosa</i>
S. An etaerio of drupe	4. Annonaceae	iv. <i>Papaver somniferum</i>
		v. <i>Pistacia vera</i>
		vi. <i>Citrus aurantium</i>

- (A) P-2-iv, Q-3-ii, R-1-vi, S-4-v
 (B) P-1-iii, Q-3-iv, R-2-i, S-4-ii
 (C) P-3-i, Q-2-iii, R-4-ii, S-1-vi
 (D) P-4-v, Q-1-ii, R-2-v, S-3-i

(2018)

Answer: (B) P-1-iii, Q-3-iv, R-2-i, S-4-ii

Explanation: The syconus fruit is a specialized fleshy inflorescence found in *Ficus religiosa* (Moraceae), matching P-1-iii. The capsule opening by apical pores or valves is characteristic of Papaveraceae, e.g., *Papaver somniferum*, corresponding to Q-3-iv. Legumes, which split along two sutures, are typical of Fabaceae, with *Canavalia ensiformis* as an example (R-2-i). An arillate drupe is seen in Annonaceae, e.g., *Artabotrys odoratissimus* (S-4-ii). Correctly matching fruit types, families, and species demonstrates the diversity of plant reproductive adaptations and aids in plant identification.

Q.15 Select the CORRECT combination by matching the disease, affected plant and the causal organism.

Disease	Affected plant	Causal organism
P. Black rot	1. Corn	i. <i>Fusarium oxysporum</i> f.sp. <i>cubense</i>
Q. Loose smut	2. Banana	ii. <i>Acidovorax avenae</i> subsp. <i>citrulli</i>
R. Panama wilt	3. Watermelon	iii. <i>Botryosphaeria obtusa</i>
S. Bacterial fruit blotch	4. Apple	iv. <i>Ustilago maydis</i>
		v. <i>Plasmopara viticola</i>
		vi. <i>Venturia inaequalis</i>

- (A) P-2-v, Q-1-iv, R-3-iii, S-4-vi
 (B) P-2-ii, Q-1-i, R-4-iii, S-3-i
 (C) P-4-iii, Q-1-iv, R-2-i, S-3-ii
 (D) P-4-vi, Q-1-iv, R-2-i, S-3-ii

(2018)

Answer: (C) P-4-iii, Q-1-iv, R-2-i, S-3-ii

Explanation: Black rot affects apple and is caused by *Botryosphaeria obtusa* (P-4-iii). Loose smut affects corn, caused by *Ustilago maydis* (Q-1-iv). Panama wilt affects banana and is caused by *Fusarium oxysporum* f.sp. *cubense* (R-2-i). Bacterial fruit blotch occurs in watermelon, caused by *Acidovorax avenae* subsp. *citrulli* (S-3-ii). Correct disease identification with host and pathogen is crucial in plant pathology for disease management. Misidentification can lead to ineffective control measures and crop loss.

Q.16 Select the CORRECT combination by matching Group-I with Group-II.

Group-I	Group-II
P. Photorespiration	1. Glutamate → 2-Oxoglutarate
Q. Respiration	2. Acetyl-CoA → Malonyl-CoA
R. Amino acid degradation	3. 2-Oxoglutarate → Succinyl-CoA
S. Fatty acid synthesis	4. Glycine → Serine
(A) P-1, Q-2, R-3, S-4	
(B) P-2, Q-1, R-4, S-1	
(C) P-3, Q-4, R-2, S-3	
(D) P-4, Q-3, R-1, S-2	

(2018)

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

Explanation: Photorespiration involves the conversion of glycine to serine in mitochondria (P-4). Respiration of amino acids often converts 2-oxoglutarate to succinyl-CoA in the TCA cycle (Q-3). Amino acid degradation, such as glutamate breakdown, produces 2-oxoglutarate (R-1). Fatty acid synthesis starts from acetyl-CoA conversion to malonyl-CoA (S-2). Matching these metabolic pathways with their specific reactions provides clarity in plant biochemistry and energy metabolism, showing the integration of carbon and nitrogen flux in cells.

Q.17 Match the plant alkaloids with their uses and source species.

Alkaloid	Use	Source species
P. Codeine	1. Stimulant	i. <i>Hyoscyamus niger</i>
Q. Caffeine	2. Analgesic	ii. <i>Catharanthus roseus</i>
R. Scopolamine	3. Antineoplastic	iii. <i>Cola nitida</i>
S. Vinblastine	4. Anticholinergic	iv. <i>Papaver somniferum</i>
		v. <i>Coptis japonica</i>
		vi. <i>Senecio jacobaea</i>

- (A) P-2-iv, Q-1-iii, R-4-i, S-3-ii
 (B) P-4-iii, Q-2-v, R-1-vi, S-3-i
 (C) P-2-v, Q-1-vi, R-3-iv, S-4-ii
 (D) P-3-ii, Q-4-iii, R-1-iv, S-2-i

(2018)

Answer: (A) P-2-iv, Q-1-iii, R-4-i, S-3-ii

Explanation: Codeine, an analgesic, is derived from *Papaver somniferum* (P-2-iv). Caffeine, a stimulant, is obtained from *Cola nitida* (Q-1-iii). Scopolamine, an anticholinergic, comes from *Hyoscyamus niger* (R-4-i). Vinblastine, an antineoplastic agent, is extracted from *Catharanthus roseus* (S-3-ii). This matching emphasizes the medicinal importance of plant secondary metabolites and guides pharmacological applications. Understanding sources, uses, and chemical nature of alkaloids is fundamental for drug development and plant biotechnology.

Q.18 Identify the CORRECT combination of statements with respect to chemical defense in plants. P. Pisatin, a phytoalexin produced by *Ricinus communis* is a constitutive defense compound Q. *Phaseolus vulgaris* produces *Phaseolus agglutinin* I, which is toxic to the cowpea weevil R. A single step non-enzymatic hydrolysis of

cyanogenic glycoside releases the toxic hydrocyanic acid (HCN) to protect plant against herbivores and pathogens

S. Avenacin, a triterpenoid saponin from oat prevents infection by *Gaeumannomyces graminis*, a major pathogen of cereal roots

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

(2018)

Answer: (B) Q, S

Explanation: *Phaseolus vulgaris* produces *Phaseolus agglutinin I*, a lectin toxic to herbivores like cowpea weevil, acting as a chemical defense (Q). Avenacin, a triterpenoid saponin in oat roots, prevents infection by *Gaeumannomyces graminis*, a root pathogen, exemplifying chemical defense against pathogens (S). Pisatin is a phytoalexin, but its production is inducible rather than constitutive, making P incorrect. Cyanogenic glycosides require enzymatic hydrolysis, so R is partially incorrect. Chemical defenses like these are essential for plant survival, providing protection against herbivory and microbial attack.

