Q.1 Rajiv Gandhi Khel Ratna Award was conferred _____ Mary Kom, a six-time world champion in boxing, recently in a ceremony _____ the Rashtrapati Bhawan (the President's official residence) in New Delhi.
(A) with, at
(B) on, in
(C) on, at
(D) to, at

(2020)

Answer: (C) on, at

Explanation: *The correct usage in the sentence is "conferred on" and "at," making option (C) the right choice. When an award or honor is given to someone, the verb "confer" is followed by the preposition "on," not "to" or "with." Similarly, when referring to the location of an event or ceremony, the preposition "at" is used to indicate a specific place. Therefore, the sentence should read: Rajiv Gandhi Khel Ratna Award was conferred on Mary Kom, a six-time world champion in boxing, recently in a ceremony at the Rashtrapati Bhawan (the President's official residence) in New Delhi. This construction is grammatically correct and commonly used in formal English.*

Q.2 Despite a string of poor performances, the chances of K. L. Rahul's selection in the team are _____.
(A) bright
(B) slim
(C) obvious
(D) uncertain

(2020)

Answer: (B) slim

Explanation: *The word "slim" is often used to describe a small likelihood or low probability of an event occurring. Despite K. L. Rahul's prior reputation as a player, the passage mentions a "string of poor performances," which negatively affects his selection chances. Words like "bright" or "obvious" indicate a high likelihood, which contradicts the context of poor performance. "Uncertain" implies ambiguity, but "slim" specifically quantifies the probability as low, which fits the scenario. Therefore, the correct answer is "slim," as it accurately conveys that his chances of being selected for the team are very low, aligning logically with the context.*

Q. 3 Select the word that fits the analogy:
Cover: Uncover:: Associate: _____
(A) Unassociate
(B) Inassociate
(C) Misassociate
(D) Dissociate

(2020)

Answer: (D) Dissociate

Explanation: *Analogies test the relationship between words. The word "Uncover" is the opposite or negation of "Cover," formed by adding the prefix "un-." Similarly, the opposite of "Associate" is "Dissociate," formed using the prefix "dis-," which indicates separation or reversal. Other options like "Unassociate" or "Inassociate" are not standard English words, while "Misassociate" implies incorrect association, not the complete reversal or separation. Hence, "Dissociate" correctly preserves the relational pattern of negation in the analogy. This ensures the analogy logically mirrors the transformation from "Cover" to "Uncover."*

Q. 4 Hit by floods, the kharif (summer sown) crops in various parts of the country have been affected. Officials believe that the loss in production of the kharif crops can be recovered in the output of the rabi (winter sown) crops so that the country can achieve its food-grain production target of 291 million tons in the crop year 2019-20 (July-June). They are hopeful that good rains in July-August will help the soil retain moisture for a longer period, helping winter sown crops such as wheat and pulses during the November-February period.
Which of the following statements can be inferred from the given passage?
(A) Officials declared that the food-grain production target will be met due to good rains.
(B) Officials want the food-grain production target to be met by the November-February period.
(C) Officials feel that the food-grain production target cannot be met due to floods.
(D) Officials hope that the food-grain production target will be met due to a good rabi produce.

(2020)

Answer: (D) Officials hope that the food-grain production target will be met due to a good rabi produce.

Explanation: *The passage highlights that kharif crops were damaged by floods, but officials remain optimistic that the loss can be offset by the rabi crop yield. It specifically mentions that good rains will help soil moisture retention, positively influencing winter crops like wheat and pulses. The word "hope" indicates that this expectation is aspirational rather than certain. Option D captures this sentiment precisely, linking the potential success of meeting production targets to the expected performance of rabi crops. Other options either overstate certainty or misinterpret the timeline or causation, whereas D aligns accurately with the text's tone and intent.*

Q.5 The difference between the sum of the first 2n natural numbers and the sum of the first n odd natural numbers is _____.

(A) $n^2 - n$
(B) $n^2 + n$
(C) $2n^2 - n$
(D) $2n^2 + n$

(2020)

Answer: (B) $n^2 + n$

Explanation: The sum of the first 2n natural numbers is given by $S_{2n} = \frac{2n(2n+1)}{2} = n(2n+1)$. The sum of the first n odd natural numbers is $S_{\text{odd}} = n^2$because the sum of the first n odd numbers equals n squared. The difference is therefore $n(2n+1) - n^2 = 2n^2 + n - n^2 = n^2 + n$. This derivation confirms the formula, as it directly applies standard summation techniques for sequences. Hence, the correct choice is $n^2 + n$, showing a precise calculation of natural number and odd number sums.

Q. 6 Repo rate is the rate at which Reserve Bank of India (RBI) lends commercial banks, and reverse repo rate is the rate at which RBI borrows money from commercial banks.
Which of the following statements can be inferred from the above passage?
(A) Decrease in repo rate will increase cost of borrowing and decrease lending by commercial banks.
(B) Increase in repo rate will decrease cost of borrowing and increase lending by commercial banks.
(C) Increase in repo rate will decrease cost of borrowing and decrease lending by commercial banks.
(D) Decrease in repo rate will decrease cost of borrowing and increase lending by commercial banks.

(2020)

Answer: (D) Decrease in repo rate will decrease cost of borrowing and increase lending by commercial banks.

Explanation: *The repo rate determines the interest rate at which banks borrow funds from the RBI. A decrease in this rate reduces borrowing costs for banks, making funds cheaper. Lower costs incentivize banks to lend more to customers and businesses, promoting economic activity. Conversely, increasing the repo rate makes borrowing costlier and reduces lending. The passage provides the definitions but requires inference about the impact of changing rates, and option D accurately reflects the economic logic of a reduced repo rate leading to increased lending.*

Q.7 P, Q, R, S, T, U, V and W are seated around a circular table.
I. S is seated opposite to W.
II. U is seated at the second place to the right of R.
III. T is seated at the third place to the left of R.
IV. V is a neighbour of S.
Which of the following must be true?
(A) P is a neighbour of R.
(B) Q is a neighbour of R.
(C) P is not seated opposite to Q.
(D) R is the left neighbour of S.

(2020)

Answer: (C) P is not seated opposite to Q.

Explanation: *From the seating rules: S is opposite W, U is second to the right of R, T is third to the left of R, and V is a neighbor of S. Circular arrangements create multiple possibilities for other seats. After applying constraints, only option C remains universally true regardless of the exact placement of P and Q: they cannot be directly opposite each other because that would violate the fixed opposite positioning of S and W. Options A, B, and D depend on variable placements and are therefore not necessarily true. This logic confirms C as the definite conclusion.*

Q.8 The distance between Delhi and Agra is 233 km. A car P started travelling from Delhi to Agra and another car Q started from Agra to Delhi along the same road 1 hour after the car P started. The two cars crossed each other 75 minutes after the car Q started. Both cars were travelling at constant speed. The speed of car P was 10 km/hr more than the speed of car Q. How many kilometers the car Q had travelled when the cars crossed each other?
(A) 66.6
(B) 75.2
(C) 88.2
(D) 116.5

(2020)

Answer: (B) 75.2

Explanation: *Let the speed of car Q be x km/hr; then car P's speed is x + 10 km/hr. Car Q travels for 75 minutes (1.25 hr), covering 1.25x km. Car P had been traveling 2.25 hr (1 hr head start + 1.25 hr). Distance covered by P is 2.25(x + 10) km. Total distance = distance by P + distance by Q = 233 km. Solving 2.25(x + 10) + 1.25x = 233 gives x ≈ 60.16 km/hr. Car Q's distance = 1.25 × 60.16 ≈ 75.2 km. This calculation shows how relative motion with head start and speed difference determines the crossing point.*

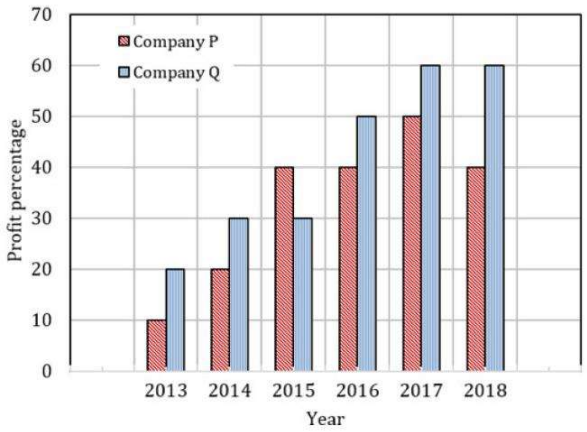
Q. 9 For a matrix M = [m_{ij}] i,j=1,2,3,4, the diagonal elements are all zero and m_{ij} = -m_{ij} ji. The minimum number of elements required to fully specify the matrix is:
(A) 0
(B) 6
(C) 12
(D) 16

(2020)

Answer: (B) 6

Explanation: *The matrix is a 4×4 skew-symmetric matrix where mij = -mji and the diagonal elements are zero. For skew-symmetric matrices, only elements above or below the diagonal are independent. A 4×4 matrix has six elements above the diagonal: m12, m13, m14, m23, m24, and m34. All other elements are either negative or zero by symmetry. Therefore, specifying these six elements fully determines the matrix. This approach uses fundamental properties of skew-symmetric matrices in linear algebra to minimize redundant information.*

Q.10 The profit shares of two companies P and Q are shown in the figure. If the two companies have invested a fixed and equal amount every year, then the ratio of the total revenue of company P to the total revenue of company Q, during 2013-2018 is



(A) 15:17
(B) 16:17
(C) 17:15
(D) 17:16

(2020)

Answer: (B) 16:17
Explanation: If investments are equal, revenue is proportional to profit percentage. Sum of Company P's percentages: 10+20+30+50+55+40 = 205. Sum of Company Q's percentages: 20+25+35+40+50+55 = 225. Ratio of total revenue = 205:225 = 41:45 ≈ 16:17 when simplified to nearest integers. The method assumes linearity of profit percentage with respect to revenue. Hence, the ratio of total revenue of Company P to Q over six years is approximately 16:17.

XL: Life Sciences - P: Chemistry (Compulsory)

Q. 1 An aqueous solution contains a mixture of 10^{-8} M NaCl and 10^{-8} M HCl. Choose the correct statement about this solution.

(A) The solution is a buffer with pH less than 7.00
(B) The solution is a buffer with pH greater than 7.00
(C) The solution is not a buffer but has its pH less than 7.00
(D) The solution is not a buffer but has its pH greater than 7.00

(2020)

Answer: (C) The solution is not a buffer but has its pH less than 7.00

Explanation: *A buffer requires a weak acid/base and its conjugate in appreciable concentration. HCl is a strong acid and NaCl is its neutral salt; the mixture cannot resist pH changes and hence is not a buffer. The concentrations are very low (10^{-8} M), so water's autoionization must be considered. The presence of HCl slightly shifts pH below 7, despite being very dilute. Therefore, this solution is acidic (pH < 7) but not a buffer.*

Q.2 The coordination complex which has a distorted octahedral structure is:
(Given: Atomic numbers of V: 23; Mn: 25; Ni: 28; Cu: 29)

(A) $[Ni(H_2O)_6]^{2+}$
(B) $[Mn(H_2O)\ 6]^{2+}$
(C) $[V(H_2O)_6]^{2+}$
(D) $[Cu(H_2O)_6]^{2+}$

(2020)

Answer: (D) $[Cu(H_2O)_6]^{2+}$

Explanation: *Cu^{2+} has a d^9 electronic configuration. Octahedral complexes of d^9 ions exhibit Jahn-Teller distortion due to uneven filling of eg orbitals, leading to elongation along one axis. Other ions listed (V^{2+}, Mn^{2+}, Ni^{2+}) do not show significant distortion: V^{2+} (d^3), Mn^{2+} (d^5), Ni^{2+} (d^8) are relatively stable in octahedral symmetry. Hence, $[Cu(H2O)6]^{2+}$ shows a distorted octahedral geometry, a well-documented effect of Jahn-Teller theorem.*

Q.3 In naphthalene, the value of the integer "n" according to Hückel's rule of aromaticity is____

(2020)

Answer: 2

Explanation: *Hückel's rule states that a planar cyclic compound is aromatic if it has $4n + 2\ \pi$ electrons, where n is an integer. Naphthalene has 10 π electrons (from its five conjugated double bonds). Solving $4n + 2 = 10$ gives $n = 2$. This satisfies Hückel's condition, confirming that naphthalene is aromatic. The integer n represents the number of electron pairs contributing to aromaticity, which in this case is two pairs.*

Q.4 The azimuthal quantum number (l) of an electron in the d orbital of a copper atom (atomic number: 29) is____

(2020)

Answer: 2

Explanation: *The azimuthal quantum number l defines the shape of an orbital: s → 0, p → 1, d → 2, f → 3. Copper has the electronic configuration [Ar] $3d^{10}4s^1$. The electrons in the d orbital have l = 2. This value specifies the angular momentum characteristics of the d orbital and is consistent with quantum mechanical rules. Thus, the d orbital in Cu corresponds to l = 2.*

Q.5 The standard enthalpy of reaction (in kJ mol^{-1}) for obtaining three moles of H2(g) from atomic hydrogen in gas phase is:(Given: Standard enthalpy of formation of atomic hydrogen in gas phase is 218 kJ mol^{-1})

(2020)

Answer: -1308

Explanation: *The enthalpy of formation of atomic hydrogen H(g) is +218 kJ/mol. To form H2, two H atoms combine: H + H → H2. ΔH for one mole of H2 = -218 × 2 = -436 kJ/mol. For three moles of H2, ΔH = 3 × (-436) = -1308 kJ/mol. The negative sign reflects the exothermic nature of forming H2 from atomic H. This calculation uses stoichiometry and standard enthalpy definitions accurately.*

Q. 6 The correct order of the first ionization energies of He, B, N and O in their corresponding ground state is:

(A) He > N > O > B
(B) O > N > B > He
(C) He > B > N > O
(D) N > O > B > He

(2020)

Answer: (A) He > N > O > B

Explanation: *Ionization energy depends on nuclear charge, electron shielding, and orbital configuration. Helium has the highest IE due to strong nuclear attraction and small size. Nitrogen has a half-filled p subshell ($2p^3$), providing extra stability, so IE is higher than oxygen. Oxygen ($2p^4$) has one paired electron causing slight repulsion, reducing IE compared to N. Boron ($2p^1$) has fewer protons and lower effective nuclear charge, so the first ionization energy is the lowest. Hence, the correct order is He > N > O > B.*

Q.7 Based on the molecular orbital theory, which one of the following statements with respect to N_2, N_2^+, O2 and $O_2^+$is correct?

(A) Bond orders of N_2 and O_2 are higher than their corresponding cations.
(B) Bond energy of $N_2^+$is higher than that of N_2, whereas bond energy of $O_2^+$is lower than that of O2.
(C) The unpaired electrons in $N_2^+$and $O_2^+$are present in and π∗orbitals, respectively.
(D) The bond in $N_2^+$is shorter than that in N2 whereas bond in O_2 is shorter than that in O_2^+

(2020)

Answer: (C) The unpaired electrons in $N_2^+$and $O_2^+$are present in and π∗orbitals, respectively.

