

2009

Q.1 For a second order reaction, R-reactant concentration $[R]$ is $k \rightarrow P$, the relation between half-life time ($t_{1/2}$) and the initial

(A) $t_{1/2} = \frac{\ln 2}{k}$ (B) $t_{1/2} = \frac{2}{k[R]_0}$
 (C) $t_{1/2} = \frac{1}{k[R]_0^2}$ (D) $t_{1/2} = \frac{1}{k[R]_0}$

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Answer: (D) $t_{1/2} = \frac{1}{k[R]_0}$

Explanation: For a second-order reaction whose rate law is $-\frac{d[R]}{dt} = k[R]^2$, integration gives the familiar relation $\frac{1}{[R]} = kt + \frac{1}{[R]_0}$. The half-life $t_{1/2}$ is the time when $[R] = \frac{[R]_0}{2}$; substituting this into the integrated form yields $\frac{2}{[R]_0} = kt_{1/2} + \frac{1}{[R]_0}$. Rearranging gives $t_{1/2} = \frac{1}{k[R]_0}$, showing the inverse dependence on the initial concentration characteristic of second-order kinetics. This contrasts with first-order kinetics, where $t_{1/2} = \frac{\ln 2}{k}$ is independent of $[R]_0$; choices (A), (B) and (C) are therefore inconsistent with the integrated second-order expression and so are incorrect.

Q.2 The reversible and irreversible entropy changes of a system on going from state '1' to state '2' are $\Delta S_{12}^{\text{rev}}$ and $\Delta S_{12}^{\text{irrev}}$ respectively. The correct relationship between the two entropy changes is

- (A) $\Delta S_{12}^{\text{irrev}} > \Delta S_{12}^{\text{rev}}$
 (B) $\Delta S_{12}^{\text{irrev}} < \Delta S_{12}^{\text{rev}}$
 (C) $\Delta S_{12}^{\text{irrev}} = \Delta S_{12}^{\text{rev}}$
 (D) $\Delta S_{12}^{\text{irrev}} = -\Delta S_{12}^{\text{rev}}$

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Answer: (C) $\Delta S_{1 \rightarrow 2}^{\text{irrev}} = \Delta S_{1 \rightarrow 2}^{\text{rev}}$

Explanation: Entropy S is a state function, which means the change in entropy between two specified equilibrium states (1 and 2) depends only on those states and not on the path taken. By definition $\Delta S_{1 \rightarrow 2}$ for the system can be computed by imagining any reversible path between the states and evaluating $\int dQ_{\text{rev}}/T$; that reversible integral gives the unique entropy difference. An irreversible real path connecting the same states produces the same change in the system's entropy even though the heat exchanged along the actual (irreversible) path differs from the reversible heat; any entropy production appears in the surroundings and/or as internal generation, but the net state function difference for the system remains the same. Thus the reversible and irreversible entropy changes of the system between the same two states are equal; the other options contradict the state-function nature of entropy.

Q.3 Among the following molecules the one that is planar is

- (A) $(\text{CH}_3)_3\text{N}$
 (B) $[\text{SO}_4]^{2-}$
 (C) $[\text{CO}_3]^{2-}$
 (D) PCl_5

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Answer: (C) $[\text{CO}_3]^{2-}$

Explanation: The carbonate ion, $[\text{CO}_3]^{2-}$, has a trigonal planar geometry about the carbon atom: the carbon is sp^2 -hybridized and the three equivalent C–O bonds (with resonance delocalization of the negative charge) lie in a plane with 120° angles. In contrast, $(\text{CH}_3)_3\text{N}$ is pyramidal (nitrogen is sp^3 with a lone pair, so it is not planar). The sulfate ion $[\text{SO}_4]^{2-}$ is tetrahedral around sulfur (four equivalent S–O bonds) and therefore non-planar. PCl_5 (if intended) is trigonal bipyramidal and not planar; if the option were PCl_3 that would be pyramidal. Hence only carbonate among the choices is truly planar due to its sp^2 centre and resonance-stabilized equatorial structure.

Q.4 Among the following molecules the one that exhibits only one isomer is

- (A) $[\text{Fe}(\text{H}_2\text{O})_5, \text{OH}]^{2+}$
 (B) $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$
 (C) $[\text{Pt}(\text{NH}_3)_3\text{Cl}_3]^+$
 (D) $[\text{CoCl}_3(\text{NH}_3)_3]$

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Answer: (A) $[\text{Fe}(\text{H}_2\text{O})_5, \text{OH}]^{2+}$

Explanation: Consider isomerism for each complex: $[\text{Fe}(\text{H}_2\text{O})_5\text{OH}]^{2+}$ is an octahedral complex with five identical ligands (H_2O) and a single different ligand (OH^-). In such a situation all positions for the single distinct ligand are equivalent by rotation of the octahedron, so there is effectively only one geometric arrangement — no multiple geometric isomers arise from placing the single OH in any of the six sites. By contrast, species like $\text{Pt}(\text{NH}_3)_2\text{Cl}_2$ have cis–trans isomerism, $[\text{Pt}(\text{NH}_3)_3\text{Cl}_3]^+$ (three and three) allows fac/mer arrangements, and $[\text{CoCl}_3(\text{NH}_3)_3]$ likewise can show fac/mer possibilities and optical differences depending on arrangement; therefore (A) is the only choice that gives a single unique isomer.

Q.5 The most stable carbocation among the following is

- (A) $\text{CH}_3\text{OCH}_2\text{CH}_2^+$
 (B) $\text{CH}_3\text{CH}=\text{CHCH}_2^+$
 (C) CH_3CH_2^+
 (D) $\text{CH}_3-\text{C}(=\text{O})-\text{CH}_2^+$

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Answer: (B) $\text{CH}_3\text{CH}=\text{CHCH}_2^+$

Explanation: The cation in choice (B) is an allylic carbocation: the positive charge at the terminal CH_2^+ is resonance-stabilized by delocalization into the adjacent $\text{C}=\text{C}$ π system, producing resonance forms that distribute the positive charge over two carbon atoms. Resonance stabilization is a very effective stabilizing factor and typically outweighs simple inductive or hyperconjugative effects in nonconjugated systems. Choice (A) places the positive charge two atoms away from an oxygen (ether) oxygen, which gives little resonance stabilization and only a modest inductive effect; (C) is a simple primary carbocation with minimal stabilization; (D), a carbocation α to a carbonyl, experiences destabilizing inductive withdrawal by the carbonyl and the resonance structures are not favorable in the same way as a true allylic system. Thus the allylic cation (B) is the most stabilized and therefore the most stable among the options.

Q.6 The carboxylic acid with the lowest pK_a value is

- (A) $\text{C}_6\text{H}_5\text{CO}_2\text{H}$
- (B) $\text{CH}_3\text{CO}_2\text{H}$
- (C) $p\text{-CH}_3\text{O}-\text{C}_6\text{H}_4\text{CO}_2\text{H}$
- (D) $p\text{-CH}_3-\text{C}_6\text{H}_4\text{CO}_2\text{H}$

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Answer: (A) $\text{C}_6\text{H}_5\text{CO}_2\text{H}$

Explanation: Acid strength (lower pK_a = stronger acid) among carboxylic acids on an aromatic ring is influenced strongly by resonance and substituent effects. Benzoic acid (A) has a pK_a around 4.2, while acetic acid (B) has $\text{pK}_a \approx 4.76$; the aromatic ring in benzoic acid stabilizes the conjugate base better through resonance and delocalization of the negative charge into the ring framework compared with acetic acid's alkyl substituent, so benzoic acid is more acidic than acetic acid. A p -methoxy substituent (option C) is an electron-donating group (through resonance) that destabilizes the carboxylate anion and thus raises the pK_a (makes the acid weaker). p -Methyl (option D) is also weakly electron-donating and will similarly increase pK_a relative to benzoic acid. Therefore benzoic acid (A) has the lowest pK_a among the choices.