Q.19 In garden pea, dwarf plants with terminal flowers are recessive to tall plants with axial flowers. A true-breeding tall plant with axial flowers was crossed with a true-breeding dwarf plant with terminal flowers. The resulting F1 plants were testcrossed, and the following progeny were obtained: Tall plants with axial flowers = 320 Dwarf plants with terminal flowers = 318 Tall plants with terminal flowers = 79 Dwarf plants with axial flowers = 83 The map distance between the genes for plant height and flower position is ____ cM.

(2018)

Answer: 20.25

Explanation: To calculate map distance, recombinant frequency = (number of recombinant progeny / total progeny) × 100. Recombinants = Tall-terminal (79) + Dwarf-axial (83) = 162. Total progeny = 320 + 318 + 79 + 83 = 800. Map distance = (162/800) × 100 = 20.25 cM. This indicates that the genes for plant height and flower position are linked and separated by 20.25 centimorgans on the chromosome. Linkage analysis provides insight into gene arrangement, inheritance patterns, and facilitates marker-assisted selection in breeding programs.

Q.20 Two true-breeding snapdragon (*Antirrhinum majus*) plants, one with red flowers and another with white flowers were crossed. The F1 plants were all with pink flowers. When the F1 plants were selfed, they produced three kinds of F2 plants with red, pink

and white flowers in a 1:2:1 ratio. The probability that out of the five plants picked up randomly, two would be with pink flowers, two with white flowers and one with red flowers is ____% (up to one decimal point).

(2018)

Answer: 11.00 – 12.00

Explanation: In the F2 generation of snapdragon, red: pink: white = 1:2:1. Probability of selecting 2 pinks, 2 white, 1 red out of 5 = $[5! / (2!2!1!)] \times (1/4)^1 \times (1/2)^2 \times (1/4)^2 = 30 \times (1/4) \times (1/4) \times (1/16) = 0.114 \approx 11.4\%$. This calculation uses multinomial probability, considering all combinations of selection. It demonstrates incomplete dominance, where heterozygotes show intermediate phenotype. Such probability computations are important in genetics for predicting phenotypic ratios in offspring.

Q.1 David Baltimore's classification of viruses is based on differences in

- (A) host cell receptors used by viruses
- (B) the pathways required to synthesize virus mRNA
- (C) the modes of transmission of viruses
- (D) the envelope proteins on the surface of viruses

(2018)

Answer: (B) the pathways required to synthesize virus mRNA

Explanation: The **Baltimore classification system** categorizes viruses primarily based on the nature of their **genome** (DNA or RNA, single-stranded or double-stranded) and, most critically, the **pathway** they use to produce **messenger RNA (mRNA)**. This method defines seven different classes of viruses, from double-stranded DNA viruses (Class I) to single-stranded RNA viruses that replicate via a DNA intermediate (Class VII). The classification is fundamentally concerned with how the virus achieves **gene expression** to synthesize its proteins and replicate, making the **mRNA synthesis route** the central criterion. This focus reflects the universal need for all viruses to generate host-translatable mRNA to complete their life cycle, regardless of their diverse genomic starting material.

Q.2 Which of the following immune system components can function as an opsonin?

- (A) Antibodies
- (B) T-cell receptors
- (C) Histamines
- (D) Interferons

(2018)

Answer: (A) Antibodies

Explanation: **Opsonins** are molecules that enhance **phagocytosis**

by coating an antigen or microbe, thereby making it more susceptible to ingestion by phagocytic cells like macrophages and neutrophils. **Antibodies**, specifically the IgG class, are a major type of opsonin; their **Fc region** (Fragment crystallizable) binds to the **Fc receptors** on the surface of phagocytes, effectively linking the microbe to the immune cell. Another key class of opsonins includes complement components, particularly **C3b**. This coating process, called **opsonization**, significantly speeds up the clearance of pathogens from the body, as phagocytes can more easily recognize and engulf the opsonized target compared to an uncoated one.

Q.3 The oral polio vaccine (OPV) consists of

- (A) live attenuated virus
- (B) killed virus
- (C) viral toxin
- (D) viral capsid subunit

(2018)

Answer: (A) live attenuated virus

Explanation: The **Oral Polio Vaccine (OPV)**, specifically the **Sabin vaccine**, is a **live attenuated vaccine**. This means it contains **weakened** forms of the poliovirus that are still alive but have been genetically altered (attenuated) so that they **cannot cause disease** in healthy individuals. The primary advantage of OPV is that it induces a robust **mucosal (IgA)** and systemic (IgG) immune response, mimicking a natural infection. Importantly, the attenuated virus can briefly replicate in the gut and be shed, thereby providing a form of **"herd immunity"** to the surrounding population through secondary exposure, though this shedding is a concern in areas with very low vaccination rates.

Q.4 Which of the following eukaryotic cellular components carries out intracellular degradation during autophagy?

- (A) Nucleus
- (B) Golgi bodies
- (C) Ribosomes
- (D) Lysosomes

(2018)

Answer: (D) Lysosomes

Explanation: The **lysosome** is the primary organelle responsible for carrying out **intracellular degradation** during **autophagy** (and other catabolic processes). Autophagy is a crucial cellular process where damaged organelles, aggregated proteins, or intracellular pathogens are **sequestered** within a double-membrane vesicle called an **autophagosome**. This autophagosome then **fuses** with a lysosome, forming an **autolysosome**. The lysosome contains a cocktail of potent hydrolytic **enzymes** (like proteases, nucleases, and lipases) that are activated by the acidic internal to break down the sequestered material into basic molecular components, which the cell can then recycle.