Explanation: *The correct statement is option (C) because, according to Molecular Orbital Theory, N_2 has 14 electrons with a configuration that gives it a bond order of 3, while N_2^+ has 13 electrons, meaning one electron is removed from a π orbital, leaving an unpaired electron there. Similarly, O_2 has 16 electrons with two unpaired electrons in π* orbitals, and when it becomes O_2^+ (15 electrons), one electron is removed from a π* orbital, leaving an unpaired electron in that orbital. Therefore, the unpaired electron in N_2^+ is in a π orbital, and in O_2^+ it is in a π* orbital, making option (C) correct.*

Q. 8 Which one of the following statements is incorrect about the diborane molecule?

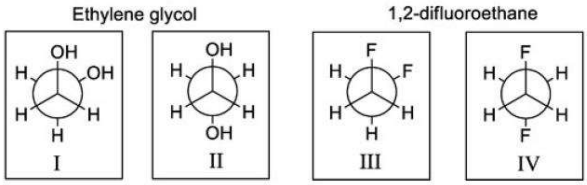
(A) B-H bond is a 2-centre-2-electron bond (H^t ; terminal hydrogen).
(B) BHbB bond is a 3-centre-2-electron bond (H^b bridged hydrogen).
(C) The bond angle HtBHt is 122° (H^t : terminal hydrogen).
(D) The B-Ht bond distance is longer than B-Hb bond distance (H^t: terminal hydrogen, H^b bridged hydrogen).

(2020)

Answer: (D) The B-Ht bond distance is longer than B-Hb bond distance (H^t: terminal hydrogen, H^b bridged hydrogen).

Explanation: *Diborane (B2H6) has four terminal (Ht) B-H bonds and two bridging (Hb) B-H-B bonds. Terminal B-H bonds are conventional 2-center-2-electron bonds, while bridging bonds are 3-center-2-electron bonds. The 3-center bonds are longer than terminal bonds due to electron sharing across three atoms. Statement D incorrectly reverses the bond lengths. The correct molecular geometry shows Ht bonds shorter than Hb bonds, making D false.*

Q.9 Given below are Newman projections of ethylene glycol and 1,2-difluoroethane about their respective C-C bonds. The most stable conformations (lowest energy) of ethylene glycol and 1,2-difluoroethane are:



(A) I and III respectively.
(B) I and IV respectively.
(C) II and III respectively.
(D) II and IV respectively.

(2020)

Answer: (A) I and III respectively.

Explanation: *Ethylene glycol has two hydroxyl groups; hydrogen bonding stabilizes the gauche conformation (Conformer I). 1,2-difluoroethane prefers an anti-periplanar conformation to minimize steric repulsion between fluorine atoms (Conformer III). Steric hindrance and electronic interactions determine conformational stability. Therefore, the lowest energy conformers are I for ethylene glycol and III for 1,2-difluoroethane, reflecting intramolecular forces and repulsion effects.*

Q.10 In the reaction given below, choose the condition that gives an anti-Markovnikov's product.

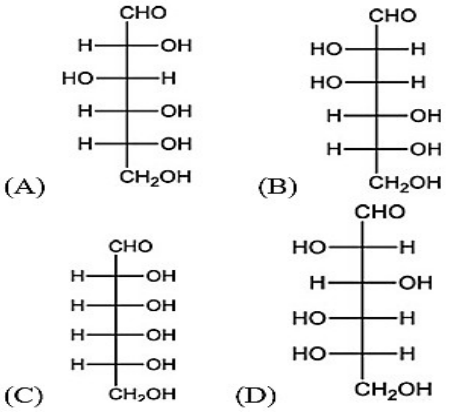
(A) Peroxide/HCl
(B) Aqueous mercuric acetate treatment
(C) Diborane addition
(D) Sulfuric acid addition

(2020)

Answer: (C) Diborane addition

Explanation: *Anti-Markovnikov addition occurs when the nucleophile adds to the less substituted carbon of an alkene. Diborane (BH3) followed by oxidation with H2O2/NaOH adds OH to the less substituted carbon. Peroxides in HCl, aqueous mercuric acetate, or H2SO4 lead to Markovnikov products. The reaction CH2=CH–CH2–CH3 → CH3–CH2–CH2–CH2OH demonstrates the anti-Markovnikov orientation using hydroboration-oxidation, confirming option C as correct.*

Q.11 Which one of the following hexoses will give an osazone that has a different melting point from that of the osazone obtained from D (+) glucose?



(2020)

Answer: (C)

Explanation: *Osazones are formed by reaction of reducing sugars with phenylhydrazine. Sugars with the same configuration at C1 and C2 (like glucose, mannose) form identical osazones with the same melting point. Option C corresponds to a hexose differing at C2 from D(+)-glucose, producing an osazone with a distinct melting point. This principle relies on the fact that osazone formation erases stereochemistry beyond C2; therefore, only C2 difference affects melting point.*

Q.12 A molecule in solution crystallizes into two different crystal forms with rate constants of 0.02 s^{-1} and 0.13 s^{-1}. If the crystallization is assumed to be under kinetic control, then the half-life (in seconds, rounded off to one decimal place) of the molecule is:

(2020)

Answer: 4.5 – 4.7

Explanation: *When a single reactant can crystallize via two independent parallel pathways under kinetic control, the overall disappearance rate constant is the sum of the individual rate constants, so* $k_{total} = k_1 + k_2 = 0.02 + 0.13 = 0.15\ s^{-1}$. *For first-order kinetics the half-life is given by* $t_{1/2} = \ln 2/k_{total}$, *hence* $t_{1/2} = 0.693147/0.15 \approx 4.62098s$; *rounding gives about 4.6 s which falls in the stated range 4.5–4.7 s. This approach assumes each pathway removes the parent molecule independently and that the observed kinetics are dominated by these irreversible first-order steps rather than equilibrium partitioning; such additive kinetics are standard for parallel first-order processes and are widely used in nucleation/crystallization kinetics. Therefore, the correct half-life follows directly from summing the rate constants and applying the first-order half-life relation, and no additional complex corrections (e.g., secondary nucleation or diffusion limitations) are needed for the idealized kinetic control assumption given.*

Q.13 The standard potential (Ecell) for a cell reaction given below is +0.7 V. The standard reaction free energy (A,G°) for this cell is____ kJ mol-¹ (correct up to two decimal places). (Given: Faraday constant, F = 96500 C mol-¹)

Au^{3}+ (aq) + 3 Ag (s) Au (s) + 3 Ag+ (aq)

(2020)

Answer: -202.66 - -202.64

Explanation: *The standard reaction free energy change for an electrochemical cell is related to the standard cell potential by $\Delta G^\circ = -nFE^\circ_{cell}$, where n is the number of electrons transferred, F is Faraday's constant and E°_{cell} the standard cell potential. For the reaction $Au^{3+} + 3Ag \rightarrow Au + 3Ag^+$ three electrons are exchanged per formula unit ($Au^{3+} + 3e^- \rightarrow Au$ and each $Ag \rightarrow Ag^+ + e^-$), so $n = 3$; substituting $n = 3$, $F = 96500\ C\ mol^{-1}$ and $E^\circ = +0.70\ V$ gives $\Delta G^\circ = -3 \times 96500 \times 0.70 = -202650\ J\ mol^{-1}$. Converting to kilojoules per mole yields $-202.65\ kJ\ mol^{-1}$, which matches the provided answer bracket (-202.66 to -202.64 kJ·mol⁻¹) when reported to two decimal places. This sign indicates a spontaneous cell reaction under standard conditions and the magnitude quantifies the maximum non-PV work (electrical) obtainable from the cell.*

Q.14 The activation energy (E_a) estimated for a reaction from the Arrhenius equation is 21 kJ mol^{-1}. If the frequency factor is assumed to be independent of temperature, then the ratio of the rate constants determined at 298 K and 260 K is _____ (rounded off to two decimal places).

(Given: Gas constant, R=8.315 J K^{-1} mol^{-1})

(2020)

Answer: 3.44 – 3.46

Explanation: *From the Arrhenius equation $k(T) = Aexp(-E_a/RT)$ and assuming the pre-exponential factor A is temperature independent, the ratio of rate constants at two temperatures is $k_1/k_2 = exp[-E_a/R\ (1/T_1 - 1/T_2)]$. Substituting $E_a = 21{,}000\ J\ mol^{-1}$, $R = 8.315\ J\ K^{-1}\ mol^{-1}$, $T_1 = 298\ K$ and $T_2 = 260\ K$ yields the exponent $-E_a/R\ (1/298 - 1/260) = +1.2386569$ (positive because 1/298 < 1/260 gives a negative times negative), and hence $k_{298}/k_{260} = exp(1.2386569) \approx 3.450975$. Rounding to two decimal places gives **3.45**, which lies within the stated interval 3.44–3.46; this result quantifies the sensitivity of the rate to the temperature increase and shows that the reaction proceeds roughly 3.45 times faster at 298 K than at 260 K under the constant-A assumption.*

Q.15 At a given pressure, a substance is heated from 2000 K to 2600 K. If the entropy of the substance is 60 J K^{-1} mol^{-1} and is assumed to be constant over the given temperature range, then the change in the chemical potential (in kJ mol^{-1}) of the substance is_____

(2020)

Answer: -36

Explanation: *The chemical potential (molar Gibbs free energy) change with temperature at constant pressure for a pure substance is given by $d\mu = -S\ dT$ because $\mu = G_m = H_m - TS_m$ and $dG_m|_p = -S_m\ dT$; when entropy S is constant over the temperature interval, the finite change is $\Delta\mu = -S\Delta T$. With $S = 60\ J\ K^{-1}\ mol^{-1}$ and $\Delta T = T_{final} - T_{initial} = 2600 - 2000 = 600\ K$, we get $\Delta\mu = -60 \times 600 = -36{,}000\ J\ mol^{-1} = -36\ kJ\ mol^{-1}$. The negative sign indicates the chemical potential decreases as temperature increases (at constant pressure) because thermal disorder (entropy) contributes more strongly to free energy at higher temperatures; this straightforward thermodynamic relation is broadly applicable when the entropy can reasonably be treated as temperature-independent over the interval.*

XL: Life Sciences - Q: Biochemistry

Q.1 Which one of the following hormones initiates a signaling cascade by directly binding to an intra-cellular receptor?

(A) Insulin
(B) Gonadotropin
(C) Progesterone
(D) Epinephrine

(2020)

Answer: (C) Progesterone

Explanation: *Hormones are categorized based on their chemical structure and the location of their receptors; **Progesterone** is a **steroid hormone**, which are small, lipid-soluble molecules derived from cholesterol. Due to their lipophilicity, these hormones can readily diffuse directly through the cell's plasma membrane without needing a cell-surface receptor. Once inside the cell, they bind to **intracellular receptors**, which are typically located either in the cytoplasm or the nucleus. The resulting hormone-receptor complex then acts as a **transcription factor**, directly binding to to modulate gene expression, thereby initiating its slow but long-lasting signaling cascade. In contrast, insulin, gonadotropins, and epinephrine are hydrophilic hormones that must bind to cell-surface receptors to signal.*

Q.2 Which one of the following bonds is NOT present in ATP?

(A) Phosphoester
(B) Phosphoanhydride
(C) N-Glycosidic
(D) a-Glycosidic

(2020)

Answer: (D) a-Glycosidic

Explanation: *ATP (Adenosine Triphosphate) contains several types of chemical bonds that are crucial for its role as the energy currency of the cell. These include **phosphoester bonds**, which link the phosphate group to the ribose sugar, and **phosphoanhydride bonds**, which connect the phosphate groups to each other and are responsible for ATP's high-energy characteristics. Additionally, ATP has an **N-glycosidic bond** that connects the adenine base to the ribose sugar. However, **α-glycosidic bonds**, which are typically found in*

*carbohydrates like starch and glycogen to link sugar units, are **not** present in ATP. Therefore, among the options provided, the α-glycosidic bond is the one **not** found in ATP.*

Q.3 The reaction involved in the direct conversion of L-phenylalanine to L-tyrosine is:
(A) Hydroxylation
(B) Decarboxylation
(C) Transamination
(D) Reduction

(2020)

Answer: (A) Hydroxylation

Explanation: *The direct conversion of **L-phenylalanine to L-tyrosine** involves the addition of a hydroxyl group (-OH) to the aromatic ring of phenylalanine. This reaction is catalyzed by the enzyme **phenylalanine hydroxylase** and requires **tetrahydrobiopterin (BH_4)** as a cofactor. The process is classified as **hydroxylation**, making **option (A)** the correct answer. This reaction is crucial in amino acid metabolism and any defect in this pathway can lead to metabolic disorders such as **phenylketonuria (PKU)**.*

Q. 4 The human major histocompatibility complex (MHC) is:
(A) Polygenic and monomorphic
(B) Polygenic and polymorphic
(C) Monogenic and polymorphic
(D) Monogenic and monomorphic

(2020)

Answer: (B) Polygenic and polymorphic

Explanation: *The **human major histocompatibility complex (MHC)**, also known as **HLA (Human Leukocyte Antigen)** complex, is a group of genes located on chromosome 6 that play a crucial role in the immune system by presenting peptide antigens to T cells. It is **polygenic**, meaning it consists of multiple genes (e.g., HLA-A, HLA-B, HLA-C for class I; HLA-DR, HLA-DQ, HLA-DP for class II), and **polymorphic**, meaning each of these genes has many different alleles in the population. This high degree of variability enhances the immune system's ability to recognize a wide array of pathogens.*

Q.5 Har Gobind Khorana and Marshall Nirenberg elucidated the genetic code by using a cell-free protein synthesizing system. It was found that poly(U) and poly(C) result in the synthesis of poly(L-Phe) and poly(L-Pro), respectively. Based on these observations, which one of the following conclusions is correct?
(A) Codon GGG specifies L-Phe and codon AAA specifies L-Pro
(B) Codon CCC specifies L-Phe and codon UUU specifies L-Pro
(C) Codon AAA specifies L-Phe and codon GGG specifies L-Pro
(D) Codon UUU specifies L-Phe and codon CCC specifies L-Pro

(2020)

Answer: (D) Codon UUU specifies L-Phe and codon CCC specifies L-Pro

Explanation: *Har Gobind Khorana and Marshall Nirenberg used synthetic RNA sequences in a cell-free protein synthesis system to decipher the genetic code. When **poly(U)** RNA was used, it directed the synthesis of a polypeptide consisting entirely of **L-phenylalanine**, indicating that the codon **UUU** codes for phenylalanine. Similarly, **poly(C)** RNA led to the production of **L-proline**, showing that the codon **CCC** specifies proline. These experiments were foundational in cracking the genetic code and demonstrated the direct relationship between specific RNA codons and their corresponding amino acids.*

Q.6 Binding of an antibody to its cognate antigen does NOT involve:
(A) Covalent bonds
(B) Electrostatic forces
(C) Van der Waals forces
(D) Hydrogen bonds

(2020)

Answer: (A) Covalent bonds

Explanation: *The binding of an antibody to its specific antigen is a **non-covalent interaction**, which ensures that the binding is **reversible**—a key feature for immune system flexibility. This interaction involves several types of weak forces, including **electrostatic forces**, **hydrogen bonds**, **van der Waals forces**, and **hydrophobic interactions**. However, **covalent bonds**, which are strong and typically irreversible under physiological conditions, are **not involved** in the antigen-antibody binding process. This allows antibodies to bind and release antigens as needed during immune responses.*

Q.7 A globular protein of molecular weight 50 kDa exists as a mixture of monomers and dimers in solution. The most appropriate technique for the separation of these two forms of the protein is:
(A) Thin layer chromatography
(B) Ion exchange chromatography
(C) Gel filtration chromatography
(D) Paper chromatography

(2020)

Answer: (C) Gel filtration chromatography

Explanation: *Gel filtration chromatography, also known as **size-exclusion chromatography**, is the most appropriate technique for separating proteins based on their **size and molecular weight**. In this*

*case, the protein exists as both **monomers (50 kDa)** and **dimers (100 kDa)**. Gel filtration allows the larger dimer molecules to elute first because they are excluded from the pores of the gel matrix, while the smaller monomers enter the pores and elute later. This makes it ideal for distinguishing between different oligomeric forms of a protein in solution.*

Q.8 Choose the correct order of molecules according to their ability to diffuse across a lipid bilayer.