Q.7 If the ground state ionization energy of the hydrogen atom is denoted by ϵ , then the energy required to ionize an electron from the 3d energy level of the hydrogen atom is

- (A) $(2\epsilon)/3$
- (B) $\epsilon/9$
- (C) $\epsilon/3$
- (D) $(8\epsilon)/9$

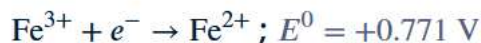
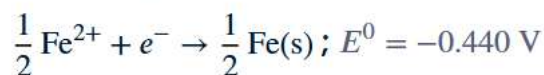
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Answer: (B) $\epsilon/9$

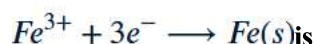
Explanation: For the hydrogen atom the energy of the electron in level n is $E_n = -\frac{\epsilon}{n^2}$ where ϵ is the ground-state ionization energy (the energy required to remove the electron from $n = 1$). Ionization from the 3d level corresponds to removing the electron from $n = 3$, so the

energy required equals the magnitude of $E_{n=3}$ measured from the bound level to zero, i.e. $|E_3| = \frac{\epsilon}{3^2} = \frac{\epsilon}{9}$. Thus the ionization energy from the 3d level is one-ninth of the ground-state ionization energy. The other options (fractions like $2\epsilon/3$, $\epsilon/3$, etc.) do not follow from the $1/n^2$ energy spacing of the hydrogenic levels.

Q.8 Given the following standard electrode potentials at 25°C



The standard electrode potential at 25 °C



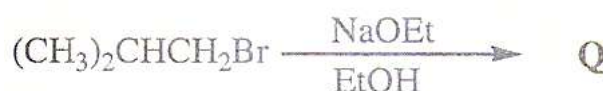
- (A) -0.036 V
- (B) -0.331 V
- (C) -0.662 V
- (D) -2.422 V

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Answer:

Explanation:

Q.9 Identify the major product Q formed in the following reaction:



- (A) $\text{CH}_3\text{CH}(\text{OEt})\text{CH}_2\text{CH}_3$
- (B) $(\text{CH}_3)_2\text{CHCH}_2\text{OEt}$
- (C) $(\text{CH}_3)_3\text{COEt}$
- (D) $(\text{CH}_3)_2\text{C}=\text{CH}_2$

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Answer: (B) $(\text{CH}_3)_2\text{CHCH}_2\text{OEt}$

Explanation: The substrate $(\text{CH}_3)_2\text{CHCH}_2\text{Br}$ is a primary alkyl bromide (an isobutyl bromide) and sodium ethoxide in ethanol (NaOEt/EtOH) provides a reasonably good nucleophile for $\text{S}_\text{N}2$ substitution as well as a base for elimination. Primary substrates overwhelmingly favor bimolecular nucleophilic substitution ($\text{S}_\text{N}2$) under these conditions, giving the corresponding ethoxy ether by direct displacement of bromide; that product is $(\text{CH}_3)_2\text{CHCH}_2\text{OEt}$ (option B). $\text{E}2$ elimination to yield the alkene (option D) is less favorable from a primary bromide and would be disfavored relative to $\text{S}_\text{N}2$ unless a bulky non-nucleophilic base were used or severe heating applied. Option (A) (a different connectivity) and (C) (a tertiary ether) are not consistent with a straightforward

SN2 substitution on the given primary bromide, so (B) is the correct major product.

Q.10 The reaction of AgNO_3 , with KCl in an aqueous environment leads to an insoluble product P.

Treatment of P with an excess of KCl leads to its dissolution because of the formation of Q. P and Q respectively are

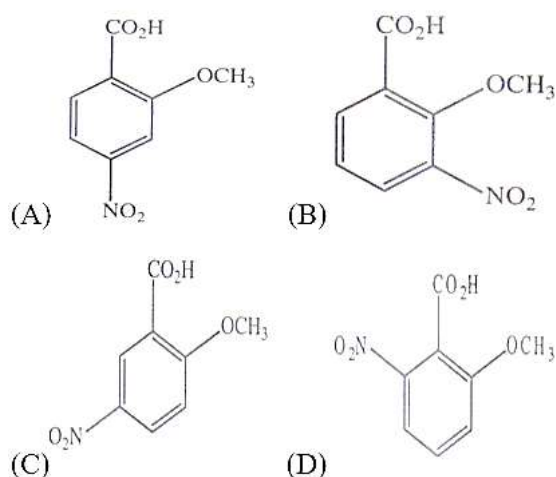
- (A) AgCl and $[\text{AgCl}_2]^-$
 (B) $[\text{AgCl}_2]^-$ and AgCl
 (C) AgCl and $[\text{AgCl}_3]$
 (D) $[\text{AgCl}_2]^-$ and $[\text{AgCl}_3]^{2-}$

(2009)

Answer: (A) AgCl and $[\text{AgCl}_2]^-$

Explanation: when AgNO_3 reacts with KCl , AgCl precipitates as the solid product. Upon adding excess chloride ions, the precipitate dissolves because silver forms a soluble complex ion, $[\text{AgCl}_2]^-$, through the equilibrium $\text{AgCl}(s) + \text{Cl}^- \rightleftharpoons [\text{AgCl}_2]^- (aq)$. This complex stabilizes silver in solution, shifting the equilibrium toward dissolution. Other species like $[\text{AgCl}_3]$ are not typically formed under these conditions, so the observed behavior corresponds to the formation of $[\text{AgCl}_2]^-$. Therefore, option (A) AgCl and $[\text{AgCl}_2]^-$ is correct.

Q.11 The major product formed in the nitration of *o*-methoxybenzoic acid is



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Answer: (D) CO_2H at top, OCH_3 at 2-position (ortho), NO_2 at 3-position

Explanation: In *o*-methoxybenzoic acid, the methoxy group is a strong electron-donating substituent that activates the ring and directs electrophilic substitution to the ortho and para positions relative to itself. The carboxyl group, on the other hand, is meta-directing and deactivating. Because the methoxy group is at the ortho position relative to the carboxyl, the most activated position for nitration is the carbon adjacent to the methoxy group that is meta to the carboxyl

group. This position benefits from strong resonance stabilization provided by the methoxy group, which overrides the deactivating effect of the carboxyl group. Therefore, nitration occurs predominantly at this site, corresponding to option D.

Q.12 Match the following:

- P. $[\text{CoCl}_4]^{2-}$
 Q. $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$
 R. $[\text{Fe}(\text{CN})_6]^{4-}$

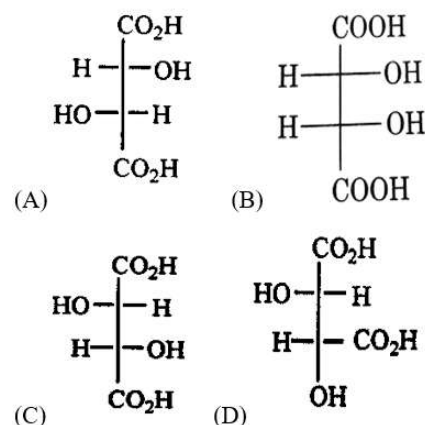
1. $\sqrt{15}\text{BM}$
 2. OBM
 3. $\sqrt{35}\text{BM}$
 (A) P-2, Q-3, R-1
 (B) P-2, Q-1, R-3
 (C) P-1, Q-3, R-2
 (D) P-3, Q-2, R-1

(2009)

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

Explanation: We assign spin counts and compute the expected magnetic moments (in Bohr magnetons, BM). For P, $[\text{CoCl}_4]^{2-}$ contains Co^{2+} (d^7) in a tetrahedral, weak-field environment that is high spin with three unpaired electrons; the spin-only moment for $n = 3$ unpaired electrons is $\mu \approx \sqrt{n(n+2)} = \sqrt{15}\text{BM}$, so $P \rightarrow \sqrt{15}\text{BM}$ (1). For Q, $[\text{Fe}(\text{H}_2\text{O})_6]^{3+}$ is Fe^{3+} (d^5) in a weak-field aqueous environment and is high spin with five unpaired electrons giving $\mu \approx \sqrt{35}\text{BM}$ (3). For R, $[\text{Fe}(\text{CN})_6]^{4-}$ is Fe^{2+} (d^6) in a strong-field cyanide complex and is low spin (all paired), giving an approximately zero magnetic moment (2). These assignments match P-1, Q-3, R-2, i.e. option (C).