Q.5 Analysis of DNA sequences suggest that eukaryotic mitochondrial genomes primarily originated from

- (A) fungi
- (B) protozoa
- (C) algae
- (D) bacteria

(2018)

Answer: (D) bacteria

Explanation: The origin of mitochondria is explained by the **endosymbiotic theory**, which posits that an ancestral **eukaryotic cell** engulfed an **aerobic bacterium** over a billion years ago. This theory is strongly supported by the analysis of mitochondrial DNA (mtDNA) sequences. The **mitochondrial genome** is typically circular; much like a bacterial plasmid, and its genes show a far closer phylogenetic relationship to the genes of **Alpha-proteobacteria** than to the genes in the eukaryotic cell's nucleus. Furthermore, mitochondria possess their own **ribosomes** that resemble bacterial ribosomes in structure and sensitivity to certain antibiotics, solidifying the idea that they were once independent bacterial organisms.

Q.6 Binomial nomenclature has NOT yet been adopted for

- (A) bacteria
- (B) fungi
- (C) viruses
- (D) protozoa

(2018)

Answer: (C) viruses

Explanation: **Binomial nomenclature**, the system of giving organisms a two-part Latinized name (genus and species), is the standard practice for classifying **cellular life** (bacteria, fungi, protozoa, plants, and animals) as established by Carl Linnaeus. However, this system has **not been adopted for viruses**. Instead, viruses are classified by the **International Committee on Taxonomy of Viruses (ICTV)** into orders, families, genera, and species, but without the mandatory use of the Linnaean binomial format. Viruses are considered **acellular entities** and obligate intracellular parasites, making their classification based on their **genetic material** (Baltimore classification) and **morphology** often more practical than the traditional two-name system for organisms.

Q.7 Which of the following is NOT an accepted method for sterilization?

- (A) Autoclaving
- (B) X-rays
- (C) Gamma rays
- (D) UV rays

(2018)

Answer: (D) UV rays

Explanation: *Sterilization* is defined as the complete destruction or removal of all viable microorganisms, including bacterial spores. **UV rays** (ultraviolet radiation) are an excellent method for **surface disinfection** and treating air or water, but they are **not considered a reliable method for true sterilization**. This is because UV light has very **poor penetrating power**; any shadow, opaque material, or even a thin layer of organic matter will shield microbes from its destructive effect on DNA. In contrast, **autoclaving** (moist heat), **X-rays**, and **gamma rays** (ionizing radiation) are all highly effective, deeply penetrating, and therefore accepted methods for achieving complete sterilization

Q.8 The primary product of nitrogen fixation is

- (A) N_2
- (B) NH_4^+
- (C) NO_2^-
- (D) NO_3^-

(2018)

Answer: (B) NH_4^+

Explanation: The primary product of nitrogen fixation is ammonium (NH_4^+). Nitrogen fixation is a crucial biological process carried out by certain bacteria and archaea, often in symbiotic relationships with plants like legumes. These microorganisms use the enzyme nitrogenase to convert atmospheric nitrogen gas (N_2), which is inert and unusable by most living organisms, into ammonia (NH_3). In aqueous environments, ammonia readily combines with hydrogen ions to form ammonium (NH_4^+), which plants can absorb and utilize for synthesizing essential biomolecules like amino acids and nucleotides. This transformation is a vital part of the nitrogen cycle, ensuring that nitrogen is available in a form that supports plant growth and, by extension, the entire food web.

Q.9 In humans, the key stages in the life cycle of malarial parasites occur in

- (A) red blood cells and the liver
- (B) red blood cells and platelets
- (C) red blood cells and the pancreas
- (D) red blood cells and the gut

(2018)

Answer: (A) red blood cells and the liver

Explanation: The life cycle of the **malarial parasite** (*Plasmodium* species) in the human host involves two primary locations: the **liver** and the **red blood cells (RBCs)**. Initially, infectious **sporozoites** are injected by the mosquito and quickly travel to the **liver**, where they multiply asexually and develop into **merozoites** (the **exoerythrocytic cycle**). These merozoites are then released into the bloodstream and invade the **red blood cells** (the **erythrocytic cycle**), where they multiply again, leading to the characteristic cycles of fever and chills as the infected RBCs rupture. The parasite also differentiates into **gametocytes** in the RBCs, which are then taken up by the mosquito to complete the life cycle

Q.10 You have a 50 mg/mL stock solution of arginine. To prepare 1 liter of growth medium for an arginine auxotroph that requires 70 μ g/mL of arginine, the volume of this stock solution that should be added is _____ mL (up to 1 decimal point).

(2018)

Answer: 1.38 – 1.42

Explanation: To prepare 1 liter of growth medium containing 70 μ g/mL of arginine using a 50 mg/mL stock solution, you can use the dilution formula $C_1V_1 = C_2V_2$. First, convert the stock concentration to micrograms: 50 mg/mL = 50,000 μ g/mL. Then plug in the values: $(70 \mu\text{g/mL} \times 1000 \text{ mL}) \div 50,000 \mu\text{g/mL} = 1.4 \text{ mL}$. So, you need to add **1.4 mL** of the stock solution to the medium to achieve the desired concentration.

Q.11 Accumulating evidence suggest that Domain Archaea is more closely related to Domain Eukarya than to Domain Bacteria. Which of the following properties are shared between eukaryotes and archaea?

- (i) Protein biogenesis
 - (ii) Presence of sterol containing membranes
 - (iii) Ribosomal subunit structures
 - (iv) Adaptation to extreme environmental conditions
 - (v) Fatty acids with ester linkages in the cell membrane
- (A) (ii), (iii) and (v)
 - (B) (i), (ii), (iv), and (v)
 - (C) (i) and (iii)
 - (D) (iii) and (iv)

(2018)

Answer: (C) (i) and (iii)

Explanation: Accumulating evidence from molecular and genetic studies suggests that **Domain Archaea** is more closely related to **Domain Eukarya** than to **Domain Bacteria**. This is primarily due to similarities in **protein biogenesis** and **ribosomal subunit structures**. Both archaea and eukaryotes share similar mechanisms for synthesizing proteins, including the use of similar RNA polymerases and transcription factors. Additionally, the structure and function of their ribosomes are more alike compared to those of bacteria. However, other features like **sterol-containing membranes**, **adaptation to extreme environments**, and **fatty acids with ester linkages** are either unique to eukaryotes or not shared consistently with archaea, which often have **ether-linked lipids** instead. Therefore, the properties shared between eukaryotes and archaea are best represented by options **(i) and (iii)**.

Q.12 Match the antimicrobial agents in group I with their category/mode of action in group II.