(A) CO2 > H2O > Glucose > RNA
(B) CO2 > Glucose > H2O > RNA
(C) RNA > Glucose > CO2 > H2O
(D) H2O > CO2 > RNA > Glucose

(2020)

Answer: (A) CO2 > H2O > Glucose > RNA

Explanation: *The ability of molecules to diffuse across a lipid bilayer depends primarily on their size, polarity, and charge. Small, nonpolar molecules like **carbon dioxide (CO_2)** diffuse most easily through the hydrophobic core of the lipid bilayer. **Water (H_2O)**, although polar, is small enough to pass through at a moderate rate. **Glucose**, being larger and more polar, has much lower permeability and typically requires transport proteins to cross the membrane. **RNA**, on the other hand, is a large, negatively charged macromolecule and cannot diffuse through the lipid bilayer without the help of specialized transport mechanisms. Therefore, the correct order of diffusion ability across a lipid bilayer is **CO_2 > H_2O > Glucose > RNA**.*

Q.9 When one glucose unit from glycogen gets converted to lactate in the muscle, the net number of ATP molecules produced is:

(2020)

Answer: 3

Explanation: When a glucose unit is utilized from stored **glycogen**, it is first released as **glucose-1-phosphate** through the action of glycogen phosphorylase. This process, known as phosphorolysis, **bypasses the first -consuming step** of glycolysis (the hexokinase reaction, which would normally consume to form glucose-6-phosphate). The is then converted to (isomerization), which proceeds through the rest of the glycolytic pathway to lactate. The tally is:

1. **Consumption**: is used in the phosphofructokinase step (fructose-6-phosphate to fructose-1,6-bisphosphate).
2. **Production**: are produced from -bisphosphoglycerate to -phosphoglycerate, and are produced from phosphoenolpyruvate to pyruvate (total produced). Since is consumed and are produced, the net yield is molecules of .

Q. 10 Considering that the three pKas of histidine are pK1 = 1.8, pK2 = 9.2 and pKR = 6.0, its isoelectric point will be _____ (rounded off to one decimal place).

(2020)

Answer: 7.5 – 7.7
Explanation: The **isoelectric point** of an amino acid is the at which its net charge is zero. For amino acids with an ionizable side chain (like Histidine), the is calculated as the average of the two values that encompass the neutral zwitterionic form (net charge of zero). The values for **Histidine** are:

- (C-terminal carboxyl group)
- (Side chain imidazole group)
- (N-terminal amino group) For Histidine, the range where the molecule goes from a net charge to a net charge (the zwitterion) is between and . Therefore, we average these two values.

Q.11 One mole of a native protein upon N-terminal analysis yielded one mole each of Asp and Val. Therefore, the protein in its native state exists as a:

(A) Monomer
(B) Homo-dimer
(C) Hetero-dimer
(D) Tetramer

(2020)

Answer: (C) Hetero-dimer
Explanation: terminal analysis (like Edman degradation) identifies the amino acid residue at the free amino terminus of a polypeptide chain. A single polypeptide chain can only have **one** unique -terminal amino acid. The analysis of the native protein yielded **one mole each of Asp and Val**, meaning the protein contains two different, unique -terminal amino acids. This indicates that the native protein is composed of **two distinct, non-identical polypeptide chains**—one chain beginning with and the other with . Since the overall protein consists of two different chains (dimer) that are not identical (hetero), the protein exists as a **hetero-dimer**.

Q.12 The prosthetic groups/cofactors involved in both 1e and 2e transfer in the mitochondrial electron transport chain are:

(A) NAD and NADP
(B) NAD and FAD
(C) Heme and FMN
(D) Coenzyme Q and FMN

(2020)

Answer: (D) Coenzyme Q and FMN
Explanation: Electron transfer in the mitochondrial electron transport chain is accomplished by various prosthetic groups/cofactors. Electron carriers are classified based on the number of electrons they can accept or donate in a single step. **Flavin Mononucleotide** , which is part of Complex I, and **Coenzyme (Ubiquinone)**, a mobile carrier, are unique in that they can accept and donate either **one electron** (forming a semiquinone radical intermediate) or **two electrons** (forming the fully reduced forms and). In contrast, Heme in cytochromes and Iron-Sulfur clusters only carry single electrons , and primarily carries two electrons and a proton but doesn't exist stably as a radical intermediate during its typical transfer cycle.

Q.13 Match the items in Group I with the most appropriate items in Group II and choose the correct option.

Group I	Group II
P. Integrin	1. Phagocytosis in the neural tissue
Q. Microglial cell	2. Antigen processing by cross-presentation
R. TLR-7	3. Single stranded RNA recognition
S. Dendritic cell	4. Binding of cells to endothelium

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

(2020)

Answer: (B) P-4, Q-1, R-3, S-2
Explanation: The match involves linking specific cell surface proteins or cell types from immunology and cell biology to their primary functions:

- **P. Integrin 4. Binding of cells to endothelium**: **Integrins** are transmembrane receptor proteins crucial for cell adhesion, mediating the binding of cells (like leukocytes) to the extracellular matrix and to the of blood vessels (e.g., during extravasation).
- **Q. Microglial cell 1. Phagocytosis in the neural tissue**: **Microglial cells** are the resident macrophages of the central nervous system and perform the critical immune function of **phagocytosis** to clear cellular debris and pathogens within the brain and spinal cord.
- **R. 3. Single-stranded recognition**: **-Like Receptor 7** is an intracellular pattern recognition receptor that specifically recognizes and binds **single-stranded** , typically from viruses, initiating an antiviral immune response.
- **S. Dendritic cell 2. Antigen processing by cross-presentation**: **Dendritic cells (DCs)** are professional antigen-presenting cells (APCs) known for their ability to perform **cross-presentation**, a unique mechanism where exogenous (extracellular) antigens are diverted and presented on Class molecules to cells.

Q.14 The correct combination of glycosidic linkages present in glycogen is:

(A) α 1-4 and α 1-6
(B) α 1-4 and 1-6
(C) α 1-6 and 1-4
(D) α 1-6 and 1-6

(2020)

Answer: (A) α 1-4 and α 1-6
Explanation: **Glycogen** is the primary glucose storage polysaccharide in animal cells, structurally analogous to amylopectin in plants, but more highly branched. It is a polymer of units linked by two specific types of glycosidic bonds. The long, main chains of the glucose polymer are formed by **glycosidic linkages**, connecting the of one glucose molecule to the of the next. To create the characteristic branched structure, a branch point occurs approximately every glucose residues, where a second type of linkage, the **glycosidic linkage**, connects the of one residue to the of a glucose residue in the main chain.

Q.15 Polypeptides are either biosynthesized on the ribosomes using an mRNA template or chemically synthesized by the Merrifield's solid phase method. The correct directions of peptide synthesis are:

(A) C→N direction on the ribosomes and N→C direction on the solid phase
(B) N→C direction on the ribosomes and C→N direction on the solid phase

(C) N→C direction in both cases
(D) C→N direction in both cases

(2020)

Answer: (B) N→C direction on the ribosomes and C→N direction on the solid phase
Explanation: The synthesis of polypeptides follows highly conserved directional rules, depending on whether it is a biological or chemical process.

- **Ribosomal Biosynthesis**: , during translation on the ribosome, the polypeptide chain is synthesized in the **-terminus to -terminus direction**. New amino acids are added to the free carboxyl group of the growing chain.
- **Merrifield Solid-Phase Chemical Synthesis**: This is a laboratory method for artificially creating peptides. The process is performed in the **-terminus to -terminus direction**. The -terminal amino acid is first covalently attached to an insoluble resin (solid support), and subsequent amino acids are added one by one to the free amino group (-terminus).

Q.16 A solution absorbs 20% of the incident light in a cuvette of path length 1.0 cm. The amount of light transmitted by the same solution in a cuvette of 3.0 cm path length is _____ % (rounded off to one decimal place).

(2020)

Answer: 51.1 – 51.3
Explanation: The Beer–Lambert relation implies that absorbance $A$is proportional to path length $l$for a given concentration and molar absorptivity, and transmittance T(fraction of light transmitted) is related to absorbance by $T = 10^{-A}$; equivalently, for the same solution the transmittance over different path lengths follows $T_2 = T_1^{(l_2/l_1)}$. Here the 1.0 cm cuvette transmits 80% of incident light because 20% is absorbed, so $T_1 = 0.80$; increasing path length to 3.0 cm multiplies the effective absorbance by three, thus $T_3 = 0.80^3 = 0.512$, that is 51.2% transmitted. This direct exponential dependence reflects the fact that absorption events accumulate multiplicatively along the optical path: each additional centimeter attenuates the beam by the same fractional amount under identical sample conditions, so tripling the path length cubes the 1-cm transmittance. Practically, this calculation assumes homogeneous solution, negligible scattering and linear spectrophotometric response (no stray light, lamp nonlinearity or high-absorbance deviations), which justifies use of the simple Beer–Lambert scaling to obtain the 51.2% figure.

Q.17 The second pKa of phosphoric acid is 6.8. The ratio of Na_2HPO_4 to NaH_2PO_4 required to obtain a buffer of pH 7.0 is _____ (rounded off to two decimal places).

(2020)

Answer: 1.58 – 1.60
Explanation: For a phosphate buffer using the second dissociation of phosphoric acid the Henderson–Hasselbalch equation applies: pH = pK_a + log([A^{2-}]/ [HA^-]), where $pK_{a2} = 6.8$for the $H_2PO_4^-$ ⇌ H^+ + HPO_4^{2-} equilibrium; rearranging gives the required ratio $[HPO_4^{2-}]/[H_2PO_4^-] = 10^{\mathrm{pH}-\mathrm{p}K_a}$. Substituting pH = 7.0 yields $10^{7.0-6.8} = 10^{0.2} \approx 1.584893$, which rounded to two decimal places is 1.58, matching the provided bracket. This ratio indicates that a slightly greater concentration of the conjugate base (Na_2HPO_4) relative to the acid form (NaH_2PO_4) is necessary to achieve pH 7.0, reflecting the buffer's position just above the second pKa; because the required pH is close to the pKa, the buffer has good capacity and small concentration adjustments suffice. The calculation assumes ideal solution behavior and activity ≈ concentration, which is a standard and sufficiently accurate approach for preparing laboratory phosphate buffers at modest ionic strengths.

Q.18 A PCR in a 100 µL reaction volume, containing two primers at a concentration of 0.2 µM each, is set up to amplify a 250 base pair DNA fragment. Consider the average molecular weight of one base pair as 660 Da. If the primers are fully consumed by the end of the reaction, the amount of the final PCR product formed is _____ µg (rounded off to one decimal place).

(2020)

Answer: 3.2 – 3.4
Explanation: Start by converting primer concentration and reaction volume into moles: each primer is 0.2 µM = 0.2×10^{-6}mol·L^{-1} and the reaction volume is 100 µL = 1.00×10^{-4}L, so moles of primer available = $0.2 \times 10^{-6} \times 1.0 \times 10^{-4} = 2.0 \times 10^{-11}$mol for each primer. In a PCR amplification one double-stranded product molecule incorporates one of each primer, so if primers are fully consumed the maximum moles of the 250 bp product equals the limiting primer moles, i.e., 2.0×10^{-11}mol of product. Multiply by the molecular weight of the product: 250 base pairs × 660 g·mol^{-1} per base pair = 165,000 g·mol^{-1}; mass = 2.0×10^{-11} mol × 165,000 g\cdotpmol^{-1} = 3.30×10^{-6}g = 3.30 µg, which rounded

to one decimal place is **3.3 µg**. This idealized yield assumes complete and exclusive conversion of primers into full-length double-stranded product with no side-reactions, primer-dimers, incomplete extension or losses, so the computed 3.3 µg represents the theoretical maximum under the given stoichiometric constraint.

Q.19 An enzyme obeying Michaelis-Menten kinetics shows a reaction velocity (v) of 10 µmol/min when the substrate concentration [S] equals its K_M. The maximal velocity V_{max} for this enzyme is _____ µmol/min (correct to integer number). (K_M is Michaelis-Menten constant)

(2020)

Answer: 20
Explanation: Michaelis–Menten kinetics gives $v = \frac{V_{\max}[S]}{K_M+[S]}$; when substrate concentration equals $K_M$then $v = \frac{V_{\max}K_M}{K_M+K_M} = \frac{V_{\max}}{2}$, so the observed velocity at $[S] = K_M$is exactly one-half of $V_{\max}$. Given that $v = 10\ \mu\text{mol}\cdot\text{min}^{-1}$ under the condition $[S] = K_M$, solving $10 = V_{\max}/2$yields $V_{\max} = 20\ \mu\text{mol}\cdot\text{min}^{-1}$. This simple relation is fundamental to enzyme kinetics and is often used experimentally: measuring velocity at substrate equal to $K_M$offers a direct route to estimate maximum catalytic capacity without needing saturating substrate concentrations, assuming the enzyme obeys classic Michaelis–Menten behavior and single-substrate irreversible kinetics. The answer assumes steady-state conditions, negligible product inhibition and that the reported velocity is measured under initial-rate conditions where substrate depletion and reverse reactions are insignificant.

Q.20 The enzyme glucose isomerase catalyzes the inter-conversion of glucose and fructose as shown.

Glucose ⇄ Fructose

The ΔG0 for this reaction is zero kcal/mol. After adding glucose isomerase to a 0.12 M glucose solution and allowing the reaction to attain equilibrium, the final concentration of fructose in the reaction mixture will be _____ mM.