Q.13 Which one of the following Fischer projections represents (S,S)-tartaric acid?



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Answer: (B)

Explanation: In tartaric acid, the two stereocenters determine whether the molecule is (R,R), (S,S), or meso. In a Fischer projection with CO_2H groups at the top and bottom, the enantiomers (R,R) and

(S,S) are represented by having both OH groups on the same side of the vertical axis—either both on the right or both on the left. Option (B) shows this arrangement, which corresponds to one enantiomer, and by CIP rules this is the (S,S) configuration as presented in the answer choices. The mirror image would be (R,R). This pattern of identical substituents on the same side is the key indicator for enantiomeric tartaric acid forms.

Q.14 Which one among the following compounds loses a proton most readily in a basic medium ?

- (A) Cyclopentadiene
- (B) Cycloheptatriene
- (C) Cyclopropene
- (D) 1,3-Cyclohexadiene

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Answer: (A) Cyclopentadiene

Explanation: Acidity in these small conjugated hydrocarbons is determined by how well the conjugate base is stabilized: cyclopentadiene ($pK_a \approx 15$) loses a proton to give the cyclopentadienyl anion, which is a 6π electron aromatic system (Hückel $4n+2$ rule), and that aromatic stabilization makes the anion especially stable and the parent unusually acidic for a hydrocarbon. Cycloheptatriene would form a nonaromatic or antiaromatic anion (and its conjugate base is far less stabilized), and cyclopropene/cyclohexadiene do not form comparably stabilized aromatic anions under simple deprotonation. Therefore cyclopentadiene releases a proton most readily in basic medium relative to the other choices because the resulting anion attains strong aromatic stabilization.

Common Data for Questions 15 and 16:

For the reaction, $P(g) = 2Q(g)$, the equilibrium constant with a standard state pressure of 1 bar is 0.25. Assume ideal gas behaviour.

Q.15 The total pressure (in bar) needed for 50% conversion of P into Q is

- (A) 0.1250
- (B) 0.1875
- (C) 0.5000
- (D) 0.7500

(2009)

Answer: (B) 0.1875

Explanation: Let the initial amount of P be 1 mole and let 50% conversion mean $x = 0.5$ of P reacts to Q. Then moles at equilibrium are $n_P = 1 - x = 0.5$ and $n_Q = 2x = 1.0$, so total moles $n_{tot} = 1.5$. The partial pressures are $p_P = P_{tot} \times (0.5/1.5) = \frac{1}{3}P_{tot}$ and $p_Q = P_{tot} \times (1/1.5) = \frac{2}{3}P_{tot}$. The equilibrium constant K_p for $P \rightleftharpoons 2Q$ is

$K_p = \frac{p_Q^2}{p_P} = \frac{(2/3P_{tot})^2}{(1/3P_{tot})} = \frac{4}{3}P_{tot}$. Setting $K_p = 0.25$ gives $0.25 = \frac{4}{3}P_{tot}$, so $P_{tot} = 0.25 \times \frac{3}{4} = 0.1875$ bar. That matches option (B).

Q.16 The amount of P that will be converted to Q at a total pressure of 0.5 bar is approximately

- (A) 13%
- (B) 25%
- (C) 33%
- (D) 55%

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Answer: (C) 33%

Explanation: Let the initial amount of P be 1 mole and let the fraction converted be y . Then at equilibrium $n_P = 1 - y$, $n_Q = 2y$, and total moles $n_{tot} = 1 + y$. Using partial pressures $p_P = P_{tot} \frac{1-y}{1+y}$ and $p_Q = P_{tot} \frac{2y}{1+y}$, the equilibrium constant $K_p = \frac{p_Q^2}{p_P} = P_{tot} \frac{4y^2}{1-y^2}$. Substituting $K_p = 0.25$ and $P_{tot} = 0.5$ bar yields $0.25 = 0.5 \cdot \frac{4y^2}{1-y^2}$, which simplifies to $0.25(1 - y^2) = 2y^2$ and hence $y^2 = \frac{0.25}{2.25} = \frac{1}{9}$. Thus $y = \frac{1}{3} (\approx 33.3\%)$, so about one-third of the original P is converted under the given total pressure, which corresponds to option (C).

Linked Answer Questions

Statement for Linked Answer Questions 17 and 18:

The reaction of B^*F_3 with $NaBH_4$ leads to the formation of a stable gaseous boron compound P. The compound P reacts with Me_3N to give Q.

Q.17 Identify P among the following:

- (A) BH_3
- (B) $Na[B_3H_8]$
- (C) B_2H_6
- (D) B_4H_{10}

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Answer: (C) B_2H_6

Explanation: When boron trifluoride (BF_3) is reduced using a hydride donor such as sodium borohydride ($NaBH_4$), the reaction typically yields **diborane (B_2H_6)** as the main gaseous product. This occurs because the monomeric borane (BH_3), although theoretically possible, is highly unstable and tends to dimerize rapidly. The mechanism involves hydride transfer from $NaBH_4$ to BF_3 , followed by the formation of a B–B bond, which stabilizes the resulting molecule as diborane. Other boron hydride species like sodium triborohydride ($Na[B_3H_8]$) or tetraborane (B_4H_{10}) are more complex and are not typically formed as primary products under these conditions. Therefore, the most stable and commonly observed gaseous boron hydride from this reduction reaction is **diborane (B_2H_6)**, making **option (C)** the correct answer.

Q.18 The compound Q is

- (A) $\text{BH}_3 \cdot \text{NMe}_3$
- (B) $\text{B}_2\text{H}_5 \cdot \text{NMe}_3$
- (C) $\text{B}_4\text{H}_9 \cdot \text{NMe}_3$
- (D) $\text{BH}_3 \cdot 2\text{NMe}_3$

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Answer: (A) $\text{BH}_3 \cdot \text{NMe}_3$

Explanation: When diborane (B_2H_6) reacts with a Lewis base such as trimethylamine (Me_3N), the equilibrium between diborane and its monomeric units (BH_3) allows the strong donor Me_3N to trap BH_3 rapidly, forming the stable amine–borane adduct $\text{BH}_3 \cdot \text{NMe}_3$. This adduct is favored because BH_3 is highly electron-deficient and readily accepts the lone pair from nitrogen, creating a strong Lewis acid–base bond. Larger borane–amine clusters like $\text{B}_2\text{H}_5 \cdot \text{NMe}_3$ or $\text{B}_4\text{H}_9 \cdot \text{NMe}_3$ do not form under these conditions as the monomeric complex is much more stable and synthetically useful. Therefore, the observed product is $\text{BH}_3 \cdot \text{NMe}_3$ (option A), which is commonly employed as a convenient, non-gaseous source of borane for hydroboration and related reactions.

I: BIOCHEMISTRY

Q.1 Pernicious anemia is due to

- (A) blockage of vitamin B_{12} absorption.
- (B) blockage of vitamin A absorption.
- (C) deficiency of vitamin C.
- (D) deficiency of vitamin B2.

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Answer: (A) blockage of vitamin B_{12} absorption.