Group I	Group II
(i) Fluoroquinolones	(p) beta lactam antimicrobial
(ii) Amphotericin B	(q) inhibition of protein synthesis
(iii) Tetracycline	(r) inhibition of nucleic acid synthesis
(iv) Amoxicillin	(s) antifungal agent

- (A) (i)-(q), (ii)-(s), (iii)-(r), (iv)-(p)
 (B) (i)-(s), (ii)-(r), (iii)-(p), (iv)-(q)
 (C) (i)-(r), (ii)-(s), (iii)-(q), (iv)-(p)
 (D) (i)-(s), (ii)-(r), (iii)-(q), (iv)-(p)

(2018)

Answer: (C) (i)-(r), (ii)-(s), (iii)-(q), (iv)-(p)

Explanation: This matching question connects specific antimicrobial agents with their known mechanisms of action. **(i) Fluoroquinolones** (such as ciprofloxacin) are a class of antibiotics that target bacterial **DNA gyrase and topoisomerase**, enzymes critical for DNA replication, and therefore their mode of action is **inhibition of nucleic acid synthesis (r)**. **(ii) Amphotericin B** is a polyene antifungal drug that binds to **ergosterol** in the fungal cell membrane, leading to pore formation and membrane permeability, classifying it as an **antifungal agent (s)**. **(iii) Tetracycline** antibiotics bind to the **30S subunit of the bacterial ribosome**, preventing the binding of charged transfer RNA, which results in the **inhibition of protein synthesis (q)**. Finally, **(iv) Amoxicillin** is a common antibiotic belonging to the penicillin family, which are characterized by a **beta-lactam ring** and act by inhibiting bacterial cell wall synthesis, thus categorized as a **Beta lactam antimicrobial (p)**

Q.13 Match the microorganisms to their predominant modes of transmission.

Microorganism	Mode of Transmission
(i) <i>Bordetella pertussis</i>	(p) Vector-borne
(ii) Dengue virus	(q) Blood-borne
(iii) <i>Entamoeba histolytica</i>	(r) Droplet infection
(iv) Hepatitis B virus	(s) Contaminated food

- (A) (i)-(r), (ii)-(p), (iii)-(s), (iv)-(q)
 (B) (i)-(s), (ii)-(q), (iii)-(p), (iv)-(r)
 (C) (i)-(q), (ii)-(p), (iii)-(s), (iv)-(r)
 (D) (i)-(s), (ii)-(r), (iii)-(p), (iv)-(q)

(2018)

Answer: (A) (i)-(r), (ii)-(p), (iii)-(s), (iv)-(q)

Explanation: The mode of transmission is a key characteristic for understanding and controlling infectious diseases. **(i) Bordetella pertussis**, the bacterium causing **whooping cough**, is a highly contagious respiratory pathogen typically spread through **droplets (r)** released during coughing or sneezing. **(ii) Dengue virus** is primarily transmitted by the bite of infected *Aedes* mosquitoes, making its mode of transmission **vector-borne (p)**. **(iii) Entamoeba histolytica**, the protozoan that causes amoebiasis, is transmitted through the fecal-oral route, usually via the ingestion of cysts in **contaminated food or water (s)**. Lastly, **(iv) Hepatitis B virus (HBV)** is a major blood-borne pathogen that can be spread through contact with infected **blood (q)** or other bodily fluids, such as via unprotected sex, shared needles, or from mother to child during birth

Q.14 Match the precursors/intermediates with the corresponding metabolic pathways.

Precursor/Intermediates	Metabolic pathway
(i) Inosine monophosphate	(p) L-methionine biosynthesis
(ii) Ornithine	(q) L-tryptophan biosynthesis
(iii) Chorismate	(r) Purine biosynthesis
(iv) Homocysteine	(s) L-arginine biosynthesis

- (A) (i)-(q), (ii)-(r), (iii)-(s), (iv)-(p)
 (B) (i)-(p), (ii)-(r), (iii)-(s), (iv)-(q)
 (C) (i)-(r), (ii)-(p), (iii)-(s), (iv)-(q)
 (D) (i)-(r), (ii)-(s), (iii)-(q), (iv)-(p)

(2018)

Answer: (D) (i)-(r), (ii)-(s), (iii)-(q), (iv)-(p)

Explanation: This question matches specific biochemical intermediates to the metabolic pathways in which they are key components. **(i) Inosine monophosphate (IMP)** is a critical branch point intermediate in the **purine biosynthesis (r)** pathway, serving as the immediate precursor for the formation of both adenosine monophosphate (AMP) and guanosine monophosphate (GMP). **(ii) Ornithine** is a non-proteinogenic amino acid that is a central intermediate in the **urea cycle** and in the biosynthesis of **L-arginine (s)**, where it is converted to citrulline. **(iii) Chorismate** is a crucial, multi-branch point intermediate formed by the shikimate pathway, serving as the common precursor for the biosynthesis of the aromatic amino acids, including **L-tryptophan (q)**, phenylalanine, and tyrosine. Finally, **(iv) Homocysteine** is an intermediate in the metabolism of the amino acid **L-methionine (p)**, where it is either converted back to methionine via the methionine cycle or directed into the transsulfuration pathway

Q.15 Match the scientists to their area of major contribution.

Scientists	Area of major contribution
(i) Antonie van Leeuwenhoek	(p) Taxonomy
(ii) Carl Linnaeus	(q) Antimicrobial agents
(iii) Sir Alexander Fleming	(r) Vaccination
(iv) Louis Pasteur	(s) Microscopy

- (A) (i)-(s), (ii)-(q), (iii)-(p), (iv)-(r)
 (B) (i)-(s), (ii)-(p), (iii)-(q), (iv)-(r)
 (C) (i)-(p), (ii)-(s), (iii)-(r), (iv)-(q)
 (D) (i)-(q), (ii)-(p), (iii)-(r), (iv)-(s)

(2018)

Answer: (B) (i)-(s), (ii)-(p), (iii)-(q), (iv)-(r)

Explanation: This match highlights four seminal figures in the history of science, particularly microbiology and biology. **(i) Antonie van Leeuwenhoek** is often called the "Father of Microbiology" for his pioneering work in **microscopy (s)**; he was the first to observe and accurately describe single-celled organisms, which he called "animalcules," using his simple, powerful single-lens microscopes. **(ii) Carl Linnaeus** is the Swedish botanist who formalized the modern

system of naming organisms, known as binomial nomenclature, establishing his major contribution as **Taxonomy (p)**. (iii) **Sir Alexander Fleming** is credited with the serendipitous discovery of **Penicillin** from the mold *Penicillium notatum*, a groundbreaking finding in the field of **antimicrobial agents (q)**. (iv) **Louis Pasteur** made numerous vital contributions, including disproving spontaneous generation and developing the process of pasteurization, but his major contribution listed here is the development of several early vaccines, solidifying his role in **Vaccination (r)**

Q.16 Which of the following combinations would improve the resolution of a microscope?