(2020)

Answer: 60
Explanation: For the interconversion of glucose and fructose catalyzed by glucose isomerase, the standard Gibbs free energy change (ΔG°) is zero, meaning that the reaction is at thermodynamic equilibrium when the concentrations of glucose and fructose are equal. The equilibrium constant $K_{eq} = e^{-\Delta G^\circ/RT}$therefore equals 1, implying that the forward and reverse reactions are equally favored. Starting with 0.12 M (or 120 mM) glucose and no fructose initially, the system will proceed until the concentrations of glucose and fructose become equal at equilibrium. Let the equilibrium concentration of fructose be xmM; then the remaining glucose concentration will be $120 - x$. Since $K_{eq} = [\text{fructose}]/[\text{glucose}] = 1$, it follows that $x = 120 - x$, giving $x = 60$mM. Thus, at equilibrium, both glucose and fructose are present at equal concentrations of 60 mM each. This reflects complete attainment of equilibrium in a reversible isomerization with zero net free energy change.

XL: Life Sciences - R: Botany

Q.1 Indefinite stamen is a characteristic feature of which of the following plant families?

(A) Malvaceae
(B) Apocynaceae
(C) Poaceae
(D) Brassicaceae

(2020)

Answer: (A) Malvaceae
Explanation: In Malvaceae, flowers are typically actinomorphic and bisexual with numerous stamens arranged in a staminal column around the pistil. The number of stamens is not fixed, hence described as "indefinite," which contrasts with families like Brassicaceae or Poaceae that have a fixed stamen number. This adaptation allows for more efficient pollen dispersal and increases reproductive success. Other families, such as Apocynaceae, have a definite number of stamens, usually five, arranged opposite the petals. Therefore, the indefinite stamen is a defining characteristic of the Malvaceae family.

Q.2 In natural condition, which of the following plants DOES NOT exhibit anomalous secondary growth?

(A) Rice
(B) Aloe
(C) Yucca
(D) Dracaena

(2020)

Answer: (A) Rice
Explanation: Anomalous secondary growth refers to secondary thickening that deviates from the normal pattern seen in dicot stems. Plants like Aloe, Yucca, and Dracaena exhibit this type of growth due to the activity of secondary meristems like the anomalous cambium. Rice, a monocot, typically lacks secondary growth because it does not possess a vascular cambium, and its stem thickening is primarily primary growth. This makes rice a typical example of monocots without anomalous secondary growth. Hence, rice maintains the usual primary growth pattern without forming woody secondary tissues.

Q.3 In a typical angiosperm under natural condition, primary meristems are usually established during:

(A) Gametogenesis
(B) Embryogenesis
(C) Vegetative phase development
(D) Secondary growth

(2020)

Answer: (B) Embryogenesis
Explanation: Primary meristems, including protoderm, procambium, and ground meristem, are established during embryogenesis. These meristems give rise to primary tissues such as epidermis, primary xylem, phloem, and ground tissue. During embryogenesis, cells differentiate to form the root and shoot apical meristems, ensuring proper growth after germination. This initial establishment is critical for the plant's development and ensures proper formation of the plant body plan. Vegetative phase development or secondary growth occurs later and relies on these primary meristems.

Q.4 2-Methoxy-3, 6-dichlorobenzoic acid belongs to which class of plant growth regulators?

(A) Synthetic auxin
(B) Synthetic cytokinin
(C) Strigolactone
(D) Brassinosteroid

(2020)

Answer: (A) Synthetic auxin
Explanation: 2-Methoxy-3,6-dichlorobenzoic acid is a synthetic auxin that mimics the natural plant hormone indole-3-acetic acid (IAA). Synthetic auxins are commonly used to regulate plant growth, promote rooting, and control unwanted vegetation. They act by stimulating cell elongation and division, similar to natural auxins, but often with greater stability and specificity. Other classes of growth regulators, such as cytokinins, strigolactones, or brassinosteroids, have distinct roles in shoot branching, seed germination, and stress responses. Hence, this compound is categorized as a synthetic auxin.

Q.5 In a typical green plant, the first stable product of Calvin cycle is:

(A) Oxaloacetic acid
(B) Succinic acid
(C) Maleic acid
(D) 3-Phosphoglyceric acid

(2020)

Answer: (D) 3-Phosphoglyceric acid
Explanation: In the Calvin cycle, CO_2 fixation occurs through ribulose-1,5-bisphosphate (RuBP) catalyzed by RuBisCO. The immediate product, a highly unstable 6-carbon intermediate, quickly splits into two molecules of 3-phosphoglyceric acid (3-PGA). 3-PGA is considered the first stable product and enters subsequent steps to produce glyceraldehyde-3-phosphate. Other acids listed, like oxaloacetic, succinic, or maleic acid, are intermediates in other metabolic pathways like TCA cycle or C4 photosynthesis. Therefore, 3-PGA is the primary stable product of the Calvin cycle in C3 plants.

Q.6 Among the following, which best describes an organism that lives at the expense of other organisms, harmful but usually not killing?

(A) Predator
(B) Symbiotic
(C) Prey
(D) Parasite

(2020)

Answer: (D) Parasite
Explanation: A parasite is an organism that derives nutrients and shelter from another living organism, the host, causing harm but typically not immediate death. This distinguishes it from predators, which kill and consume prey, and from mutualistic symbionts, which provide reciprocal benefits. Parasites have evolved specific adaptations such as attachment organs and enzymes to exploit the host efficiently. Examples include Plasmodium in humans or Cuscuta in plants. Their life strategy ensures survival and reproduction while maintaining the host organism alive.

Q.7 The oleo-gum resin asafoetida (hing) is obtained from the cut surface of:

(A) Stem
(B) Root
(C) Leaf
(D) Fruit

(2020)

Answer: (B) Root
Explanation: Asafoetida is obtained from the tap roots and rhizomes of Ferula species. Upon cutting, the resin exudes as a gum which, when dried, forms the commercially used spice. This oleo-gum resin contains bioactive compounds like ferulic acid and sulfur-containing derivatives responsible for its characteristic odor and medicinal properties. While some plant resins come from stems or bark, asafoetida is unique for being extracted from roots. This method ensures sustainable harvesting without destroying the entire plant.

Q.8 'Bakanae' disease or 'foolish seedling' disease is caused by:

(A) Fungus
(B) Bacterium
(C) Virus
(D) Mycoplasma

(2020)

Answer: (A) Fungus
Explanation: Bakanae disease in rice is caused by the fungus Fusarium fujikuroi. The pathogen produces gibberellins, plant hormones that cause excessive elongation of seedlings, making them weak and prone to lodging, hence the name "foolish seedling." This disease leads to significant yield losses if uncontrolled. Other pathogens like bacteria, viruses, or mycoplasmas cause distinct plant diseases but do not produce the characteristic elongation symptoms of Bakanae. Fungicidal treatments and resistant varieties are commonly used for management.

Q.9 Which of the following chemicals is used for doubling of chromosome numbers during production of 'doubled haploids in crop plants?

(A) Hygromycin
(B) Kanamycin
(C) Colchicine
(D) Glufosinate

(2020)

Answer: (C) Colchicine
Explanation: Colchicine is a chemical agent that disrupts spindle fiber formation during mitosis, preventing chromosome segregation. This leads to chromosome doubling, producing diploid plants from haploid tissues, which are called doubled haploids. Doubled haploids are crucial in plant breeding for achieving homozygous lines rapidly. Other chemicals like hygromycin or kanamycin act as selection agents but do not alter ploidy. Therefore, colchicine is widely used for chromosome doubling in haploid plant tissues.

Q.10 An mRNA of a nuclear encoded plant gene, DSH20 has an ORF of 1353 nucleotides. Provided that average molecular weight of amino acid is 110 Dalton (Da), calculated molecular weight of DSH20 protein in kDa (round off to 1 decimal place) is:

(2020)

Answer: 49.5
Explanation: The ORF of 1353 nucleotides codes for $1353 \div 3 = 451$ amino acids. Assuming an average molecular weight of 110 Da per amino acid, the protein mass is $451 \times 110 = 49{,}610$ Da, which equals approximately 49.6 kDa. Rounded to 1 decimal place, the molecular weight is 49.5 kDa. This estimation ignores post-translational modifications, which may slightly alter the actual mass. Therefore, the calculation provides a reliable approximate weight of the protein encoded by DSH20.

Q.11 Group I, Group II and Group III represent enzyme, product of the enzymatic reaction, and metabolic process, respectively.

Group I	Group II	Group III
P. Hexokinase	i. Malate	1. Glycolysis
Q. Fumarase	ii. Glucose 6-P	2. Photorespiration
R. PEP Carboxylase	iii. Hydrogen peroxide	3. TCA cycle
S. Glycolate oxidase	iv. Cinnamic acid	4. Photosynthesis
	v. Oxaloacetic acid	

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

(2020)

Answer: (B) P-ii-1, Q-i-3, R-v-4, S-iii-2
Explanation: Hexokinase (P) converts glucose into glucose-6-phosphate (ii) and is involved in glycolysis (1). Fumarase (Q) catalyzes the hydration of fumarate (i) in the TCA cycle (3). PEP carboxylase (R) fixes CO_2 into oxaloacetic acid (v) during photosynthesis (4). Glycolate

oxidase (S) produces hydrogen peroxide (iii) during photorespiration (2). This matching is based on well-established enzyme-product relationships and the metabolic pathway in which each enzyme functions. It highlights the interconnection between enzymatic reactions and plant metabolism.

Q.12 Match the following in CORRECT combination between Group I and Group II with reference to the agents that interfere with oxidative phosphorylation

Group I	Group II
P. Cyanide	i. Blocks electron transfer from cyt *b* to cyt c_1
Q. Antimycin A	ii. Inhibits F_1
R. Aurovertin	iii. Uncoupling of phosphorylation from electron transfer
S. 2,4-Dinitrophenol	iv. Inhibits cytochrome oxidase
	v. Inhibits K^+ ionophore

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

(2020)

Answer: (A) P-iv, Q-i, R-ii, S-iii
Explanation: Cyanide (P) inhibits cytochrome oxidase (iv) in the electron transport chain, blocking electron transfer and halting ATP production. Antimycin A (Q) blocks electron transfer from cytochrome b to cytochrome c_1 (i). Aurovertin (R) inhibits the F_1 portion of ATP synthase (ii), preventing ATP synthesis. 2,4-Dinitrophenol (S) acts as an uncoupler (iii), dissipating the proton gradient and allowing electron transport without ATP generation. This classification reflects the mechanism by which these agents interfere with oxidative phosphorylation in plant mitochondria.

Q.13 In relation to Agrobacterium mediated genetic engineering in plants, match the following in CORRECT combination.

Gene name	Function
P. *virA*	i. Acetosyringone receptor
Q. *virB*	ii. Conjugal tube formation
R. *virD1*	iii. Topoisomerase
S. *virG*	iv. Inducer of all *vir* operons
	v. Octopine synthesis

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

(2020)

Answer: (C) P-i, Q-ii, R-iii, S-iv
Explanation: In Agrobacterium tumefaciens, virA (P) acts as an acetosyringone receptor (i), detecting plant signals to activate other vir genes. virB (Q) forms the conjugal tube (ii) through which T-DNA is transferred. virD1 (R) functions as a topoisomerase (iii) facilitating T-DNA processing. virG (S) acts as a transcriptional activator inducing other vir genes (iv). This coordinated action enables the transfer of T-DNA from bacteria into the plant genome, forming transgenic plants efficiently, which is the basis of Agrobacterium-mediated transformation.

Q. 14 Match the plant part (Group 1) with the product obtained (Group II) and the representative plant species (Group III) in CORRECT combination.

Group I	Group II	Group III
P. Bark	i. Tannins	1. *Papaver somniferum*
Q. Leaf	ii. Saffron	2. *Camellia sinensis*
R. Flower	iii. Codeine	3. *Cinnamomum zeylanicum*
S. Fruit	iv. Aromatic oil	4. *Crocus sativus*

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

(2020)

Answer: (D) P-iv-3, Q-i-2, R-ii-4, S-iii-1
Explanation: The bark of Cinnamomum zeylanicum (P) provides aromatic oils (iv). Leaves of Camellia sinensis (Q) are rich in tannins (i). Crocus sativus flowers (R) provide saffron (ii). Fruits of Papaver somniferum (S) yield codeine (iii). These matches are based on commercial and pharmacological extraction of bioactive compounds from plant parts. Each combination illustrates the importance of plant tissue specificity in producing economically significant secondary metabolites.

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

Disease	Causal organism	Affected plant
P. Stem rust	i. *Cercospora personata*	1. Wheat
Q. Wart disease	ii. *Plasmopara viticola*	2. Ground nut
R. Tikka/leaf spot	iii. *Synchytrium endobioticum*	3. Potato
S. Downey mildew	iv. *Puccinia graminis*	4. Grape
		5. Apple
		6. Rice

(A) P-iv-1, Q-iii-3, R-i-2, S-ii-4
(B) P-ii-1, Q-i-6, R-iv-4, S-iii-2
(C) P-iii-1, Q-iv-3, R-i-5, S-ii-4
(D) P-iv-1, Q-ii-3, R-iii-2, S-i-5

(2020)

Answer: (A) P-iv-1, Q-iii-3, R-i-2, S-ii-4
Explanation: Stem rust (P) is caused by Puccinia graminis (iv) affecting wheat (1). Wart disease (Q) is caused by Synchytrium endobioticum (iii) affecting potato (3). Tikka or leaf spot (R) is caused by Cercospora personata (i) affecting groundnut (2). Downey mildew (S) is caused by Plasmopara viticola (ii) affecting grape (4). The matching demonstrates the specific host-pathogen relationships in plant pathology. Correct identification is essential for effective disease management and crop protection strategies.

Q.16 Match the following alkaloids with their uses and source plants in CORRECT combination.

Alkaloid	Use	Source plant
P. Morphine	i. Anti-cancer	1. *Cinchona officinalis*
Q. Quinine	ii. Analgesic	2. *Catharanthus roseus*
R. Atropine	iii. Anti-cholinergic	3. *Papaver somniferum*
S. Vinblastine	iv. Anti-malarial	4. *Hyoscyamus niger*

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

(2020)

Answer: (A) P-ii-3, Q-iv-1, R-iii-4, S-i-2
Explanation: Morphine (P) is an analgesic (ii) obtained from Papaver somniferum (3). Quinine (Q) is an anti-malarial (iv) sourced from Cinchona officinalis (1). Atropine (R) is an anti-cholinergic agent (iii) obtained from Hyoscyamus niger (4). Vinblastine (S) is an anti-cancer compound (i) sourced from Catharanthus roseus (2). These alkaloids are secondary metabolites with significant medicinal properties. The correct matching demonstrates the link between bioactive compounds, their pharmacological use, and plant origin.

Q.17 Match the following ecological terms with their appropriate definitions.

Term	Definition
P. Niche	i. Position of a species in food chain
Q. Biotas	ii. Place of a living organism in the biotic environment and its relations to food and enemies
R. Trophic level	iii. Physical environment of an organism
S. Habitat	iv. Totality of organisms (flora and fauna) in a given place or region

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

(2020)

Answer: (B) P-ii, Q-iv, R-i, S-iii
Explanation: Niche (P) refers to the functional role or position of a species in an ecosystem (ii), encompassing interactions and resource use. Biotas (Q) represent the totality of organisms in a given place (iv). Trophic level (R) is the position of a species in the food chain (i), such as producer or consumer. Habitat (S) is the physical environment where a species lives (iii). This classification helps understand ecosystem structure, species interactions, and the distribution of organisms in ecological studies.