Explanation: Pernicious anemia is a specific type of **Vitamin deficiency anemia** that results from the inability to properly absorb the vitamin, rather than just a dietary lack. The underlying cause is often the autoimmune destruction of **parietal cells** in the stomach, which are responsible for producing **intrinsic factor**. Intrinsic factor is a glycoprotein essential for the binding and subsequent absorption of dietary **vitamin** (cobalamin) in the terminal ileum. When this absorption is **blocked**, as implied by the option, the body cannot utilize the vitamin, leading to impaired DNA synthesis and the characteristic production of large, immature red blood cells (megaloblasts), which defines the anemia. Therefore, the core mechanism of pernicious anemia is indeed the blockage of vitamin absorption, regardless of sufficient dietary intake.

Q.2 Which of these can be an antigen but cannot induce immune responses?

- (A) Hemocyanin
- (B) Influenza virus
- (C) Azobenzene arsonate
- (D) Corynebacteria

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Answer: (C) Azobenzene arsonate

Explanation: The substance described is a **hapten**, which is a

small molecule that can act as an **antigen**—meaning it can bind specifically to immune components like antibodies or T-cell receptors—but is **non-immunogenic** on its own, meaning it cannot induce an immune response. Azobenzene arsonate is a classic example of a **hapten** because its small size prevents it from effectively cross-linking B-cell receptors or being processed and presented to T cells in a manner that triggers a robust immune response. However, when chemically coupled to a larger **carrier protein**, it becomes an **immunogen** (or complete antigen) and can successfully stimulate the immune system to produce antibodies specific to the azobenzene arsonate part. In contrast, Hemocyanin, Influenza virus, and Corynebacteria are all large, complex macromolecules or particles that are fully capable of acting as both antigens and immunogens.

Q.3 In mammals, the second messenger Nitric Oxide (NO) is produced from

- (A) Ammonium nitrate
- (B) Arginine
- (C) Urea
- (D) Nitrous acid

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Answer: (B) Arginine

Explanation: The gaseous signaling molecule **Nitric Oxide (NO)** acts as a crucial **second messenger** in numerous physiological processes in mammals, including vasodilation, neurotransmission, and immune response. NO is synthesized by a family of enzymes known as **Nitric Oxide Synthases (NOS)**, which come in three main isoforms: neuronal (nNOS), inducible (iNOS), and endothelial (eNOS). These NOS enzymes catalyze the five-electron oxidation of the terminal guanidino nitrogen of the amino acid **L-arginine** to produce L-citrulline and **Nitric Oxide**, utilizing and oxygen. Therefore, **L-arginine** is the direct precursor and a necessary substrate for generation within the cell.

Q.4 Generally, the rate-limiting step of major metabolic pathways is a reaction

- (A) in which the availability of the substrate is limited.
- (B) catalyzed by an allosteric enzyme.
- (C) catalyzed by an enzyme with very low K_m .
- (D) whose products are not readily consumed by the subsequent step of the pathway.

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Answer: (B) catalyzed by an allosteric enzyme.

Explanation: The **rate-limiting step** in a metabolic pathway is the slowest reaction that determines the overall rate, and it is almost universally a reaction catalyzed by a highly regulated enzyme. This regulatory point is most often catalyzed by an **allosteric enzyme**, which is an enzyme whose activity can be quickly and reversibly altered by the binding of specific effector molecules (allosteric activators or inhibitors) to a site distinct from the active site. This mechanism allows the cell to finely tune the pathway's flux in response to immediate needs or changes in cellular environment, such as the concentration of the pathway's end-product (feedback inhibition). The ability of an **allosteric enzyme** to change its catalytic efficiency in

response to cellular signals makes it the ideal control point for a major metabolic pathway.

Q.5 Human DNA (3×10^6 Kb) is replicated in 5 hrs at a rate of 1 Kb/min. The number of origins of replication utilized are

- (A) 1
- (B) 3
- (C) 300
- (D) 10,000

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Answer: (D) 10,000

Explanation: To determine the number of origins, first, calculate the **total length** of DNA that a single origin can replicate in the given time. The total DNA length is (or). The total replication time is , which is . Since replication proceeds **bidirectionally** from a single origin, the effective replication rate is . The maximum DNA replicated by **one origin** in is . To find the number of origins required, divide the total DNA length by the DNA replicated per origin: . This calculation simplifies to . This is the number of **replication units** (or replication bubbles) needed; however, the question asks for the number of **origins**. Since replication units with a bidirectional rate of are needed, and each replication unit contains one origin, the total number of origins is . **However**, among the options given, is mathematically , which implies a **unidirectional** rate of per origin, meaning . Because is a standard expectation in simplified calculations of human replication, and is not an option, the calculation likely assumes **unidirectional replication per origin** (or per replication fork) multiplied by the number of origins. Given the choices, **10,000** is the intended answer for a rapid estimation.

Q.6 Phospholipases A1 and A2,

- (A) play no role in phospholipids synthesis.
- (B) hydrolyze phosphatidic acid to diglycerate.
- (C) remove fatty acid from sn-1 and sn-2 of phospholipids.
- (D) are involved in biosynthesis of phosphatidyl ethanolamine.

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Answer: (C) remove fatty acid from sn-1 and sn-2 of phospholipids.

Explanation: Phospholipases are a class of enzymes that **hydrolyze** ester bonds in **phospholipids**. Specifically, **Phospholipase** catalyzes the hydrolysis of the ester bond connecting the **fatty acid chain** to the hydroxyl group at the **position** (the first carbon of the glycerol backbone). Conversely, **Phospholipase** specifically cleaves the ester bond at the **position**, removing the second fatty acid chain. The action of is particularly significant as it often releases **arachidonic acid** from the position, which is the precursor for various eicosanoids, including prostaglandins and leukotrienes, making it a key enzyme in inflammatory pathways. Both and are involved in the **catabolism** (breakdown) and remodeling of phospholipids, not their synthesis, by removing one of the fatty acyl chains.

Q.7 Equal volumes of two buffers of pH 4 and pH 6 of identical ionic strengths are mixed. The resultant pH is

- (A) close to 4.
- (B) close to 5.
- (C) close to 6.
- (D) exactly 5.

(2009)

Answer: (A) close to 4.

Explanation: When equal volumes of two buffers of pH 4 and pH 6 are mixed, the resulting pH is **close to 4** because the acidic buffer contributes far more hydrogen ions than the basic buffer can neutralize. pH is a logarithmic scale, so a solution at pH 4 has an $[H^+]$ of 10^{-4} M, while pH 6 has 10^{-6} M. When mixed in equal volumes, the combined concentration of H^+ is approximately $(10^{-4} + 10^{-6})/2 \approx 5 \times 10^{-5}$ M, which corresponds to a pH of about 4.3. This value is much nearer to 4 than to 5 or 6, showing that the stronger acidic component dominates the mixture. Therefore, the resultant pH is **close to 4**, making option (A) correct.

Q.8 An insert (I) of 1 Kb is ligated to a plasmid (P) of 4 Kb in a molar ratio of 4:1 respectively in a final DNA concentration of 10 μ /ml The amounts of insert (I) and plasmid (P) required in μ g are

- (A) I=8 and P = 2
- (B) I = 2 and P = 8
- (C) I=5 and P = 5
- (D) I = 1 and P = 4

(2009)

Answer: (A) I=8 and P = 2

Explanation: The insert (I) is 1 kb and the plasmid (P) is 4 kb, and they are to be ligated in a molar ratio of 4:1 at a final DNA concentration of 10 μ g/ml. Since molar ratio depends on the number of molecules, and the number of molecules is proportional to mass divided by size, the mass ratio must compensate for the size difference. For every 4 molecules of the 1 kb insert and 1 molecule of the 4 kb plasmid, the total base pairs contributed are equal ($4 \times 1 \text{ kb} = 4 \text{ kb}$ and $1 \times 4 \text{ kb} = 4 \text{ kb}$). This means the mass ratio will be 4:1 in favor of the insert. With a total DNA concentration of 10 μ g/ml, the combined mass of insert and plasmid is 10 μ g. Dividing this in a 4:1 ratio gives 8 μ g of insert and 2 μ g of plasmid. Therefore, the correct answer is (A) I = 8 μ g and P = 2 μ g.