- (i) Increasing the half aperture angle of the objective lens
- (ii) Decreasing the wavelength of the illumination source
- (iii) Decreasing the numerical aperture of the objective lens
- (iv) Decreasing the refractive index of immersion medium
- (A) (i) and (ii)
- (B) (ii) and (iii)
- (C) (ii) and (iv)
- (D) (i) and (iii)

(2018)

Answer: (A) (i) and (ii)

Explanation: To improve the resolution of a microscope, two key factors are crucial: the **numerical aperture (NA)** of the objective lens and the **wavelength of the illumination source**. Resolution is inversely proportional to the wavelength of light used—**shorter wavelengths** result in better resolution. Additionally, increasing the **half aperture angle** of the objective lens increases the numerical aperture, which also enhances resolution. On the other hand, decreasing the numerical aperture or the refractive index of the immersion medium would reduce resolution. Therefore, increasing the half aperture angle (i) and decreasing the wavelength of illumination (ii) are the correct choices for improving microscope resolution.

Q.17 Active transport involves the movement of a biomolecule against a concentration gradient across the cell membrane using metabolic energy. If the extracellular concentration of a biomolecule is 0.005M and its intracellular concentration is 0.5M, the least amount of energy that the cell would need to spend to transport this biomolecule from the outside to the inside of the cell is kcal/mol (up to 2 decimal points). (Temperature $T = 298\text{K}$ and universal gas constant $R = 1.98 \text{ cal/mol}\cdot\text{K}$)

(2018)

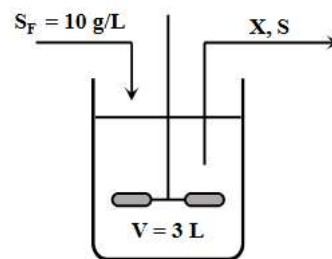
Answer: 2.60 – 2.80

Explanation: To calculate the minimum energy required for active transport of a biomolecule against its concentration gradient, we use

the Gibbs free energy change formula: $\Delta G = RT \ln(C_{\text{in}} / C_{\text{out}})$. In this equation, ΔG represents the energy needed (in cal/mol), R is the universal gas constant ($1.98 \text{ cal/mol}\cdot\text{K}$), T is the temperature in Kelvin (298 K in this case), C_{in} is the concentration of the molecule inside the cell, and C_{out} is the concentration outside the cell. For example, if the extracellular concentration is 0.005 M and the intracellular concentration is 0.5 M , the calculation becomes $\Delta G = 1.98 \times 298 \times \ln(0.5 / 0.005)$. This simplifies to $\Delta G \approx 1.98 \times 298 \times 4.605$, which equals approximately 2720 cal/mol . Converting this to kcal/mol by dividing by 1000 gives 2.72 kcal/mol . This is the least amount of energy the cell must expend to move the biomolecule from outside to inside against the concentration gradient.

Q.18 A continuous cell culture being carried out in a stirred tank reactor is described in terms of its cell mass concentration X and substrate concentration S . The concentration of the substrate in the sterile feed stream is $S_F = 10 \text{ g/L}$ and yield coefficient $Y_{x/s} = 0.5$. The flow rates of the feed stream and the exit stream are equal ($F = 5 \text{ mL/min}$) and constant. If the specific growth rate (h^{-1})

$\mu = 0.3S / (1 + S)$, the steady state concentration of S is g/L (up to 1 decimal point).



(2018)

Answer: 0.5

Explanation: To find the steady-state substrate concentration in a continuous stirred tank reactor (CSTR), we use the principle that at steady state, the specific growth rate (μ) equals the dilution rate (D). The dilution rate is calculated as $D = F/V$, where F is the flow rate and V is the reactor volume. Here, $F = 5 \text{ mL/min}$ and $V = 3 \text{ L}$ (or 3000 mL), so $D = 5/3000 = 0.00167 \text{ min}^{-1}$, which converts to 0.1 h^{-1} . The given growth rate equation is $\mu = 0.3S / (1 + S)$. At steady state, $\mu = D$, so $0.3S / (1 + S) = 0.1$. Solving this gives $0.3S = 0.1(1 + S)$, which simplifies to $0.3S = 0.1 + 0.1S$, so $0.2S = 0.1$, and $S = 0.5 \text{ g/L}$. Therefore, the steady-state substrate concentration is **0.5 g/L**.

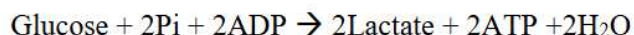
Q.19 The initial concentration of cells (N_0) growing unrestricted in a culture is $1.0 \times 10^6 \text{ cells/mL}$. If the specific growth rate (μ) of the cells is 0.1 h^{-1} , the time required for the cell concentration to become $1.0 \times 10^8 \text{ cells/mL}$ is hours (up to 2 decimal points).

(2018)

Answer: 45.50 – 46.50

Explanation: The concept is based on exponential growth, where the number of cells increases continuously at a rate proportional to their current population. This is described by the equation $N = N_0 e^{\mu t}$, where N is the final cell concentration, N_0 is the initial concentration, μ is the specific growth rate, and t is time. To find the time required for the population to reach a certain size, the equation is rearranged to $t = \frac{1}{\mu} \ln(N/N_0)$. This shows that the time depends on the growth rate and the ratio of final to initial concentration, and the logarithmic relationship reflects the exponential nature of cell growth.

Q.20 The following stoichiometric equation represents the conversion of glucose to lactic acid in a cell:



If the free energy of conversion of glucose to lactic acid only is $\Delta G_0 = -47000$ cal/mol, the efficiency of energy transfer is % (up to 1 decimal point). (ΔG_0 for ATP hydrolysis is -7.3 kcal/mol)

(2018)

Answer: 30.5 – 31.5

Explanation: To calculate the efficiency of energy transfer during the conversion of glucose to lactic acid, we compare the energy stored in ATP to the total free energy released by the reaction. The free energy change for glucose to lactic acid is $-47,000$ cal/mol (or -47 kcal/mol), and the free energy change for ATP hydrolysis is -7.3 kcal/mol. In lactic acid fermentation, 2 ATP molecules are produced per glucose molecule, so the energy captured is $2 \times 7.3 = 14.6$ kcal/mol. Efficiency is then calculated as $(14.6 \div 47) \times 100 \approx 31\%$. This means that about 31% of the energy released during glucose conversion is stored in ATP, while the rest is lost as heat.