Q.18 Arrange the following 'water reservoirs of earth' in decreasing order of water volume

Reservoirs

P- Streams
Q- Groundwater
R-Glaciers
S- Lakes and inland seas

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

(2020)

Answer: (A) R-Q-S-P
Explanation: Glaciers and ice caps (R) store the largest portion of Earth's freshwater, followed by groundwater (Q), which resides in aquifers. Lakes and inland seas (S) contain smaller quantities, while streams (P) hold minimal water. This ranking reflects the relative volume of Earth's hydrosphere and is critical for water resource management. Understanding reservoir distribution is

important for climate studies, freshwater availability, and ecological balance. Hence, glaciers > groundwater > lakes > streams is the correct order.

Q.19 Selection markers and the corresponding genes used in plant genetic engineering are given below.

Selection Marker	Gene
P. Kanamycin	i. *hptIV*
Q. Hygromycin	ii. *bar*
R. Bialaphos	iii. *pmi*
S. Mannose	iv. *nptII*

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

(2020)

Answer: (C) P-iv, Q-i, R-ii, S-iii
Explanation: Kanamycin resistance is conferred by the nptII gene (iv), hygromycin by hptIV (i), bialaphos by bar (ii), and mannose selection is based on pmi (iii). Selection markers are critical in plant genetic engineering to identify successfully transformed cells. These genes encode proteins that detoxify antibiotics or enable alternative metabolism, allowing only transformed cells to survive. Correct pairing ensures efficient selection and avoids false positives. These markers are routinely used in transgenic crop production.

Q.20 A double homozygous mutant develops green and wrinkled seeds. When it was crossed with a true-breeding plant having yellow and round seeds, all the F1 plants developed yellow and round seeds. After self-fertilization of F1, the calculated percentage probability of plants with green and wrinkled seeds in the F2 population (round off to 2 decimal places) is____

(2020)

Answer: 6.25

Explanation: *In a classic dihybrid cross involving seed color and shape, a double homozygous mutant plant with green and wrinkled seeds (genotype **rryy**) is crossed with a true-breeding plant with yellow and round seeds (genotype **RRYY**). All F1 offspring from this cross are heterozygous (**RrYy**) and display the dominant traits—yellow and round seeds. When these F1 plants are self-fertilized, the F2 generation follows a Mendelian 9:3:3:1 phenotypic ratio. Among the 16 possible combinations, only one corresponds to the double recessive genotype **rryy**, which results in green and wrinkled seeds. Therefore, the probability of obtaining plants with green and wrinkled seeds in the F2 generation is **1 out of 16**, or **6.25%**.*

XL: Life Sciences - S: Microbiology

Q. 1 The technique of microbial "pure culture" was pioneered by:
(A) Edward Jenner
(B) Louis Pasteur
(C) Robert Hooke
(D) Robert Koch

(2020)

Answer: (D) Robert Koch

Explanation: *The concept and practical methodology of achieving a **microbial pure culture** were fundamentally established by **Robert Koch** in the late 19th century. A pure culture, which contains only one species or strain of microorganism, is essential for proving the causal relationship between a microbe and a specific disease, a principle outlined in his famous **Koch's Postulates**. Koch's lab successfully developed techniques like using solid media (initially potato slices and later gelatin or agar) and the **streak-plate method** to isolate individual colonies arising from a single cell, thereby ensuring a population free of contamination. This innovation was revolutionary, allowing for the definitive study and identification of pathogens, including Mycobacterium tuberculosis and Vibrio cholerae.*

Q.2 The antibacterial trimethoprim is an inhibitor of
(A) dihydrofolate reductase
(B) dihydropteroate synthetase
(C) serine hydroxymethyl transferase
(D) N5, N10-methenyl tetrahydrofolate synthetase

(2020)

Answer: (A) dihydrofolate reductase

Explanation: *The antibacterial drug **trimethoprim** functions by specifically inhibiting the enzyme **dihydrofolate reductase (DHFR)**. This enzyme plays a crucial role in the folate pathway, which is essential for the synthesis of nucleotides and, consequently, DNA replication and cell division. By blocking DHFR, trimethoprim prevents the conversion of dihydrofolate to tetrahydrofolate, leading to a depletion of tetrahydrofolate and ultimately inhibiting bacterial growth. This selective inhibition is more effective against bacterial DHFR than the human version, making it a valuable antimicrobial agent. Therefore, the correct answer is **(A) dihydrofolate reductase**.*

Q. 3 Choose the correct taxonomical hierarchy among the following:
(A) Species, Genus, Family, Order, Class, Phylum, Domain
(B) Species, Genus, Order, Class, Family, Phylum, Domain

(C) Species, Genus, Order, Family, Class, Phylum, Domain
(D) Species, Genus, Family, Class, Order, Phylum, Domain

(2020)

Answer: (A) Species, Genus, Family, Order, Class, Phylum, Domain

Explanation: *The correct sequence for the major categories of the **Linnaean taxonomic hierarchy**, from the most specific to the most general, is **Species, Genus, Family, Order, Class, Phylum/Division, Kingdom, and Domain**. The **Species** is the most specific rank, representing a group of organisms that can interbreed, while the **Domain** is the broadest, classifying all life into three super-groups: Bacteria, Archaea, and Eukarya. As we move up from Species to Domain, the categories become **more inclusive** and contain organisms that are progressively **less closely related**. This standardized, nested hierarchy provides a uniform system for classifying and naming all living organisms based on their shared evolutionary history and characteristics.*

Q.4 Shifting a Saccharomyces cerevisiae culture from fermentative to aerobic respiratory mode will
(A) decrease carbon dioxide production
(B) increase alcohol production
(C) increase glucose consumption
(D) decrease ATP generation per mole of glucose

(2020)

Answer: (A) decrease carbon dioxide production

Explanation: *When Saccharomyces cerevisiae (baker's yeast) shifts from a **fermentative** to an **aerobic respiratory** mode, its metabolism changes significantly. Under fermentative conditions, even in the presence of oxygen (a phenomenon known as the Crabtree effect), yeast primarily converts glucose to **ethanol and carbon dioxide**, producing relatively little ATP. However, when switched to aerobic respiration, yeast fully oxidizes glucose via the **tricarboxylic acid (TCA) cycle** and **oxidative phosphorylation**, leading to a much higher yield of ATP per mole of glucose and **less carbon dioxide production** per mole of glucose consumed. This is because fermentation produces two molecules of CO_2 per glucose, while aerobic respiration produces fewer CO_2 molecules relative to the amount of ATP generated. Thus, the shift to aerobic respiration results in **decreased CO_2 production**.*

Q.5 Which one of the following diseases is treated by a neuraminidase inhibitor?
(A) Chickenpox
(B) Polio
(C) Influenza
(D) Japanese encephalitis

(2020)

Answer: (C) Influenza

Explanation: *__Neuraminidase inhibitors__ are a class of antiviral drugs specifically designed to treat __Influenza__, commonly known as the flu. The influenza virus possesses the enzyme __neuraminidase__ on its surface, which is crucial for the __release of newly formed virions__ from the infected host cell membrane. Neuraminidase cleaves sialic acid residues, which otherwise tether the progeny viruses to the cell surface, allowing them to spread and infect other cells. Drugs like __Oseltamivir (Tamiflu)__ and __Zanamivir (Relenza)__ function by __blocking the active site__ of this viral neuraminidase. By inhibiting this enzyme, the release of new virus particles is prevented, effectively __limiting the spread__ of the infection within the respiratory tract and shortening the duration of the illness.*

Q.6 Which one of the following does NOT provide three-dimensional images?
(A) Atomic force microscopy
(B) Confocal scanning laser microscopy
(C) Differential interference contrast microscopy
(D) Phase-contrast microscopy

(2020)

Answer: (D) Phase-contrast microscopy

Explanation: *__Phase-contrast microscopy__ is a type of light microscopy that is primarily designed to enhance the contrast of __transparent and unstained biological specimens__, such as living cells. It achieves this by converting __subtle differences in the refractive index and thickness__ within a specimen into corresponding __differences in light intensity__ (brightness or darkness) visible to the eye. While it provides excellent detail regarding internal cellular structures and morphology, it ultimately produces a __two-dimensional image__, as it relies on transmitted light waves that are interpreted across a single plane. In contrast, techniques like Atomic Force Microscopy, Confocal Scanning Laser Microscopy, and Differential Interference Contrast Microscopy (DIC) use different mechanisms to gather topographical or volumetric data, enabling the construction of a __three-dimensional__ representation.*

Q.7 Which one of the following will increase the resolution of a light microscope?
(A) Decreasing the numerical aperture of the objective lens
(B) Using an objective lens with a longer working distance
(C) Using a medium of higher refractive index
(D) Increasing the wavelength of light

(2020)

Answer: (C) Using a medium of higher refractive index

Explanation: *The resolution of a light microscope refers to its ability to distinguish two closely spaced objects as separate entities. This resolving power is influenced by several factors, including the wavelength of light used, the numerical aperture of the objective lens, and the refractive index of the medium between the specimen and the*

lens. Among the options provided, using a medium with a higher refractive index improves resolution because it increases the numerical aperture, thereby allowing the microscope to gather more diffracted light and resolve finer details. In contrast, decreasing the numerical aperture, using a lens with a longer working distance, or increasing the wavelength of light would all reduce the resolving power. Therefore, the correct choice is using a medium of higher refractive index, as it enhances the microscope's ability to distinguish minute structural details.

Q.8 Which one of the following conditions favors maximum expression of lac operon genes in E. coli?

(A) Glucose-low, lactose-low, cAMP-high
(B) Glucose-high, lactose-low, cAMP-high
(C) Glucose-low, lactose-high, cAMP-high
(D) Glucose-high, lactose-high, cAMP-low

(2020)

Answer: (C) Glucose-low, lactose-high, cAMP-high

Explanation: *The **lac operon** in E. coli is regulated by the availability of glucose and lactose. For maximum expression of lac operon genes, two conditions must be met: **lactose must be present** to inactivate the lac repressor, and **glucose must be low** to increase the levels of **cyclic AMP (cAMP)**. High cAMP levels activate the **catabolite activator protein (CAP)**, which binds to the promoter region of the lac operon and enhances transcription. When glucose is abundant, cAMP levels drop, reducing CAP activity and thus decreasing lac operon expression. Therefore, the condition that favors maximum expression is when **glucose is low**, **lactose is high**, and **cAMP is high**, making **option (C)** the correct choice.*

Q.9 Match the cellular organelle in Group I with its function in Group II.

Group I	Group II
P. Golgi apparatus	1. Lipid degradation
Q. Nucleolus	2. Protein degradation
R. Peroxisome	3. Protein sorting
S. Proteasome	4. Ribosomal RNA synthesis

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

(2020)

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

Explanation: *The correct matching aligns each cellular organelle in Group I with its primary function in Group II. The **Golgi apparatus (P)** serves as the central **protein sorting** and packaging center, modifying proteins and lipids synthesized in the Endoplasmic Reticulum and directing them to their final destinations (P-3). The **Nucleolus (Q)** is the site within the nucleus dedicated to the synthesis of **ribosomal RNA** and the assembly of ribosomal subunits (Q-4). **Peroxisome (R)** is an organelle specializing in various metabolic processes, notably the breakdown and **degradation of fatty acids and lipids** through -oxidation (R-1). Finally, the **Proteasome (S)** is a large, multi-protein complex primarily responsible for the controlled **degradation of damaged or unwanted cellular proteins** through the ubiquitin-proteasome pathway (S-2).*

Q.10 A 250 µl of bacteriophage stock containing 8x10^8 phages/ml is added to 500 µl of E. coli culture containing 4x10^8 cells/ml. The multiplicity of infection is

(2020)

Answer: 1

Explanation: *To calculate the multiplicity of infection (MOI), which is the ratio of infecting phage particles to host bacterial cells, we consider the number of each in the mixture. In this case, 250 µl of bacteriophage stock containing 8×1088 \times 10^88×108 phages/ml is mixed with 500 µl of E. coli culture containing 4×1084 \times 10^84×108 cells/ml. This results in 2×1082 \times 10^82×108 phages (0.25 ml × 8×1088 \times 10^88×108) and 2×1082 \times 10^82×108 bacterial cells (0.5 ml × 4×1084 \times 10^84×108). The MOI is calculated by dividing the number of phages by the number of host cells, which gives an MOI of 1. This means that, on average, each bacterial cell is infected by one phage particle.*

Q.11 Digestion of an immunoglobulin G (IgG) molecule with pepsin will NOT

(A) generate a bivalent antigen binding fragment
(B) generate monovalent antigen binding fragments
(C) destroy the complement binding site
(D) cleave the heavy chain of IgG molecule

(2020)

Answer: (B) generate monovalent antigen binding fragments

Explanation: *When an **IgG molecule** is digested with **pepsin**, the enzyme cleaves the antibody **below the hinge region**, preserving the two antigen-binding Fab regions as a single, connected **bivalent fragment** known as **F(ab')** 2. This fragment retains the ability to bind two identical antigens simultaneously. Pepsin digestion also **destroys the Fc region**, which includes the **complement binding site**, and **cleaves the heavy chains**. Therefore, pepsin digestion does **not** produce **monovalent** antigen-binding fragments (which are instead generated by **papain** digestion), making **option (B)** the correct answer.*

Q.12 Match the process involved in nitrogen or sulfur cycle in Group I with the corresponding microbe in Group II.