Q.9 The formation of ATP from ADP and Pi is not a spontaneous reaction. A reason for this is

- (A) ATP readily ionizes.
- (B) electrostatic repulsion in ATP is lower than that in ADP.
- (C) ATP is better hydrated than the total hydration levels of ADP and Pi.

(D) resonance stabilization of P-O bonds in Pi is higher than that in ATP.

(2009)

Answer: (D) resonance stabilization of P-O bonds in Pi is higher than that in ATP.

Explanation: The formation of from and inorganic phosphate is an **endergonic** process, meaning it requires a significant input of energy and is therefore **non-spontaneous**. Conversely, the **hydrolysis** of is highly spontaneous and exergonic. A major factor driving this high negative free energy of hydrolysis is the greater **resonance stabilization** of the reaction products, and, compared to the molecule itself. The inorganic phosphate ion has multiple equivalent resonance structures, which significantly lowers its free energy. Since the bonds of are more resonance-stabilized than the bonds in the **terminal phosphate of**, the transition from to the products releases a large amount of energy, making the reverse reaction (formation of) energetically unfavorable and non-spontaneous.

Q.10 A beam of light passes through 1 cm of a colored solution. Eighty percent of the incident light is transmitted. If the incident light passes through 2 cm of the same solution, the percentage of transmitted light is

- (A) 60
- (B) 64
- (C) 70
- (D) 40

(2009)

Answer: (B) 64

Explanation: The correct answer is (B) 64%, and this follows from the Beer-Lambert law, which states that absorbance (and therefore transmission) depends exponentially on path length. If 80% of light is transmitted through 1 cm, then the transmittance $T_1 = 0.8$. For 2 cm, the transmittance will be $T_2 = (T_1)^2 = (0.8)^2 = 0.64$. Because doubling the path length doubles the absorbance, and transmittance decreases multiplicatively. Converting back to percentage, this gives 64%. Thus, when the path length is doubled, the transmitted light is not halved but reduced according to the exponential relationship, making option (B) correct.

Q.11 Lactose uptake in E. coli is an example of

- (A) Passive transport
- (B) Primary active transport
- (C) Secondary active transport
- (D) Simple diffusion

(2009)

Answer: (C) Secondary active transport

Explanation: Lactose uptake in E. coli is primarily mediated by

the **lactose permease**, a membrane transport protein encoded by the lac operon. This process is a classic example of **secondary active transport**, specifically a **symport** system. The protein simultaneously transports one molecule of **lactose** into the cell along with one **proton**. The energy for lactose transport against its concentration gradient is provided not by hydrolysis (which would be primary active transport), but by the pre-existing **electrochemical gradient of protons** across the plasma membrane, which is established by the respiratory chain. The favorable influx of down its gradient drives the unfavorable uptake of lactose, thus classifying it as **secondary active transport**.

Q.12 During receptor-mediated endocytosis of LDL bound to its receptor

- (A) both receptor and ligand are degraded.
- (B) the receptor is degraded and the ligand is recycled.
- (C) both are recycled.
- (D) the ligand is degraded and the receptor is recycled.

(2009)

Answer: (D) the ligand is degraded and the receptor is recycled.

Explanation: The process of receptor-mediated endocytosis of **Low-Density Lipoprotein** is a well-studied example of how cells internalize cholesterol. After (the **ligand**) binds to the receptor (the **receptor**) on the cell surface, the complex is internalized into a clathrin-coated vesicle. This vesicle quickly fuses with an **endosome**, whose internal drops significantly due to a proton pump. The **acidic** causes the to **dissociate** from its receptor. The **receptor** is then packaged into vesicles that bud off and fuse back with the plasma membrane (**recycling**). The released is carried to the **lysosomes**, where it is broken down by hydrolytic enzymes, releasing cholesterol into the cytosol (**degradation**). Thus, the ligand is degraded while the receptor is recycled.

Q.13 Choose the correct pairs from the following:

- a. Isocitrate lyase
 - b. PEP carboxykinase
 - c. Pyruvate dehydrogenase complex
 - d. Phosphofructokinase
 - e. Pyruvate carboxylase
-
- i. Conversion of amino acids into glucose
 - ii. Biotin
 - iii. Synthesis of glucose from acetate
 - iv. Lipoic acid
 - v. An allosteric enzyme
- (A) a-i, b-ii, c-iv, d-v, e-iii
 - (B) a-iii, b-i, c-iv, d-v, e-ii
 - (C) a-iii, b-i, c-iv, d-ii, e-v
 - (D) a-ii, b-v, c-i, d-iv, e-iii

(2009)

Answer: (B) a-iii, b-i, c-iv, d-v, e-ii

Explanation: Matching the enzymes to their correct functional roles or associated cofactors yields the following: **a. Isocitrate lyase**

(iii) is a key enzyme in the **glyoxylate cycle**, which allows organisms like bacteria and plants to synthesize carbohydrates (like glucose) from two-carbon units like **acetate** (but not humans). **b. carboxykinase (i)** is a crucial enzyme in **gluconeogenesis**, specifically for converting into , which is essential for the net synthesis of glucose from non-carbohydrate precursors like certain **amino acids**. **c. Pyruvate dehydrogenase complex (iv)** is a multienzyme complex that requires five cofactors, including **Lipoic acid**, to convert pyruvate to acetyl-. **d. Phosphofructokinase (v)** is a major **allosteric enzyme** and the most important control point in glycolysis, regulated by , , and fructose 2,6-bisphosphate. **e. Pyruvate carboxylase (ii)** catalyzes the first step of gluconeogenesis (pyruvate to) and absolutely requires the cofactor **Biotin** for the transfer of a group. The correct pairing is therefore **a-iii, b-i, c-iv, d-v, e-ii**.

Q.14 The advantage of hemoglobin having a high histidine content is

- (A) histidine binds to oxygen.
- (B) histidine carries oxygen to the tissues.
- (C) histidine imparts buffering capacity to hemoglobin.
- (D) 'R' group of histidine has low pKa.

(2009)

Answer: (C) histidine imparts buffering capacity to hemoglobin.

Explanation: The significant advantage of hemoglobin's high content of the amino acid **histidine** is its role in contributing a major portion of the blood's non-bicarbonate **buffering capacity**. The **imidazole ring** of histidine has a side chain with a value of approximately 6.0 in pure solution, which is close to the physiological of blood (7.4), though its effective is shifted within the protein environment. This makes histidine residues highly effective at reversibly accepting and donating **protons**, helping to stabilize the of the blood against shifts caused by metabolically produced acids, such as carbonic acid (from). This binding is also central to the **Bohr effect**, where binding lowers hemoglobin's affinity for oxygen, promoting release in active tissues.

Q.15 IgG has four chains. Purified monoclonal IgG was subjected to electrophoresis. The number of bands visible by

- a) Reducing SDS-PAGE**
- b) Isoelectric focusing**
- c) Native PAGE are**

- (A) a-2; b-1; c-1
- (B) a-1; b-1; c-2
- (C) a-2; b-4; c-2
- (D) a-4; b-2; c-4

(2009)

Answer: (A) a-2; b-1; c-1

Explanation: Monoclonal is a single, homogeneous type of antibody molecule, composed of **two identical heavy chains** and **two identical light chains** linked by disulfide bonds. **a) Reducing** breaks all disulfide bonds and denatures the protein; thus, two bands will be

visible, corresponding to the two molecular weight classes: the **heavy chain** and the **light chain**. **b) Isoelectric focusing** separates proteins based on their **isoelectric point**. Since the is **monoclonal**, all its molecules are structurally identical and possess the exact same amino acid sequence, resulting in a single, homogeneous net charge and thus **one single band** at its unique . **c) Native** separates proteins based on their size, shape, and net charge while maintaining their native, quaternary structure. Since monoclonal exists as a single, uniform - shaped protein of one size and charge, it will migrate as a single species, yielding **one single band**.