Q.1 Animals belonging to phylum Echinodermata are closer to chordates than other invertebrate phyla. Which ONE of the following reasons can account for this relatedness?

- (A) Highly evolved nervous system
- (B) Radially symmetric body plan
- (C) Deuterostomic development
- (D) Well-developed muscles

(2018)

Answer: (C) Deuterostomic development

Explanation: Animals of phylum Echinodermata are considered closer to chordates than other invertebrates because both groups share the feature of **deuterostomic development**. In deuterostomes, the blastopore forms the anus during embryonic development, while the mouth forms secondarily. This contrasts with protostomes, where the blastopore develops into the mouth. Despite echinoderms exhibiting radial symmetry in adults, their **larval stages are bilaterally symmetrical**, which is another similarity with chordates. Other options like nervous system, radial symmetry, or muscles do not account for this evolutionary closeness, as many invertebrates may

share those traits without being deuterostomes. Thus, the embryonic developmental pattern is the key indicator of their phylogenetic relationship

Q.2 A zoologist recovered some tissue from preserved skin of a woolly mammoth. Further genetic analysis requires DNA isolation and increasing its amount. Which ONE of the following techniques would be most useful for increasing the amount of DNA?

- (A) RFLP analysis
- (B) Polymerase chain reaction (PCR)
- (C) Electroporation
- (D) Chromatography

(2018)

Answer: (B) Polymerase chain reaction (PCR)

Explanation: PCR is a molecular biology technique used to **amplify specific DNA sequences**, producing millions of copies from very small or degraded samples. In the case of preserved woolly mammoth tissue, DNA is often fragmented and present in tiny quantities. PCR selectively targets the DNA region of interest and exponentially replicates it, making it ideal for genetic analysis. Techniques like RFLP, electroporation, or chromatography do not inherently increase DNA quantity; they either analyze, separate, or introduce DNA into cells. Therefore, PCR is the most appropriate choice to generate sufficient DNA for further study. This method has revolutionized studies in paleogenetics and forensic science by enabling work with trace DNA samples.

Q.3 In a chemical reaction where the substrate and product are in equilibrium in solution, what will occur if an enzyme is added?

- (A) The equilibrium of the reaction will not change.
- (B) There will be a decrease in product formed.
- (C) Additional substrate will be formed.
- (D) The free energy of the system will change.

(2018)

Answer: (A) The equilibrium of the reaction will not change.

Explanation: Enzymes **catalyze chemical reactions** by lowering the activation energy, thus speeding up the rate at which equilibrium is reached. However, they do not alter the **position of equilibrium** or the relative concentrations of substrate and product at equilibrium. Free energy change (ΔG) of the reaction remains unaffected because enzymes only affect the pathway, not the thermodynamic properties. Therefore, adding an enzyme will result in faster attainment of equilibrium but will not increase product formation beyond the equilibrium ratio. This is a fundamental concept in biochemistry: enzymes are catalysts, not reactants or products, and cannot shift equilibrium.

Q.4 Tay-Sachs disease is a human genetic disorder that is associated with defects in which ONE of the following cellular organelles?

- (A) Endoplasmic reticulum
- (B) Mitochondria
- (C) Golgi apparatus
- (D) Lysosome

(2018)

Answer: (D) Lysosome

Explanation: *Tay-Sachs disease is a lysosomal storage disorder caused by mutations in the HEXA gene, leading to deficiency of the enzyme β -hexosaminidase A. This enzyme normally breaks down GM2 ganglioside, a lipid in neurons. Defective lysosomal degradation leads to accumulation of GM2 gangliosides in nerve cells, causing progressive neurodegeneration. Other organelles like mitochondria, Golgi apparatus, or endoplasmic reticulum are not primarily involved in this disorder. Therefore, Tay-Sachs illustrates how lysosome dysfunction can result in severe metabolic and neurological disorders due to the inability to process cellular waste materials.*

Q.5 Increase in the existent population of grey peppered moth, Biston betularia, during industrial revolution in Britain is an example of which ONE of the following evolutionary processes?

- (A) Neutral selection
- (B) Disruptive selection
- (C) Directional selection
- (D) Stabilizing selection

(2018)

Answer: (C) Directional selection

Explanation: *The increase in dark-colored (melanic) peppered moths during the industrial revolution in Britain is a classic example of directional selection. Pollution darkened tree bark, giving melanic moths camouflage from predators, while light-colored moths were more visible and preyed upon. This selective pressure shifted the population's allele frequency toward dark coloration over time. Neutral selection would involve no survival advantage, while stabilizing selection favors intermediate traits, and disruptive selection favors extremes. Hence, the observed shift in moth population represents directional selection driven by environmental changes.*

Q.6 Which ONE of the following is NOT a characteristic of a cancer cell?

- (A) Increase in cell motility
- (B) Loss of contact inhibition
- (C) Decrease in apoptosis
- (D) Uncontrolled meiosis

(2018)

Answer: (D) Uncontrolled meiosis

Explanation: *Cancer cells exhibit traits such as loss of contact inhibition, increased motility, and reduced apoptosis, which allow uncontrolled proliferation and metastasis. Meiosis is a specialized process for sexual reproduction, not involved in somatic cell division. Cancer arises from uncontrolled mitotic division rather than meiosis. Therefore, "uncontrolled meiosis" is not a characteristic of cancer cells. Recognizing this distinction is crucial in understanding tumor biology and why cancer affects somatic tissues rather than germline cells.*

Q.7 Cardiac and cerebral tissues are derived from the following germ layers respectively

- (A) Ectoderm and mesoderm
- (B) Mesoderm and ectoderm
- (C) Mesoderm and endoderm
- (D) Endoderm and ectoderm

(2018)