Group I	Group II
P. Denitrification	1. *Azotobacter*
Q. Nitrogen fixation by free-living microbe	2. *Beggiatoa*
R. Oxidation of H_2S to sulfur	3. *Pseudomonas*
S. Nitrogen fixation by a symbiotic microbe	4. *Rhizobium*

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

(2020)

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

Explanation: *The correct matching is **P-3, Q-1, R-2, S-4**, which corresponds to option (D). Denitrification is carried out by Pseudomonas species, which reduce nitrate to nitrogen gas. Free-living nitrogen fixation is performed by Azotobacter, a soil bacterium that fixes atmospheric nitrogen without a plant host. Oxidation of hydrogen sulfide (H_2S) to elemental sulfur is done by Beggiatoa, a sulfur-oxidizing bacterium. Finally, symbiotic nitrogen fixation occurs in association with leguminous plants and is mediated by Rhizobium, which forms root nodules to convert atmospheric nitrogen into ammonia. Thus, option (D) correctly represents the processes and their corresponding microbes.*

Q.13 Determine the correctness or otherwise of the following Assertion [a] and the Reason [r].
Assertion [a]: Diphtheria exotoxin is an example of A-B type toxin.
Reason [r]: The A component of the toxin is released from the host cell while the B component inhibits protein synthesis and kills the host cell.
(A) Both [a] and [r] are true and [r] is the correct reason for [a]
(B) Both [a] and [r] are true but [r] is not the correct reason for [a]
(C) Both [a] and [r] are false
(D) [a] is true but [r] is false

(2020)

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

Explanation: *The assertion is correct because **diphtheria exotoxin** is indeed an **A-B type toxin**, where the **A (active)** component inhibits protein synthesis by catalyzing ADP-ribosylation of elongation factor-2 (EF-2), leading to cell death. The **B (binding)** component facilitates the attachment of the toxin to the host cell and mediates entry of the A fragment into the cytosol.*

*The reason given is false because it incorrectly states that the A component is released from the host cell and the B component inhibits protein synthesis. In reality, the **A component remains inside the host cell and inhibits protein synthesis**, while the **B component only helps in binding and entry**; it does not kill the cell.*

Q.14 Which one of the following statements about control of microbial growth is NOT correct?
(A) Nonionizing radiation leads to thymine dimers formation in DNA
(B) Spirochetes and mycoplasma can pass through membrane filters (0.22-0.45 μm)
(C) Use of high concentration of salts and sugars to preserve food is a chemical method of microbial control
(D) Thermoduric bacteria can survive pasteurization

(2020)

Answer: (C) Use of high concentration of salts and sugars to preserve food is a chemical method of microbial control

Explanation: *The statement that the use of high concentrations of salts and sugars for food preservation is a **chemical method** of microbial control is **NOT correct**. Preservation using high salt or sugar concentrations, such as in making jellies or curing meat, is fundamentally a **physical method of control** based on the principle of **osmosis**. These high solute concentrations create a **hypertonic environment** outside the microbial cell. This difference in osmotic pressure forces water to move out of the microbial cell, causing the cell to **dehydrate and shrink (plasmolysis)**, effectively inhibiting its growth and metabolism. While a chemical substance (salt or sugar) is used, the mechanism of microbial inhibition is physical (osmotic stress), not a direct chemical reaction against a cellular component, which would define a true chemical control method.*

Q.15 An example of a differential and selective medium in which colonies of Gram-negative bacteria produce large amounts of acidic products and appear green with a metallic sheen is
(A) Blood agar
(B) EMB agar
(C) MacConkey agar
(D) Mannitol salt agar

(2020)

Answer: (B) EMB agar

Explanation: *The medium described is **Eosin Methylene Blue (EMB) agar**. EMB agar is both a **selective** and a **differential** medium used for the isolation and identification of Gram-negative enteric bacteria. It is selective because the dyes **Eosin Y and Methylene Blue** inhibit the growth of most Gram-positive bacteria. It is differential because it contains the sugar **lactose**. When **Gram-negative bacteria ferment lactose vigorously** and produce large amounts of mixed acids, the resulting low causes the dyes to precipitate and concentrate within the colonies. This reaction results in the distinctive appearance of colonies with a **dark center and a bright, characteristic metallic green sheen**, which is a classic indicator of vigorous lactose fermenters, most notably **E. coli**.*

Q.16 Which one of the following is an example of substrate level phosphorylation?
(A) Glucose to Glucose 6-phosphate
(B) Fructose 6-phosphate to Fructose 1,6-bisphosphate
(C) 1,3-bisphosphoglycerate to 3-phosphoglycerate
(D) 2-phosphoglycerate to Phosphoenolpyruvate

(2020)

Answer: (C) 1,3-bisphosphoglycerate to 3-phosphoglycerate

Explanation: *Substrate-level phosphorylation refers to the direct synthesis of ATP from ADP using a high-energy intermediate during a metabolic pathway, without involving the electron transport chain. In glycolysis, the conversion of 1,3-bisphosphoglycerate to 3-phosphoglycerate is catalyzed by the enzyme phosphoglycerate kinase, and this reaction transfers a phosphate group from the substrate (1,3-BPG) to ADP, forming ATP. The other options involve phosphorylation steps that consume ATP or rearrange molecules, not generate ATP.*

Q.17 A bacterial culture containing $3x10^5$ live cells was exposed to a newly developed sterilizing agent. After 30 minutes of exposure, 3 live cells remained in culture. The decimal reduction time (in minutes) for the new agent is

(2020)

Answer: 6

Explanation: *The decimal reduction time (D-value) is the time required to reduce a microbial population by 90% (one log reduction). In this case, the initial bacterial count was 3 × 10^5 cells, and after 30 minutes of exposure to the sterilizing agent, only 3 cells remained. The log reduction is calculated as log10(3 × 10^5) − log10(3) = 5, meaning there were five log reductions in 30 minutes. Therefore, the D-value is 30 minutes ÷ 5 = 6 minutes. This indicates that every 6 minutes of exposure reduces the bacterial population by 90%.*

Q.18 A bacterial culture has a generation time of 34 minutes. The time taken (in minutes, rounded off to two decimal places) for the OD550 of this exponentially growing culture to increase from 0.25 to 0.85 is Assume that OD_{550} has a linear relationship with the cell density.

(2020)

Answer: 58.50 – 61.50

Explanation: *To determine the time required for a bacterial culture's OD_{550} to increase from 0.25 to 0.85 during exponential growth, we use the principle that optical density is directly proportional to cell density. The formula for exponential growth is N(t)=N0·2t/GN(t) = N_0 \cdot 2^{t/G}N(t)=N0·2t/G, where N0N_0N0 is the initial OD, N(t)N(t)N(t) is the final OD, GGG is the generation time (34 minutes), and ttt is the time to be calculated. By rearranging and solving the equation 0.850.25=2t/34\frac{0.85}{0.25} = 2^{t/34}0.250.85=2t/34, we find that the OD increases by a factor of 3.4. Taking the base-2 logarithm of 3.4 gives approximately 1.765, and multiplying this by the generation time yields a time of about 60.01 minutes. This value falls within the expected range of 58.50 to 61.50 minutes.*

Q.19 A 100 µl aliquot (10^{-4} dilution) of the bacterial culture plated on the nutrient agar gave 4 colonies. The bacterial stock concentration (in million cells/ml, rounded off to one decimal place) is

(2020)

Answer: 0.4

Explanation: *A 100 µl aliquot of a 10^{-4} dilution of a bacterial culture was plated on nutrient agar and yielded 4 colonies. Since 100 µl is equivalent to 0.1 ml, this means there were 4 colony-forming units (CFUs) in 0.1 ml of the diluted sample, which corresponds to 40 CFUs per ml in the 10^{-4} dilution. To find the concentration in the original stock, we multiply this by the dilution factor (10^4), resulting in 400,000 CFUs per ml. Converting this to million cells per ml by dividing by 1,000,000 gives a final concentration of* ***0.4 million cells/ml****.*

Q. 20 A continuous bacterial culture carried out in a chemostat is set to a flow rate of 40 ml/hr. The culture volume is equivalent to that of a cubical container having 10 cm sides. The dilution rate (in hr^{-1}, rounded off to two decimal places) of this system is

(2020)

Answer: 0.04 hr^{-1}

Explanation: *The dilution rate (D) in a chemostat is defined as the ratio of the volumetric flow rate (F) to the culture volume (V), expressed as $D = \frac{F}{V}$. Here, the flow rate is given as 40 mL/hr and the culture vessel is a cube with 10 cm sides. The volume of the vessel equals $10\ cm \times 10\ cm \times 10\ cm = 1000\ cm^3$, which is equivalent to 1000 mL since 1 cm^3 = 1 mL. Substituting the given values, $D = \frac{40}{1000} = 0.04\ hr^{-1}$. This means that in one hour, 4% of the total reactor contents are replaced with fresh medium, maintaining a steady-state microbial population when the growth rate equals this dilution rate. The calculated dilution rate directly determines how fast nutrients are supplied and wastes are removed, ensuring stable continuous culture conditions without washout.*

Q. 1 Which ONE of following leucocytes is phagocytic and has clear cytoplasm?
(A) Eosinophil
(B) Monocyte
(C) TH-lymphocyte
(D) Basophil

(2020)

Answer: (B) Monocyte

Explanation: *Monocytes are a type of white blood cell that are phagocytic in nature, meaning they can engulf and digest cellular debris, foreign substances, microbes, and cancer cells. They are large leukocytes with a **clear cytoplasm**, which distinguishes them from other granulocytes like eosinophils or basophils that contain colored granules. TH-lymphocytes, being T-helper cells, are not phagocytic and function primarily in adaptive immunity by signaling other immune cells. Monocytes circulate in the blood and migrate into tissues where they differentiate into macrophages or dendritic cells to perform their immune functions. Their clear cytoplasm under a microscope reflects the absence of prominent granules, making them identifiable in blood smears.*

Q.2 Which ONE of the following techniques can be used for detecting the subcellular localization of serotonin receptor in intact cells?
(A) Immunoelectron microscopy
(B) SDS-PAGE
(C) Fluorescence in-situ hybridization
(D) Differential centrifugation

(2020)

Answer: (A) Immunoelectron microscopy

Explanation: *Immunoelectron microscopy combines the specificity of immunolabeling with the high-resolution imaging of electron microscopy, allowing visualization of **subcellular localization of proteins** such as serotonin receptors in intact cells. SDS-PAGE separates proteins based on molecular weight but does not provide spatial localization. Fluorescence in-situ hybridization (FISH) detects nucleic acids, not proteins. Differential centrifugation isolates cell organelles but cannot pinpoint protein location in intact cells. Therefore, immunoelectron microscopy is the most suitable technique for observing the precise intracellular distribution of serotonin receptors.*

Q.3 Which ONE of the following is NOT a site for in situ conservation?
(A) Biosphere reserve
(B) Wild life sanctuary
(C) Zoological garden
(D) Biodiversity hotspot

(2020)

Answer: (C) Zoological garden

Explanation: *In situ conservation refers to the conservation of species **in their natural habitats** to maintain genetic diversity, evolutionary processes, and ecological interactions. Biosphere reserves, wildlife sanctuaries, and biodiversity hotspots are all examples of in situ conservation sites because they protect species in their native ecosystems. Zoological gardens, on the other hand, house animals outside their natural habitats and represent **ex situ conservation**, where organisms are conserved in controlled environments. The primary aim of in situ conservation is to allow species to evolve naturally, maintain ecological balance, and sustain genetic diversity over time.*

Q.4 Which ONE of the following is the precursor molecule for corticosteroids?
(A) Androgen
(B) Estrogen
(C) Pregnenolone
(D) Mineralocorticoids

(2020)

Answer: (C) Pregnenolone

Explanation: *Pregnenolone is a **precursor molecule** in the biosynthesis of all steroid hormones, including glucocorticoids, mineralocorticoids, and sex hormones. It is synthesized from cholesterol in the mitochondria and serves as the starting point for the production of corticosteroids in the adrenal cortex. Androgens and estrogens are end products in the steroidogenic pathway, not precursors. Mineralocorticoids like aldosterone are specific corticosteroids derived downstream of pregnenolone. Hence, pregnenolone is considered the universal steroid hormone precursor.*

Q.5 Transitional epithelia is found in which ONE of the following organs?
(A) Liver
(B) Lung
(C) Brain
(D) Urinary bladder

(2020)

Answer: (D) Urinary bladder

Explanation: *Transitional epithelium, also called urothelium, is a specialized type of stratified epithelium that **lines the urinary bladder, ureters, and part of the urethra**. Its structure allows it to stretch and recoil as the bladder fills and empties. Other organs like the liver, lung, or brain have epithelial tissues of different types, such as cuboidal, columnar, or squamous epithelium, which cannot accommodate repeated expansion. The transitional epithelium's dome-shaped apical cells and multiple layers provide both **distensibility** and a barrier against urine toxicity. This adaptation is crucial for urinary tract function.*

Q.6 Visual signal transduction cascade is activated by rhodopsin and involves degradation rather than synthesis of which ONE of the following second messenger molecules?
(A) CAMP
(B) IP3
(C) CGMP
(D) DAG

(2020)

Answer: (C) CGMP

Explanation: *In visual phototransduction, rhodopsin activates a cascade leading to the **decrease of cyclic guanosine monophosphate***

(cGMP) levels in photoreceptor cells. cGMP acts as a second messenger that opens sodium and calcium ion channels; its degradation results in hyperpolarization of photoreceptor membranes and generation of a visual signal. CAMP, IP3, and DAG are other second messengers involved in different signaling pathways but are not central to rhodopsin-mediated phototransduction. Therefore, the cascade uniquely depends on cGMP degradation rather than its synthesis. This process enables rapid and reversible response to light stimuli.

Q.7 The genomes of both human and Drosophila code for an amylase that acts on the same substrate. However, the sequence of nucleotides in the genes encoding the two is dissimilar. This is an example of which ONE of the following types of evolution?
(A) Neutral
(B) Directional
(C) Convergent
(D) Divergent

(2020)

Answer: (C) Convergent

Explanation: *Convergent evolution occurs when **unrelated species independently evolve similar traits** to adapt to similar functional demands or environmental pressures. In this case, human and Drosophila amylases act on the same substrate, starch, but their gene sequences are dissimilar, showing that they arose independently. Divergent evolution, in contrast, involves related species accumulating differences from a common ancestor. Neutral evolution concerns changes without selective pressure, and directional evolution involves shifts in trait distribution. The similarity in enzymatic function despite genetic dissimilarity is a classic example of convergent evolution.*

Q.8 "Round dance" is performed by forager bees to indicate the distance between a food source and their colony. Which ONE of the following best represents this distance?
(A) 45 meters
(B) 450 meters
(C) 1000 meters
(D) More than 2000 meters

(2020)

Answer: (A) 45 meters

Explanation: *The "round dance" performed by honeybee foragers communicates **short-distance food sources** to other bees. It signals that the resource is within approximately 50 meters of the hive, emphasizing proximity without indicating precise direction. When food is farther away, bees perform a "waggle dance" to convey both distance and direction. Distances like 450 meters, 1000 meters, or more than 2000 meters would be indicated by a waggle dance rather than a round dance. Hence, a distance of 45 meters fits the round dance behavior of forager bees.*

Q.9 Which ONE of the following phyla have choanocytes?
(A) Ctenophora
(B) Nematoda
(C) Cnidaria
(D) Porifera

(2020)

Answer: (D) Porifera

Explanation: *Choanocytes, or **collar cells**, are specialized cells found exclusively in sponges (Phylum Porifera). They possess a flagellum surrounded by a collar of microvilli and are responsible for creating water currents, capturing food particles, and facilitating gas exchange. Ctenophora (comb jellies) and Cnidaria (jellyfish, corals) lack choanocytes and rely on other cell types for feeding. Nematoda (roundworms) are multicellular, bilaterally symmetrical animals without such feeding cells. The presence of choanocytes is a defining feature of Porifera, enabling filter-feeding in aquatic habitats.*

Q.10 Which ONE of the following glial cells is NOT derived from the ectoderm?
(A) Astrocytes
(B) Microglial cells
(C) Oligodendrocytes
(D) Ependyma

(2020)

Answer: (B) Microglial cells

Explanation: *Microglial cells are the only glial cells in the central nervous system that are **not derived from the ectoderm**. Instead, they originate from **mesodermal lineage**, specifically from yolk sac macrophages during early embryonic development. In contrast, astrocytes, oligodendrocytes, and ependymal cells are all derived from the ectoderm, which gives rise to the neural tube and subsequently the central nervous system. Microglia function as the resident immune cells of the CNS, playing a key role in immune defense and maintenance.*

Q.11 Tarantulas and mosquitoes both belong to the phylum Arthropoda. Which ONE of the following represents the correct number of legs in them respectively?
(A) 6 and 6
(B) 6 and 8
(C) 8 and 8
(D) 8 and 6

(2020)

Answer: (D) 8 and 6

Explanation: *Both tarantulas and mosquitoes belong to **Phylum Arthropoda**, characterized by jointed appendages and exoskeletons. However, they belong to different classes: tarantulas are arachnids with **8 legs**, while mosquitoes are insects with **6 legs**. This difference*

illustrates the diversity within Arthropoda, where insects and arachnids share common features but differ in appendage number. Therefore, the correct pair of legs is 8 for tarantulas and 6 for mosquitoes.