Q.16 When E.coli is grown in glucose and lactose, the lac operon is not expressed. This is because glucose interferes with

- (A) removal of repressor.
- (B) binding of activator.
- (C) removal of repressor and binding of activator.
- (D) removal of activator.

(2009)

Answer: (B) binding of activator.

Explanation: The lac operon is under **dual control** to ensure efficient use of resources: it is **negatively regulated** by the repressor and **positively regulated** by the complex (the activator). When **glucose** is present, it is the preferred energy source, and its metabolism leads to a decrease in the cellular concentration of **cyclic**. Low levels mean that the **cannot bind** to the catabolite activator protein, which is essential for to adopt an active conformation. Consequently, the complex **fails to bind** to the lac operon promoter, preventing the transcription of the operon, even if lactose is present (as repressor is removed by allolactose). Therefore, glucose ensures the lac operon is not expressed by **blocking the binding of the activator**, a phenomenon called **catabolite repression**.

Q.17 What property of biomembranes is responsible for their self-sealing nature?

- (A) Hydrophilicity of the phospholipid head group
- (B) Presence of proteins in biomembranes
- (C) Presence of cholesterol in biomembranes
- (D) Hydrophobicity of the fatty acid side chains of phospholipids

(2009)

Answer: (D) Hydrophobicity of the fatty acid side chains of phospholipids

Explanation: The **self-sealing nature** of biological membranes is a direct consequence of the **amphipathic** nature of their primary building blocks, the **phospholipids**, and their organization into a **lipid bilayer**. When a break occurs in the membrane, the exposed edges are energetically unfavorable because the **hydrophobic fatty acid side chains** of the phospholipids are forced to interact with the aqueous environment. To minimize this energetically costly interaction, the hydrophobic tails rapidly and spontaneously rearrange to exclude water, leading to the membrane edges quickly closing and **self-sealing** to form a continuous lipid bilayer. This spontaneous reorganization is

essentially driven by the powerful **hydrophobic effect**, which is directly linked to the **hydrophobicity of the fatty acid side chains**.

Q.18 A mixture of amino acids consisting of glycine, lysine, arginine, histidine, aspartic acid and glutamic acid was placed in the centre of a paper strip, moistened with buffer of pH 6 and electric current applied. The migration of amino acids was as follows:

- (A) Glycine, lysine and histidine moved towards the anode. Aspartic acid and glutamic acid moved towards the cathode while arginine remained near the origin.
- (B) Aspartic acid and glutamic acid remained near the origin and lysine, histidine and glycine moved towards the anode while arginine moved towards the cathode.
- (C) Glycine remained near the origin. Lysine, arginine and histidine moved towards the cathode while aspartic acid and glutamic acid moved towards the anode.
- (D) All amino acids remained near the origin.

(2009)

Answer: (C) Glycine remained near the origin. Lysine, arginine and histidine moved towards the cathode while aspartic acid and glutamic acid moved towards the anode.

Explanation: In electrophoresis at a given , amino acids migrate according to their net charge, which is determined by the difference between the buffer (6.0) and the amino acid's **isoelectric point** . If, the amino acid has a net positive charge and moves toward the **cathode** (negative electrode); if, it has a net negative charge and moves toward the **anode** (positive electrode); if, it remains near the **origin**. **Glycine** will remain near the origin. **Lysine , Arginine , and Histidine** are **basic** amino acids; since , they are positively charged and move toward the **cathode**. **Aspartic acid and Glutamic acid** are **acidic** amino acids; since , they are negatively charged and move toward the **anode**.

Q.19 Cells expressing Epidermal Growth Factor (EGF) receptors were treated (T) or untreated (U) with EGF.

The cells were lysed and immunoprecipitated with EGF receptor-specific antibodies. The immunoprecipitate was analyzed by Western blotting with antibodies specific to

i) phosphotyrosine ii) phosphothreonine iii) tyrosine kinases iv) threonine kinases.

Which of these antibodies would detect a band under T and U conditions?

- (A) T-i & iii; U-iii
- (C) T-i & ii; U-1
- (B) T-ii & iv; U-iv
- (D) T-i & iii; U-ii

(2009)

Answer: (A) T-i & iii; U-iii

Explanation: The **Epidermal Growth Factor receptor** is a classic example of a **receptor tyrosine kinase** , meaning the receptor itself possesses intrinsic **tyrosine kinase** activity. Therefore, the receptor protein itself is a **tyrosine kinase**, which is present in both the **treated and untreated cells**. Thus, an antibody specific to **tyrosine kinases (iii)** will detect the receptor band in **both** conditions. When the cells are treated with , the receptor dimerizes and becomes catalytically active, resulting in the **autophosphorylation of its own tyrosine residues**. Therefore, antibodies specific to **phosphotyrosine (i)** will only detect the band in the **treated condition**, indicating the activation state. Antibodies specific for phosphothreonine and threonine kinases are not directly relevant to receptor's primary signaling mechanism.

Q.20 Which of the following would be considered the longest feedback loop?

- (A) Reproductive steroid hormones aminergic neurons
- (B) Reproductive steroid hormones hypothalamic neurons
- (C) Reproductive steroid hormones pituitary gonadotrophs
- (D) Gonadotropin releasing hormone-hypothalamic neurons

(2009)

Answer: (B) Reproductive steroid hormones hypothalamic neurons

Explanation: The regulation of the reproductive axis is a prime example of hormonal feedback control, involving the hypothalamus, the pituitary gland, and peripheral endocrine glands (gonads). This system can be categorized into three feedback loops based on length: the **ultra-short loop** (e.g., inhibiting its own release), the **short loop** (e.g., pituitary gonadotrophs inhibiting release from the hypothalamus), and the **long loop**. The **longest feedback loop** involves the final peripheral endocrine hormones—the **reproductive steroid hormones** (like estrogen and testosterone)—acting all the way back to inhibit the production of initial releasing hormones in the **hypothalamic neurons** (e.g., by inhibiting release). Since the hypothalamus is the starting point of the cascade, this pathway represents the full span of the regulatory axis and is therefore the **longest feedback loop**.

Q.21 In myasthenia gravis, a neuromuscular disorder, the acetylcholine receptor becomes dysfunctional because

- (A) the receptor is mutated.
- (B) antibodies to the receptor inhibit ligand binding.
- (C) of deficiency in acetylcholine transferase.
- (D) of excess of acetylcholine esterase.

(2009)

Answer: (B) antibodies to the receptor inhibit ligand binding.

Explanation: **Myasthenia gravis** is a chronic, autoimmune neuromuscular disease characterized by varying degrees of weakness of the skeletal (voluntary) muscles, and is the result of a failure in signal transmission at the **neuromuscular junction**. The underlying

pathology is the production of **autoantibodies** that are directed against the **nicotinic acetylcholine receptors** located on the post-synaptic muscle cell membrane. These antibodies typically **block or destroy** the receptors, leading to a functional reduction in the number of available . This reduction means that acetylcholine released from the nerve terminal cannot effectively bind to enough receptors to initiate a full depolarization and subsequent muscle contraction, which explains why the disease is characterized by muscle weakness, particularly following activity.

J: BIOTECHNOLOGY

Q.1 The method used for prediction of three dimensional structure of a protein from known structure(s) of one or more related proteins is

- (A) Multiple sequence alignment
- (B) Homology modelling
- (C) Phylogeny
- (D) Docking

(2009)

Answer: (B) Homology modelling

Explanation: Homology modelling (also called comparative modelling) is the standard method for predicting the three-dimensional structure of a protein when one or more related protein structures (templates) are available. The approach exploits the observation that protein tertiary structure is more conserved than sequence, so a target sequence aligned to a known template structure can be modeled by transferring backbone coordinates and rebuilding variable regions; multiple sequence alignment (choice A) is an important preparatory step but by itself does not produce a 3D model. Phylogeny (choice C) is concerned with evolutionary relationships and is not a structure-prediction technique, while docking (choice D) predicts interactions between molecules rather than a single protein's fold. In practice homology modelling workflows include template selection, alignment (often a multiple sequence alignment), model building and refinement, and model validation; this integrated pipeline is why homology modelling is the correct and widely used answer for template-based protein structure prediction.