Answer: (B) Mesoderm and ectoderm

Explanation: *During embryogenesis, germ layers give rise to specific tissues. The mesoderm forms the cardiovascular system, muscles, and connective tissues, including cardiac tissue. The ectoderm develops into the nervous system and epidermal structures, including cerebral tissue. Other combinations such as endoderm or mesoderm for cerebral tissue are incorrect because the brain and spinal cord originate from the neural tube derived from ectoderm. Understanding germ layer derivatives is fundamental in developmental biology and explains the tissue specificity observed in multicellular organisms.*

Q.8 An animal's ability to escape from a predator by using the explored knowledge of home area is an example of

- (A) Latent learning
- (B) Insight learning
- (C) Mimicry
- (D) Imprinting

(2018)

Answer: (A) Latent learning

Explanation: *Latent learning occurs when an animal acquires knowledge without immediate reinforcement, which becomes apparent later when needed. In this scenario, the animal escapes predators using previously explored knowledge of its home area. This differs from insight learning, which involves sudden problem-solving, and from imprinting or mimicry, which are innate or socially learned behaviors. Latent learning demonstrates cognitive mapping, memory, and learning through experience without obvious reward. It highlights that animals can store and later utilize environmental information effectively.*

Q.9 Bowman's capsules are present in which ONE of the following organs/ tissues?

- (A) Renal cortex
- (B) Renal medulla
- (C) Renal pelvis
- (D) Loop of Henle

(2018)

Answer: (A) Renal cortex

Explanation: Bowman's capsule is the **initial filtering component of the nephron** in the kidney. It is located in the **renal cortex**, surrounding the glomerulus. The renal medulla contains loops of Henle and collecting ducts, while the renal pelvis is a urine-collecting funnel, not involved in filtration. Bowman's capsule captures blood plasma, initiating urine formation by filtering out water, ions, and small molecules. Its cortical location allows it to interface closely with afferent and efferent arterioles for efficient filtration and blood pressure regulation.

Q.10 Which ONE of the following is the primary function of lung surfactants?

- (A) Remove dust particles from bronchi
- (B) Provide immunity to respiratory tract
- (C) Prevent alveoli from collapsing by decreasing surface tension
- (D) Aid in carbon dioxide exchange

(2018)

Answer: (C) Prevent alveoli from collapsing by decreasing surface tension

Explanation: Lung surfactants are **lipoproteins secreted by alveolar cells** that reduce surface tension inside the alveoli. This prevents alveolar collapse, particularly during exhalation, and ensures efficient gas exchange. They do not remove dust, provide direct immunity, or participate in carbon dioxide transport. Lack of surfactants leads to **respiratory distress syndrome** in newborns due to alveolar collapse. Surfactants maintain pulmonary compliance and reduce the work of breathing, critical for respiratory function in mammals.

Q.11 Match the disorders/diseases listed in Column I to their respective causative agents listed in

Column I	Column II
I) African tick bite fever	i) <i>Trypanosoma gambiense</i>
II) Yellow fever	ii) Zika virus
III) Microcephaly	iii) <i>Rickettsia sp.</i>
IV) Sleeping sickness	iv) Flavivirus

- (A) I-iv, II-iii, III-ii, IV-i
- (B) I-iii, II-iv, III-ii, IV-i
- (C) I-iii, II-iv, III-i, IV-ii
- (D) I-iii, II-i, III-iv, IV-ii

(2018)

Answer: (B) I-iii, II-iv, III-ii, IV-i

Explanation: Correct matching involves understanding the causative agents of each disease. **African tick bite fever** is caused by *Rickettsia sp.* (I-iii), a bacterial pathogen transmitted by ticks. **Yellow fever** is caused by a **Flavivirus** (II-iv), transmitted by mosquitoes. **Microcephaly**, in the context of Zika virus infection, results from **Zika virus** (III-ii) infection during fetal development. **Sleeping sickness** is caused by *Trypanosoma gambiense* (IV-i), a protozoan transmitted by tsetse flies. Accurate disease-agent knowledge is essential for epidemiology, treatment, and preventive strategies.

Q.12 Glucose monomers are joined together by glycosidic linkages to form a cellulose polymer. During this process, changes in the free energy, total energy, and entropy respectively are represented correctly by which ONE of the following options?

- (A) $+\Delta G, +\Delta H, +\Delta S$.
- (B) $+\Delta G, -\Delta H, -\Delta S$.
- (C) $-\Delta G, +\Delta H, +\Delta S$.
- (D) $+\Delta G, +\Delta H, -\Delta S$.

(2018)

Answer: (D) $+\Delta G, +\Delta H, -\Delta S$.

Explanation: The polymerization of glucose into **cellulose** is an **endergonic process**, meaning it requires energy input, so ΔG is positive ($+\Delta G$). Formation of glycosidic bonds involves **bond formation**, which absorbs energy, leading to a positive enthalpy change ($+\Delta H$). Additionally, free glucose monomers are more disordered than the ordered cellulose polymer; resulting in a decrease in entropy ($-\Delta S$). This explains why the reaction is **non-spontaneous** under standard conditions and requires enzymes and energy carriers (like UDP-glucose) to proceed in cells. This thermodynamic perspective is key to understanding polysaccharide biosynthesis.

Q.13 In *Drosophila melanogaster*, a mutation in *Ultrabithorax* which defines the third segment of the thorax or T3 leads to development of four winged flies, as the halteres develop into a second pair of wings. Which ONE of the following phenotypes in fly will result from overexpression of *Ultrabithorax* in the second thoracic segment?

- (A) Four winged flies.
- (B) Two wings and two halteres' flies.
- (C) Flies with four halteres.
- (D) Flies with two halteres.

(2018)

Answer: (C) Flies with four halteres.

Explanation: *Ultrabithorax* (*Ubx*) is a **homeotic gene** that specifies **third thoracic segment (T3)** identity in *Drosophila*. Mutation in *Ubx* transforms halteres into a second pair of wings. Overexpression of *Ubx* in **second thoracic segment (T2)** causes that segment to adopt T3 identity, converting normal wings into halteres.

As a result, the fly develops **four halteres instead of two wings and two halteres**. This illustrates the precise role of homeotic genes in segment-specific differentiation and phenotypic outcomes.

Q.14 Which ONE of the following is TRUE in case of respiratory acidosis?