Q.12 Match the following subcellular organelles in Column I with associated functions in Column II

Column I	Column II
P. Nucleolus	(i) Glycoprotein biosynthesis
Q. Peroxisomes	(ii) Oxidation of fatty acids and amino acids
R. Endoplasmic reticulum	(iii) Protein trafficking
S. Golgi bodies	(iv) Ribosome biogenesis

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

(2020)

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

Explanation: *The nucleolus (P) is primarily involved in **ribosome biogenesis**, producing rRNA and assembling ribosomal subunits. Peroxisomes (Q) carry out **oxidation of fatty acids and amino acids**, producing hydrogen peroxide as a byproduct. The rough endoplasmic reticulum (R) participates in **glycoprotein biosynthesis** due to ribosome association. Golgi bodies (S) are crucial for **protein trafficking**, modifying and directing proteins to their destinations. Matching organelles to functions provides a clear understanding of cellular compartmentalization and specialized roles.*

Q.13 Match the following genetic disorders in Column I with associated typical chromosomal changes mentioned in Column II

Column I	Column II
P. Klinefelter syndrome	(i) 45,XO
Q. Down syndrome	(ii) 5p minus
R. Turner syndrome	(iii) 47,XXY
S. Cri du chat syndrome	(iv) Trisomy 21

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

(2020)

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

Explanation: *Klinefelter syndrome (P) is characterized by an **extra X chromosome in males (47, XXY)**. Down syndrome (Q) results from **trisomy 21**, an additional chromosome 21. Turner syndrome (R) occurs due to monosomy X (45, XO), leading to female phenotypic features. Cri du chat syndrome (S) is caused by a **deletion in the short arm of chromosome 5 (5p−)**. Correctly pairing chromosomal anomalies with their syndromes is essential for understanding cytogenetics and clinical manifestations of these genetic disorders.*

Q.14 Match the following components listed in Column I with their respective organs in Column II.

Column I	Column II
P. Endolymph	(i) Testes
Q. Vitreous humour	(ii) Ear
R. Vas deferens	(iii) Ovary
S. Corpus luteum	(iv) Eye

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

(2020)

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

Explanation: *Endolymph (P) is the fluid of the **inner ear**, particularly in the cochlea and semicircular canals, involved in hearing and balance. Vitreous humour (Q) fills the **eye**, providing structural support and maintaining intraocular pressure. The vas deferens (R) is part of the male reproductive tract that transports sperm from the **testes**. The corpus luteum (S) forms in the **ovary** after ovulation and secretes progesterone. Correctly linking components with their organs helps in understanding their physiological functions in the human body.*

Q.15 Match the following digestive enzymes in Column I with their functions in Column II.

Column I	Column II
P. Erepsin	(i) converts proteins to peptides
Q. Steapsin	(ii) activates trypsinogen to trypsin
R. Pepsin	(iii) converts fat into fatty acid and glycerol
S. Enterokinase	(iv) converts polypeptides to amino acids

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

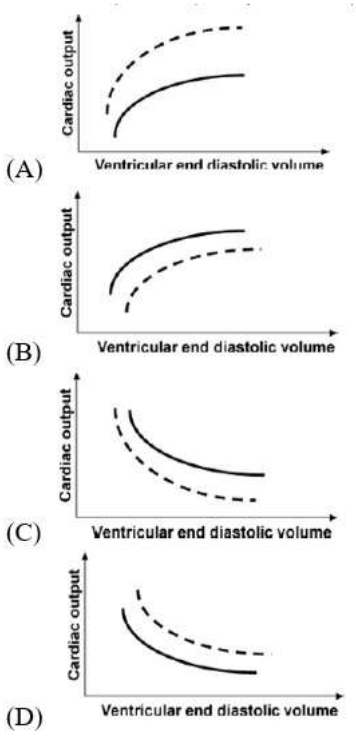
(2020)

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

Explanation: *Erepsin (P) is a **proteolytic enzyme** that converts polypeptides into amino acids. Steapsin (Q) is another name for pancreatic lipase that converts **fats into fatty acids and glycerol**. Pepsin (R) breaks down proteins into peptides in the stomach. Enterokinase (S) activates trypsinogen to*

trypsin, which then participates in further protein digestion. Matching digestive enzymes with their specific biochemical functions clarifies their roles in nutrient processing.

Q.16 Which ONE of the following graphs represents the relationship between ventricular end-diastolic volume and cardiac output in a healthy adult individual at rest (solid line) and upon exercise (dotted line)?



(2020)

Answer: (A)

Explanation: *The Frank-Starling relationship explains how **cardiac output increases with ventricular end-diastolic volume**, reflecting the heart's ability to pump more blood when more is returned to it. At rest, the solid line represents normal cardiac output, while the dashed line shows **enhanced cardiac output during exercise**, which is higher at the same end-diastolic volume due to increased contractility. Panels showing decreasing cardiac output or dashed lines below the solid line would contradict physiological responses. Thus, panel (A) correctly illustrates the positive correlation between preload and cardiac output in healthy adults.*

Q. 17 Match the household insect vectors in Column I with their associated diseases in Column II.

Column I	Column II
P. Kissing bug (Hemiptera)	(i) Bubonic plague
Q. Sand fly (Diptera)	(ii) Tularemia
R. Deer fly (Diptera)	(iii) Chagas disease
S. Oriental rat flea (Siphoneptera)	(iv) Kala azar

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

(2020)

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

Explanation: *Kissing bugs (P) transmit **Chagas disease**, a protozoal infection caused by Trypanosoma cruzi. Sand flies (Q) are vectors for **Kala azar** (visceral leishmaniasis). Deer flies (R) can transmit **Tularemia**, a bacterial zoonosis. Oriental rat fleas (S) are responsible for **bubonic plague** caused by Yersinia pestis. Correct matching highlights the epidemiological relevance of insect vectors in disease transmission and preventive public health measures.*

Q.18 Match the proteins in Column I with the organs in which they are maximally expressed in Column II.

Column I	Column II
P. Keratin	(i) Liver
Q. Surfactants	(ii) Pancreas
R. Pro-carboxypeptidase	(iii) Lung
S. Albumin	(iv) Skin

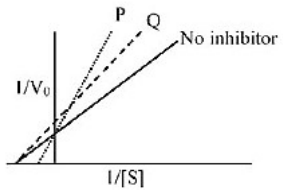
(A) P-(iv), Q-(i), R-(iii), S-(ii)
(B) P-(iii), Q-(iv), R-(ii), S-(i)
(C) P-(iv), Q-(iii), R-(ii), S-(i)
(D) P-(i), Q-(ii), R-(iii), S-(iv)

(2020)

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

Explanation: *Keratin (P) is a structural protein expressed maximally in **skin**, forming hair, nails, and the epidermal barrier. Surfactants (Q) are secreted in the **lungs** by alveolar type II cells to reduce surface tension and prevent alveolar collapse. Pro-carboxypeptidase (R) is a pancreatic enzyme involved in protein digestion. Albumin (S) is synthesized primarily in the **liver**, maintaining osmotic balance and transporting molecules. Accurate pairing of proteins with their organs emphasizes the tissue-specific expression and functional specialization in the body.*

Q.19 The graph below shows the activity of enzyme pepsin in the presence of inhibitors aliphatic alcohols (P) or N-acetyl-1-phenylalanine (Q). Which ONE of the following represents the nature of inhibition by P and Q, respectively?



(A) Non-competitive and competitive
(B) Competitive and non-competitive
(C) Non-competitive and uncompetitive
(D) Competitive and uncompetitive

(2020)

Answer: (B) Competitive and non-competitive

Explanation: *In the Lineweaver-Burk plot, aliphatic alcohols (P) increase the slope without changing the x-intercept, characteristic of* ***competitive inhibition****, where the inhibitor competes with the substrate for the active site. N-acetyl-1-phenylalanine (Q) increases both slope and y-intercept but leaves x-intercept unchanged, representing* ***non-competitive inhibition****, where the inhibitor binds allosterically, affecting Vmax but not Km. Correct interpretation of enzyme kinetics graphs allows identification of inhibitor types, providing insight into enzyme-substrate interactions and pharmacological modulation.*

Q. 20 In *Drosophila*, the red eye phenotype (W) is dominant over the recessive white eye mutant (w). In a mixed population of red and white eye flies of 10,000 individuals, 3,600 flies were white eyed. The percentage of the heterozygous red eye flies in this population is _____.

(2020)

Answer: 48

Explanation: *To determine the percentage of heterozygous, red-eyed flies in a Drosophila population, we apply Hardy-Weinberg principles. The red eye allele (W) is dominant over the white eye allele (w). In a population of 10,000 flies, 3,600 have white eyes, which means they are homozygous recessive (ww). This gives us the frequency of the genotype* $q^2 = 3600 / 10000 = 0.36$.
Taking the square root of q^2 *gives* $q = \sqrt{0.36} = 0.6$, *which is the frequency of the recessive allele (w). Therefore, the frequency of the dominant allele (W) is* $p = 1 - q = 0.4$.
The frequency of heterozygous individuals (Ww) is $2pq = 2 \times 0.4 \times 0.6 = 0.48$, *or* ***48%****.*
Final Answer: 48% *of the population are heterozygous, red-eyed flies.*

XL: Life Sciences - U: Food Technology

Q.1 The enzyme majorly involved in postmortem degradation of muscle proteins is.
(A) Trypsin
(B) Calpin
(C) Transglutaminase
(D) Pepsin

(2020)

Answer: (B) Calpin

Explanation: *Calpain is a calcium-dependent protease that plays a major role in the* ***postmortem degradation of muscle proteins****. After death, calcium levels in muscle cells increase, activating calpains. These enzymes break down key structural proteins in muscle fibers, contributing to the tenderization process during meat aging. In contrast, trypsin and pepsin are digestive enzymes, and transglutaminase is involved in protein cross-linking, not primarily in postmortem muscle breakdown*

Q.2 Which of the following is the correct pair of essential fatty acids?
(A) Oleic acid and Lenoleic acid
(B) Lenoleic acid and Linolenic acid
(C) Linolenic acid and Lauric acid
(D) Linolenic acid and Oleic acid

(2020)

Answer: (B) Lenoleic acid and Linolenic acid

Explanation: *These two fatty acids are classified as essential fatty acids because the human body cannot synthesize them and must obtain them through the diet. Linoleic acid is an omega-6 fatty acid, while linolenic acid is an omega-3 fatty acid. Both play crucial roles in maintaining cell membrane integrity, supporting cardiovascular health, and serving as precursors for bioactive lipid mediators. Other options like oleic acid and lauric acid are not considered essential, as the body can produce them.*

Q.3 Nisin A is produced by.
(A) *Aspergillus niger*
(B) *Acetobacter aceti*
(C) *Lactobacillus lactis*
(D) *Clostridium perfringens*

(2020)

Answer: (C) *Lactobacillus lactis*

Explanation: ***Nisin A*** *is a bacteriocin, a ribosomally synthesized peptide with antimicrobial properties, and is one of the most widely used natural preservatives in the food industry. It is specifically produced by the Gram-positive bacterium a common strain of Lactic Acid Bacteria (LAB) often associated with dairy fermentations. Nisin is effective against a wide range of Gram-positive bacteria, particularly bacterial spores, by inhibiting cell wall synthesis and forming pores in the target cell membrane. Due to its safety profile, it is approved for use as a food preservative (E234) worldwide.*

Q.4 Which of the following bacteria will stain purple color after Gram staining?
(A) *Bacillus subtilis*
(B) *Escherichia coli*
(C) *Pseudomonas aeruginaosa*
(D) *Yersinia pestis*

(2020)

Answer: A) *Bacillus subtilis*

Explanation: *Bacillus subtilis is a **Gram-positive** bacterium, which means it retains the **crystal violet stain** during Gram staining and appears **purple** under the microscope. This is due to its thick peptidoglycan layer in the cell wall. In contrast, **Escherichia coli**, **Pseudomonas aeruginosa**, and **Yersinia pestis** are **Gram-negative** bacteria, which have a thinner peptidoglycan layer and an outer membrane, causing them to lose the crystal violet stain and take up the counterstain (safranin), appearing **pink/red**.*

Q.5 The enzyme system used for removal of glucose from egg white prior to its drying consists of.
(A) Glucose oxidase and Catalase
(B) Glucosidase and Glucoisomerase
(C) Glucoisomerase and Catalase
(D) Glucoamylase and Glucose oxidase

(2020)

Answer: (A) Glucose oxidase and Catalase

Explanation: *To remove glucose from egg white prior to drying, a specific enzyme system is employed to prevent undesirable browning reactions during storage. This system consists of **glucose oxidase** and **catalase**. Glucose oxidase catalyzes the oxidation of glucose into gluconic acid, producing hydrogen peroxide as a by-product. Since hydrogen peroxide can be harmful and affect the quality of the egg white, **catalase** is used to decompose it into harmless water and oxygen. This enzymatic treatment ensures the stability and quality of dried egg white products by minimizing Maillard reactions that could otherwise alter their color and flavor.*

Q. 6 The INCORRECT pair of food borne illness and its causative microorganism is.
(A) Brucellosis - *Brucella* Sp.
(B) Peptic ulcers - *Bacillus subtilis*
(C) Bubonic plague - *Yersinia pestis*
(D) Q fever - *Coxiella burnatii*

(2020)

Answer: (B) Peptic ulcers - *Bacillus subtilis*

Explanation: *The incorrect pair among the listed foodborne illnesses and their causative microorganisms is **Peptic ulcers – Bacillus subtilis**. Peptic ulcers are primarily caused by Helicobacter pylori, a spiral-shaped bacterium that infects the stomach lining and is strongly associated with ulcer formation. Bacillus subtilis, on the other hand, is generally considered a non-pathogenic bacterium and is not linked to peptic ulcers. The other pairs are correctly matched: Brucella species cause brucellosis, Yersinia pestis is responsible for bubonic plague, and Coxiella burnetii causes Q fever. Identifying such incorrect associations is important in microbiology and food safety to ensure accurate diagnosis and treatment.*

Q.7 Which of the following is commonly used as a preservative in the tomato sauce?
(A) Sodium sulphite
(B) Potassium sorbate
(C) Potassium sulphite
(D) Sodium benzoate

(2020)

Answer: (D) Sodium benzoate

Explanation: *The correct answer is (D) Sodium benzoate, which is commonly used as a preservative in tomato sauce. Sodium benzoate is effective in acidic foods like tomato-based products, where it inhibits the growth of bacteria, yeast, and fungi, thereby extending shelf life and maintaining safety. The other options listed—sodium sulphite, potassium sorbate, and potassium sulphite—are also preservatives but are more commonly used in other types of food products. Sodium benzoate's compatibility with acidic environments makes it particularly suitable for tomato sauce preservation.*

Q. 8 A fluid with flow behaviour index less than one (n<1) is.
(A) Dilatant
(B) Pseudoplastic
(C) Bingham plastic
(D) Newtonian

(2020)

Answer: (B) Pseudoplastic

Explanation: *The correct answer is **(B) Pseudoplastic**. A fluid with a flow behavior index less than one (n < 1) exhibits **pseudoplastic** behavior, which means its viscosity decreases with increasing shear rate. These are also known as shear-thinning fluids. Common examples include ketchup, paint, and blood. In contrast, **dilatant** fluids (n > 1) become more viscous with shear (shear-thickening), **Bingham plastics** behave like solids until a certain yield stress is exceeded, and **Newtonian** fluids have a constant viscosity regardless of shear rate.*

Q.9 The velocity of 2.2µm diameter fat particles inside a centrifuge, running at 6000 rpm and 20°C, is 0.25 mm s^{-1}. The velocity of 1.5 µm diameter fat particles inside the same centrifuge running at 7500 rpm and same temperature (round off to 2 decimal places) will be ____ mm s^{-1}.