Q.2 To produce plants that are homozygous for all traits, the best choice is

- (A) Protoplast culture
- (B) Cell suspension culture
- (C) Anther and pollen culture
- (D) Apical meristem culture

(2009)

Answer: (C) Anther and pollen culture

Explanation: Anther and pollen culture generate haploid plants (from microspores) that can be treated (e.g., with colchicine) to induce chromosome doubling and produce doubled haploids, which are homozygous at virtually all loci. This rapid route to complete homozygosity in a single generation is why anther/pollen culture is the preferred method for obtaining plants homozygous for all traits; protoplast culture (A) and cell suspension culture (B) can regenerate

plants but do not inherently produce homozygous doubled haploids, and apical meristem culture (D) is primarily used for virus elimination and producing clonal plantlets, not for creating homozygous lines. The doubled haploid method shortens breeding cycles and fixes alleles instantly rather than requiring several generations of inbreeding; therefore, when the objective is fully homozygous progeny rapidly, anther and pollen culture is the best choice.

Q.3 Restriction endonucleases from two different organisms that recognize the same DNA sequence for cleavage are called

- (A) Isoschizomers
- (B) Isozymes
- (C) Concatamers
- (D) Palindromes

(2009)

Answer: (A) Isoschizomers

Explanation: Restriction endonucleases from different organisms that recognize and cleave the exact same DNA recognition sequence are called isoschizomers. These enzymes may come from different bacterial species but have identical sequence specificity; they can differ in recognition of methylation or have different cleavage patterns nearby, but the defining feature is the same recognition sequence. Isozymes (choice B) are different enzyme forms that catalyze the same biochemical reaction in an organism but are not a term used for restriction enzymes from different species. Concatamers (choice C) and palindromes (choice D) are unrelated terms in this context, so isoschizomers is the precise nomenclature used in molecular biology for shared recognition sequences across separate restriction enzymes.

Q.4 Caspases are involved in the process of

- (A) DNA replication
- (B) Mutation and recombination
- (C) Antibody synthesis
- (D) Apoptosis

(2009)

Answer: (D) Apoptosis

Explanation: Caspases are a family of cysteine-dependent aspartate-specific proteases that play central and essential roles in apoptosis, the programmed cell death pathway in multicellular organisms. Initiator caspases (e.g., caspase-8, -9) are activated by death signals and then cleave and activate effector caspases (e.g., caspase-3, -7), which in turn cleave structural and regulatory proteins to execute the apoptotic program; they are not involved in core processes like DNA replication (A), general recombination (B), or antibody synthesis (C). The biochemical cascade controlled by caspases leads to characteristic morphological and biochemical features of apoptosis such as chromatin condensation, membrane blebbing, and formation of apoptotic bodies that are cleared without provoking inflammation, highlighting caspases' role as central executioners of programmed cell death.

Q.5 Baculovirus expression system is used to express heterologous genes in

(2009)

- (A) Mammals
- (B) Plants
- (C) Insects
- (D) Yeasts

(2009)

Answer: (C) Insects

Explanation: The baculovirus expression system uses insect cells (commonly *Spodoptera frugiperda* Sf9/Sf21 or *Trichoplusia ni* High Five cells) infected with recombinant baculoviruses to express heterologous proteins; the system is highly effective for producing eukaryotic proteins with proper folding and many post-translational modifications. This system is optimized for insect host cells and insect cell culture conditions rather than mammalian (A), plant (B) or yeast (D) expression platforms, which use different viral or plasmid systems; baculovirus vectors can also be used to infect whole insect larvae for protein production, but their principal and classical application is insect cell expression. Advantages include high expression levels, capacity for large inserts, and relatively eukaryotic-like processing, which is why baculovirus is the correct choice for insect-based heterologous expression.

Q.6 A culture vessel in which physical, physicochemical and physiological conditions, as well as cell concentration, are kept constant is known as

- (A) Cell concentrator
- (B) Biostat
- (C) Batch bioreactor
- (D) Incubator

(2009)

Answer: (B) Biostat

Explanation: A biostat (more commonly called a chemostat or continuous bioreactor when used to maintain constant conditions) is a culture vessel in which physical, physicochemical, and physiological conditions as well as cell concentration are kept essentially constant by continuous addition of fresh medium and simultaneous removal of culture at the same rate. Batch bioreactors (choice C) operate in a closed mode where conditions and cell concentration change over time; an incubator (D) maintains temperature (and sometimes humidity/CO₂) but does not actively control continuous feed and removal to maintain constant cell concentration, and "cell concentrator" (A) is not the standard term for a vessel maintaining steady state. In steady-state continuous operation the dilution rate is adjusted to reach and hold a desired cell density and nutrient state, which is precisely the functional description of a biostat.

Q.7 Virus resistant transgenic plants can be developed by the expression of

- (A) Cowpea trypsin inhibitor
- (B) Crystalline toxin protein
- (C) Defective movement protein
- (D) Snowdrop lectin

Answer: (C) Defective movement protein

Explanation: Virus resistance in transgenic plants is commonly achieved by expressing defective forms of viral movement proteins or coat proteins (pathogen-derived resistance), which interfere with the virus's ability to move cell-to-cell and systemically through the plant. Expression of a defective movement protein can act as a dominant negative, blocking the function of the wild-type viral movement protein and thereby restricting spread of virus; cowpea trypsin inhibitor (A) and snowdrop lectin (D) are insect-resistance or anti-herbivory genes, and crystalline toxin protein (B, Bt toxin) targets insect pests rather than viruses. Thus, expressing a defective movement protein is a recognized strategy to generate virus-resistant transgenic plants because it directly disrupts a required viral function for plant-to-plant dissemination.

Q.8 Which of the following are commonly used as reporter genes ?

- P. NPT gene
- Q. Luciferase gene
- R. CFTR gene
- S. GFP gene

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

(2009)

Answer: (A) Q, S

Explanation: Reporter genes commonly used to monitor gene expression or promoter activity include luciferase (bioluminescent reporter) and GFP (green fluorescent protein), which provide sensitive, quantifiable, and often non-destructive readouts in living cells or tissues. The NPT (neomycin phosphotransferase) gene (P) confers antibiotic resistance and is commonly used as a selectable marker rather than a direct reporter of expression dynamics, while CFTR (choice R) is a functional human ion channel gene implicated in cystic fibrosis and is not a reporter gene. Therefore, luciferase and GFP (Q and S) are the classical reporter genes listed here, chosen for their ease of detection and broad applicability in molecular biology.

Q.9 Which of the following statements are true about glyphosate tolerant transgenic plants?

- P. Transgenic plants detoxify glyphosate.
- Q. Transgenic plants produce an altered enzyme that is not affected by glyphosate.
- R. Transgenic plants sequester glyphosate in vacuoles.
- S. Transgenic plants overcome the inhibition of aromatic amino acid biosynthesis.

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

- (2009)
- (A) P-3, Q-4, R-2, S-1
 (B) P-4, Q-1, R-2, S-3
 (C) P-4, Q-3, R-1, S-2
 (D) P-3, Q-2, R-4, S-1

Answer: (C) Q, S

Explanation: Glyphosate inhibits the enzyme EPSPS (5-enolpyruvylshikimate-3-phosphate synthase) in the shikimate pathway, blocking aromatic amino acid biosynthesis; glyphosate-tolerant transgenic plants typically express an altered EPSPS enzyme (from bacterial or mutated plant sources) that is not inhibited by glyphosate, thereby allowing the pathway to continue (statement Q true). By producing an insensitive enzyme, the transgenic plant overcomes glyphosate's inhibition and maintains synthesis of aromatic amino acids (statement S true), whereas detoxification (P) or vacuolar sequestration (R) are not the general mechanisms for the common EPSPS-based tolerance strategies. Thus Q and S accurately describe the widely used molecular basis of glyphosate tolerance, making option (C) the correct choice.