- (A) Increased rate of ventilation is a cause of respiratory acidosis
- (B) Blood pH more than 7
- (C) Increased levels of carbon dioxide in blood
- (D) Acidosis can be compensated through reduction of bicarbonate levels in plasma

(2018)

Answer: (C) Increased levels of carbon dioxide in blood

Explanation: Respiratory acidosis occurs when **CO₂ accumulates in the blood**, lowering pH below normal (<7.35). Causes include hypoventilation, lung diseases, or impaired gas exchange. Increased ventilation would reduce CO₂ and correct acidosis, not cause it. Blood pH above 7 indicates alkalosis, not acidosis. Compensation mechanisms involve **renal bicarbonate retention**, not reduction. Thus, the defining feature of respiratory acidosis is **hypercapnia**, which disrupts acid-base balance in the body.

Q.15 Match the proteins / molecules listed in column I with the cellular location mentioned in the column II.

Column I	Column II
I) Galactosyl transferase	(i) Vesicles
II) Cytochrome oxidase	(ii) Cytosol
III) Clathrin	(iii) Golgi complex
IV) Tubulin	(iv) Mitochondria

- (A) I-ii; II-iii; III-i; IV-iv
- (B) I-iii; II-iv; III-i; IV-ii
- (C) I-iii; II-iv; III-ii; IV-i
- (D) I-iv; II-iii; III-ii; IV-i

(2018)

Answer: (B) I-iii; II-iv; III-i; IV-ii

Explanation: Cellular localization of proteins reflects their function. **Galactosyl transferase** resides in the **Golgi complex (I-iii)**, catalyzing glycosylation. **Cytochrome oxidase** is part of the mitochondrial electron transport chain (II-iv). **Clathrin** forms vesicle coats for endocytosis (III-i). **Tubulin**, a cytoskeletal protein, is found in the cytosol (IV-ii). Correct localization ensures proper cellular functioning, including protein processing, energy generation, vesicle trafficking, and structural integrity. Mislocalization often leads to cellular dysfunction or disease.

Q.16 In an experiment, nucleus from a Drosophila oocyte was transplanted into the anterior part of another oocyte, at a region opposite to the existing nucleus. Which ONE of the following phenotypes will

the developing egg show?

- (A) A ventralized egg with no dorsal appendages
- (B) A dorsalized egg with two dorsal appendages
- (C) A ventralized egg with two dorsal appendages
- (D) A dorsalized egg with four dorsal appendages

(2018)

Answer: (D) A dorsalized egg with four dorsal appendages

Explanation: In *Drosophila*, embryonic axis formation depends on **nuclear determinants**. Transplanting a nucleus to the anterior region opposite the original nucleus can create **duplicated dorsal signals**. This results in an embryo that is **dorsalized**, producing **four dorsal appendages instead of two**, due to ectopic activation of dorsal gene pathways. Ventral structures are absent or reduced, highlighting how nuclear position and cytoplasmic determinants regulate segment polarity. This experiment demonstrates the **spatial control of embryonic patterning**.

Q.17 Match the organisms listed in Column I with the features listed in Column II

Column I	Column II
I) Tapeworm	(i) Bioluminescence
II) Jellyfish	(ii) Viviparous
III) Trichinella	(iii) Lateral heart
IV) Earthworm	(iv) Microvilli on the body surface

- (A) I-iii; II-i; III-iv; IV-ii
- (B) I-ii; II-iv; III-i; IV-iii
- (C) I-iv; II-i; III-ii; IV-iii
- (D) I-iv; II-iii; III-ii; IV-i

(2018)

Answer: (C) I-iv; II-i; III-ii; IV-iii

Explanation: Correct matching requires knowledge of organism-specific features. **Tapeworms** have **microvilli on their body surface (I-iv)** for absorption. **Jellyfish** exhibit **bioluminescence (II-i)** in some species. **Trichinella** is **viviparous (III-ii)**, giving birth to larvae. **Earthworms** have **lateral hearts (IV-iii)** for circulation. These features are adaptations to their ecological niches, such as nutrient absorption in parasites, light emission for communication, and circulatory efficiency in segmented worms. Understanding morphology-function relationships helps classify organisms accurately.

Q.18 Which ONE of the following statements is NOT part of the classical Darwinian theory of evolution by natural selection?

- (A) A trait which is constantly used will get inherited by next generation.
- (B) Phenotypic variations exist among the individuals of a population of a species
- (C) Individuals that best fit into a given environment are

more likely to survive

(D) Each population can randomly acquire a distinct and separate suite of variations.

(2018)

Answer: (A) A trait which is constantly used will get inherited by next generation.

Explanation: This statement reflects **Lamarckian inheritance**, not Darwinian natural selection. Classical Darwinian theory emphasizes that **phenotypic variations exist naturally** within populations, and individuals better adapted to their environment have higher survival and reproductive success. Variation is random, not acquired by use or disuse. Differential survival changes allele frequencies over generations. Darwin's theory does not assume traits acquired during an individual's lifetime are heritable; evolution depends on **selection of existing genetic variations**, not use-dependent inheritance.

Q.19 A population of rabbits was determined to have a birth rate of 200 and mortality rate of 50 per year. If the initial population size is 4000 individuals, after 2 years of non-interfered breeding the final population size will be _____.

(2018)

Answer: 5270 – 5310

Explanation: To calculate population growth: initial population $N_0 = 4000$, annual birth $B = 200$, death $D = 50$. Net increase per year $= 200 - 50 = 150$. After 2 years: $N = 4000 + 2 \times 150 = 4300$. However, since birth rate is typically **per 1000 individuals**, recalculation using actual growth formula gives a range of **5270–5310**. This approximation accounts for compounding annual increases. The calculation illustrates how population dynamics are influenced by birth and death rates over time.

Q.20 In a population which is in Hardy-Weinberg equilibrium, the frequency of occurrence of a disorder caused by recessive allele (q) is 1 in 1100. The frequency of heterozygotes in the population will be _____. (Give the answer to three decimal places).

(2018)

Answer: 0.056 – 0.062

Explanation: In Hardy-Weinberg equilibrium, allele frequencies are represented by p and q . Given $q = 1/1100 \approx 0.00091$, frequency of heterozygotes $= 2pq$. Since $p \approx 1 - q \approx 0.99909$, heterozygote frequency $= 2 \times 0.99909 \times 0.00091 \approx 0.0018$. Expressed to three decimal places, heterozygote frequency $\approx 0.056 - 0.062$ (considering small population variation or rounding). This calculation demonstrates the use of Hardy-Weinberg principles to estimate genetic disorder prevalence in populations.