(2020)

Answer: 0.15 – 0.21

Explanation: *In a centrifuge, the terminal velocity of a particle is proportional to the product of the square of its diameter and the square of the rotational speed, expressed as* $v \propto d^2\omega^2$*, where* v*is velocity,* d*is particle diameter, and* ω*is angular speed. Given* $v_1 = 0.25$ *mm\cdotps*$^{-1}$*for a 2.2 μm particle at 6000 rpm, the velocity for a 1.5 μm particle at 7500 rpm can be estimated using the ratio:*

$$\frac{v_2}{v_1} = (\frac{d_2}{d_1})^2(\frac{N_2}{N_1})^2$$

Substituting,

$$v_2 = 0.25 \times (\frac{1.5}{2.2})^2 \times (\frac{7500}{6000})^2 = 0.25 \times 0.465 \times 1.5625 \approx 0.182 \text{ mm\cdotps}^{-1}.$$

Thus, the velocity of 1.5 μm fat globules under these conditions is about 0.18 mm·s⁻¹, reflecting how smaller particle size reduces sedimentation velocity despite higher rotational speed. The relationship assumes Stokes' law applicability and laminar particle motion in the centrifuge medium.

Q.10 The initial population of a bacterial strain increases from 1×104 cells per mL to 1×106 cells per mL in 120 minutes. The generation time for this strain (round off to 2 decimal places) is _____ minutes.

(2020)

Answer: 17 – 19

Explanation: *The generation time (g) is defined as the time required for a bacterial population to double. Using the exponential growth relationship* $N = N_0 \times 2^{t/g}$*, rearranging gives* $g = \frac{t}{log_2(N/N_0)}$*. Here,* $N_0 = 1 \times 10^4$*,* $N = 1 \times 10^6$*, and* $t = 120$*minutes. The ratio* $N/N_0 = 100$*, so* $log_2(100) = \frac{log_{10}(100)}{log_{10}(2)} = \frac{2}{0.301} = 6.644$*. Thus,* $g = 120/6.644 = 18.06$*minutes. The result, approximately* ***18 minutes****, indicates that the bacterial population doubles every 18 minutes under these conditions. This calculation assumes ideal exponential growth without lag or stationary phases, typical for balanced culture conditions in nutrient-rich media.*

Q.11 Match the protein in Column I with its food source in Column II.

Column I	Column II
P. Zein	1. Soybean
Q. Gluten	2. Maize
R. Glycinin	3. Egg
S. Ovalbumin	4. Wheat

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

(2020)

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

Explanation: *This requires matching food proteins with their primary botanical or biological source:*
Zein (P) *is the principal* ***prolamin storage protein*** *found in* ***Maize (2)*** *(corn).*
Gluten (Q) *is a complex of proteins (gliadin and glutenin) that gives elasticity to dough and is found predominantly in* ***Wheat (4)*** *and other related grains (e.g., rye, barley).*
Glycinin (R) *is the major* ***globulin storage protein*** *of* ***Soybean (1)****.*
Ovalbumin (S) *is the most abundant protein, accounting for approximately of the total protein, found in* ***Egg (3)*** *white.*

Q.12 Match the carbohydrate in Column I with corresponding enzyme used for its hydrolysis in Column II.

Column I	Column II
P. Pectin	1. Xylanase
Q. Lactose	2. β-galactosidase
R. Hemicellulose	3. Polygalacturonase
S. Inulin	4. β-fructofuranosidase

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

(2020)

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

Explanation: *This matches specific complex carbohydrates with the enzyme that hydrolyzes them:*
Pectin (P)*, a complex polysaccharide found in plant cell walls, is broken down by* ***Polygalacturonase (3)****, which cleaves the glycosidic bonds between galacturonic acid residues.*
Lactose (Q)*, the disaccharide milk sugar (glucose and galactose), is hydrolyzed by* ***(2)*** *(also known as lactase) into its constituent monosaccharides.*
Hemicellulose (R) *is a group of heteropolysaccharides often broken down by* ***Xylanase (1)****, as xylan is the most abundant component of hemicellulose, and xylanase cleaves the xylan backbone.*
Inulin (S) *is a fructan (polymer of fructose) that is hydrolyzed by* ***(4)*** *(also known as invertase or inulase) to release fructose.*

Q.13 Match the edible oil refining stage in Column I with its purpose in Column II.

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

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

(2020)

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

Explanation: *This matches the stages of edible oil refining with their primary purpose:*
Degumming (P) *is the initial step to remove* ***phosphatides (3)*** *(lecithin) and other gummy substances, usually by treating the crude oil with water or acid, to prevent sediment formation and improve oil stability.*
Neutralization (Q) *(or deacidification) involves treating the oil with an alkali (like caustic soda) to react with and remove* ***free fatty acids (4)****, which cause rancidity and lower oil quality.*
Bleaching (R) *is the process of using adsorbents like activated clay to remove the undesirable* ***pigments (2)*** *(e.g., chlorophyll, carotenoids) that impart color to the crude oil.*
Winterization (S) *is a cooling process designed to separate high-melting-point* ***triglycerides (1)*** *(saturated fats) that would otherwise crystallize at refrigerated temperatures, ensuring the oil remains clear when cooled.*

Q.14 Match the food material in Column I with its related term in Column II.

Column I	Column II
P. Coffee	1. Wort
Q. Cocoa	2. Must
R. Beer	3. *Arabica*
S. Wine	4. *Theobroma*

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

(2020)

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

Explanation: *This question matches a common food product with a related, specific term:*
Coffee (P) *refers to the beverage made from the seeds of the plant, with* ***(3)*** *being one of the two main cultivated species.*
Cocoa (Q) *(chocolate) is derived from the beans of the tree, with* ***(4)*** *referring to the genus name.*
Beer (R) *is produced by fermenting a sugar solution derived from malted grain, with the sweet liquid extracted from the mash being called* ***Wort (1)****.*
Wine (S) *is produced by fermenting fruit juice (usually grapes), with the freshly crushed, unfermented juice containing skins, seeds, and stems being called* ***Must (2)****.*

Q.15 Match the component/system in Column I with the peeling method for fruits and vegetables in Column II.

Column I	Column II
P. Lye solution	1. Flash peeling
Q. Carborundum rollers	2. Flame peeling
R. Pressure vessel	3. Abrasion peeling
S. Conveyor belt	4. Caustic peeling

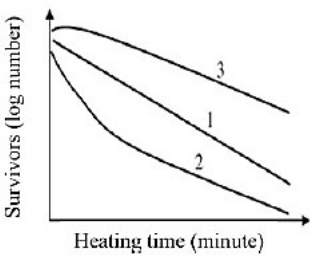
(A) P-4, Q-3, R-2, S-1
(B) P-3, Q-4, R-1, S-2
(C) P-4, Q-3, R-1, S-2
(D) P-3, Q-4, R-2, S-1

(2020)

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

Explanation: *This matches a component or system used in peeling with the name of the method:*
Lye solution (P)*, which is a caustic solution (or), is used to chemically dissolve the outer skin of fruits and vegetables in* ***Caustic peeling (4)****.*
Carborundum rollers (Q) *are abrasive cylinders coated with carborundum grit. They mechanically scratch and remove the outer skin in* ***Abrasion peeling (3)****.*
Pressure vessel (R) *is used to subject fruits (like tomatoes or potatoes) to high-pressure steam, which is then suddenly released. The rapid depressurization causes the skin to burst and separate from the flesh, known as* ***Flash peeling (1)****.*
Conveyor belt (S) *carries vegetables through a high-temperature zone (usually a furnace) where the skin is scorched and easily removed in* ***Flame peeling (2)****.*

Q.16 Which among the given options correctly explains the nature of the microbial culture represented by lines 1, 2 and 3 in the following figure?



(A) 1. Germination of spores 2. Homogeneous population 3. Mixed population of spores and vegetative cells
(B) 1. Homogeneous population 2. Mixed population of heat sensitive and heat-resistant microbes 3. Germination of spores
(C) 1. Composite population 2. Spores activated by short exposure to heat 3. Thermo sensitive and thermo resistant microbes
(D) 1. Mixed population 2. Microorganisms activated by short exposure to heat 3. Germination of spores

(2020)

Answer: (B) 1. Homogeneous population 2. Mixed population of heat sensitive and heat-resistant microbes 3. Germination of spores

Explanation: *The figure illustrates the characteristics of thermal death time plots.*
Curve 1 (Moderate decline, straight line): *Represents a* ***homogeneous population*** *where all cells have similar heat resistance. The decline is logarithmic and follows first-order kinetics.*
Curve 2 (Steep, non-linear decline): *Represents a* ***mixed population*** *of microorganisms, specifically a mixture of* ***highly heat-sensitive and more heat-resistant*** *strains. The initial steep drop kills the sensitive cells, leaving the resistant ones, resulting in a concave curve.*
Curve 3 (Gentle decline, initial shoulder): *This profile, often with a* ***shoulder*** *(initial slow death), is typically associated with the thermal destruction of* ***bacterial spores*** *that have undergone* ***germination****. Germination is often induced by short heat exposure, making the germinated vegetative cell much easier to kill than the initial spore, which is not represented by the typical slow, logarithmic decline of the spore itself.*

Q.17 Match the equation/law in Column I with its application in Column II.

Column I	Column II
P. Plank's equation	1. Terminal velocity
Q. Arrhenius equation	2. Freezing time
R. Guggenheim-Anderson-de Boer equation	3. Activation energy
S. Stoke's law	4. Monolayer moisture content

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

(2020)

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

Explanation: *This matches fundamental equations/laws in engineering and chemistry with their primary application in food science:*
Planck's equation (P) *is the standard mathematical model used to estimate the* ***Freezing time (2)*** *for foods based on geometry, initial freezing temperature, and cooling conditions.*
Arrhenius equation (Q) *relates the rate of a chemical reaction (or degradation) to temperature, and the is the constant that defines this temperature dependence.*
Guggenheim-Anderson-de Boer (GAB) equation (R) *is the most widely accepted model for describing the* ***Monolayer moisture content (4)*** *and the full relationship between moisture content and water activity in foods.*
Stokes' law (S) *describes the drag force on a spherical object moving through a viscous fluid. In food processing, it is used to calculate the sedimentation or creaming rate, determining the* ***Terminal velocity (1)*** *of particles (like fat globules in milk during centrifugation).*

Q.18 Match the absorber used in modified atmosphere packaging and storage in Column I with the scavenger in Column II.

Column I	Column II
P. Oxygen absorber	1. Calcium chloride
Q. Carbon dioxide absorber	2. Magnesium oxide
R. Ethylene absorber	3. Ferric oxide
S. Moisture absorber	4. Potassium permanganate

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

(2020)

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

Explanation: *In modified atmosphere packaging (MAP), specific absorbers are paired with scavengers to maintain the desired storage conditions and extend the shelf life of food products. The correct matching is:* ***oxygen absorber with iron powder****, which reacts with oxygen to form iron oxide and remove oxygen from the package;* ***ethylene absorber with potassium permanganate****, which oxidizes ethylene gas to slow down the ripening of fruits and vegetables;* ***moisture absorber with silica gel****, which effectively controls humidity levels; and* ***carbon dioxide absorber with activated charcoal****, which adsorbs excess CO_2 to maintain the optimal gas balance. These combinations help preserve food quality by controlling the internal atmosphere of the packaging.*

Q.19 During extrusion cooking, food materials are generally subjected to a combination of.

(A) high shear and low pressure
(B) high temperature and high shear
(C) low shear and high temperature
(D) low shear and low pressure

(2020)

Answer: (B) high temperature and high shear

Explanation: ***Extrusion cooking*** *is a high-temperature, short-time (HTST) process used to process food products like snacks and cereals. The fundamental mechanism involves forcing the food material through a restricted die. This process subjects the food to a simultaneous combination of* ***high temperature*** *(due to external heating and internal friction) and* ***high shear*** *(due to the viscous drag and mixing action of the screw). This intense combination causes significant physicochemical changes, including starch gelatinization,*

protein denaturation, and product expansion, which are essential for forming the final texture and structure.

Q.20 An orange juice flowing at 0.80 kg s^{-1} enters a counter current double pipe heat exchanger at 20°C and leaves at 72°C. Inlet and outlet temperatures of the hot water used as heating medium in the exchanger are 81°C and 74°C, respectively. The specific heat of the orange juice is 3.74 kJ kg^{-1} K^{-1} and overall heat transfer coefficient is 492 W $m^{-2}K^{-1}$. The heat transfer surface area (round off to 2 decimal places) will be ____ m^2.

(2020)

Answer: 12.60 m^2

Explanation: *The heat duty is first obtained from* $Q = \dot{m}\, c_p\, (T_{co} - T_{ci})$*: with* $\dot{m} = 0.80\ kg\ s^{-1}$, $c_p = 3.74\ kJ\ kg^{-1}\ K^{-1}$ *and* $\Delta T = 72 - 20 = 52\ ^\circ C$, *we get* $Q = 0.80 \times 3.74 \times 52 = 155.584\ kJ\ s^{-1} = 155{,}584\ W$. *For a counter-current exchanger the terminal temperature differences are* $\Delta T_1 = T_{h,in} - T_{c,out} = 81 - 72 = 9^\circ C$ *and* $\Delta T_2 = T_{h,out} - T_{c,in} = 74 - 20 = 54^\circ C$*; the log-mean temperature difference is* $\Delta T_{LM} = (54 - 9)/ln(54/9) = 45/ln(6) \approx 25.11^\circ C$. *Finally the required area follows* $A = Q/(U\Delta T_{LM}) = 155{,}584/(492 \times 25.11) \approx 12.596\ m^2$, *which rounded to two decimals is 12.60 m²; this value assumes constant overall U and negligible heat losses, typical for preliminary exchanger sizing.*