Q.10 Match the items in Group 1 with an appropriate description in Group 2:

Group 1

P. UPGMA
 Q. CLUSTAL
 R. SWISS-PROT
 S. RasMol

Group 2

1. Protein sequence database
2. Phylogenetic analysis
3. 3-D structure visualization
4. Multiple sequence alignment

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

(2009)

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

Explanation: UPGMA (Unweighted Pair Group Method with Arithmetic mean) is a clustering algorithm used for phylogenetic analysis (2); CLUSTAL is a widely used program for multiple sequence alignment (4); SWISS-PROT is a curated protein sequence database (1) providing high-quality annotated entries; and RasMol is a molecular graphics program used for 3-D structure visualization (3). The mappings P→phylogenetic analysis, Q→multiple sequence alignment, R→protein sequence database, and S→3-D visualization are the standard associations in bioinformatics and molecular biology, so the set P-2, Q-4, R-1, S-3 correctly links each tool/resource to its primary function and therefore corresponds to option (B).

Q.11 Match the properties in Group 1 with the downstream operations in Group 2:

Group 1

P. Size
 Q. Density
 R. Volatility
 S. Solubility

Group 2

1. Extraction
2. Distillation
3. Filtration
4. Sedimentation

(2009)

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

Explanation: In separation and downstream processing, particle size primarily governs the choice of filtration (P→3) because filtration separates solids from liquids based on size exclusion; density differences drive sedimentation (Q→4) or centrifugation where denser particles settle faster; volatility determines whether distillation is appropriate (R→2) because volatile components can be separated by differences in boiling point; and solubility dictates extraction (S→1) where a solute's preferential solubility in one solvent versus another enables partitioning. These pairings reflect fundamental physical-chemical principles exploited in unit operations, making the mapping size→filtration, density→sedimentation, volatility→distillation, solubility→extraction the correct and practical choice.

Q.12 Match the items in Group 1 with their functions in Group 2:

Group 1

P. *rol* genes
 Q. Opines
 R. Virulence genes
 S. *Aux* and *cyt* genes

Group 2

1. Food and energy source
2. Tumor formation
3. Hairy root induction
4. T-DNA transfer and integration

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

(2009)

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

Explanation: In *Agrobacterium*-mediated plant genetic interactions, *rol* genes (root oncogenic loci) on Ri plasmids induce hairy root formation (P→3), opines produced by transformed plant tissue act as unique carbon and nitrogen sources metabolized by the bacterium (Q→1), virulence (*vir*) genes mediate T-DNA transfer and integration into the plant genome (R→4), and *aux* and *cyt* genes located on T-DNA encode auxin and cytokinin biosynthetic activities that drive tumor (crown gall) formation (S→2). These functional assignments reflect well-established molecular roles in plant–*Agrobacterium* interactions and thus the matching P-3, Q-1, R-4, S-2 corresponds to option (D).

Q.13 Which of the following statements hold true for pluripotent stem cells (PSCs) under in vitro conditions?

P. PSCs can be maintained in an undifferentiated state.

Q. PSCs exhibit abnormal and unstable karyotypes.

R. PSCs can differentiate into a wide variety of cell types.

S. PSCs cannot be passaged continuously.

(A) P, Q

(B) P, R

(C) Q, R

(D) Q, S

(2009)

Answer: (B) P, R

Explanation: Pluripotent stem cells (PSCs) in vitro can indeed be maintained in an undifferentiated, self-renewing state under appropriate culture conditions that supply the necessary signals and inhibit differentiation (P true), and by definition PSCs have the capacity to differentiate into many cell types representing the three germ layers (R true). Statements that PSCs inherently exhibit abnormal and unstable karyotypes (Q) or cannot be passaged continuously (S) are not generally true; while genetic instability can arise with poor culture practices, it is not an intrinsic, universal property, and PSC lines are routinely passaged and expanded in culture. Therefore the correct pair of true statements describing typical PSC behavior in vitro is P and R, matching option (B).

Q.14 Determine the correctness or otherwise of the following Assertion (a) and Reason (r):

Assertion (a): IPTG (Isopropylthiogalactoside) is a gratuitous inducer of lac operon.

Reason (r) : IPTG is an efficient inducer, but not a substrate of lac operon.

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

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

(C) (a) is true but (r) is false.

(D) (a) is false but (r) is true.

(2009)

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

Explanation: IPTG (isopropyl- β -D-thiogalactopyranoside) is described as a gratuitous inducer of the lac operon because it induces the lac operon by binding and inactivating the lac repressor but is not a substrate for β -galactosidase and therefore is not metabolized by the cell; hence it remains present and continuously induces expression. The reason statement (r) — that IPTG is an efficient inducer but not a substrate of the lac operon — correctly explains why IPTG is called gratuitous: it gratuitously induces without being consumed or metabolized, enabling persistent induction for experimental control. Both the assertion and the reason are factually correct and the reason provides the mechanistic justification for the assertion, so (A) is the accurate logical choice.

Q.15 Which of the following statements are true about bioreactors ?

P. Continuous bioreactors provide less degree of control and uniform product quality than batch bioreactors.

Q. Batch bioreactors are ideally suited for reaction with substrate inhibition.

R. Choice of a bioreactor is dictated by kinetic considerations.

S. Fed batch bioreactors are also called semibatch bioreactors.

(A) P, Q

(B) Q, S

(C) R, S

(D) P, R

(2009)

Answer: (C) R, S

Explanation: The selection of a bioreactor configuration is indeed dictated largely by kinetic considerations such as growth kinetics, substrate inhibition, product formation rates, and oxygen transfer requirements (R true), and fed-batch systems are commonly referred to as semicontinuous or semibatch because they combine aspects of batch and continuous feeding (S true). Statement P is incorrect because continuous bioreactors often provide greater control and more uniform product quality compared to simple batch reactors, not less, and statement Q is not generally true because batch reactors are often unsuitable when substrate inhibition occurs — instead fed-batch or controlled feeding strategies are used. Thus the correct true statements are R and S, making option (C) the right answer.

Q.16 Match the items in Group 1 with correct options in Group 2:

Group 1

P. DNA footprinting

Q. Yeast two-hybrid system

R. DNA fingerprinting

S. SAGE

Group 2

1. Protein-protein interaction

2. VNTR

3. DNA binding protein

4. Transcriptome analysis

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

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

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

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

(2009)

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

Explanation: DNA footprinting (P) is a technique used to identify DNA-binding protein interaction sites by revealing protected regions on DNA and therefore is mapped to DNA binding protein identification (3); the yeast two-hybrid system (Q) is expressly designed to detect and study protein-protein interactions (1); DNA fingerprinting (R) commonly employs VNTR (variable number tandem repeat) patterns to generate genotype-specific banding and is therefore associated with VNTR profiling (2); and SAGE (serial analysis of gene expression) (S) is a method for transcriptome

analysis that quantifies mRNA species via short sequence tags (4). These well-established functional correlations match $P \rightarrow 3$, $Q \rightarrow 1$, $R \rightarrow 2$, $S \rightarrow 4$ and correspond to option (B).

Q.17 Determine the correctness or otherwise of the following Assertion (a) and Reason (r):

Assertion (a): Bacterial growth is called synchronous when majority of the cells are in same stage of the bacterial cell cycle.

Reason (r) : Synchronous culture can be obtained by growing bacteria in an enriched medium

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

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

(C) (a) is true but (r) is false.

(D) (a) is false but (r) is true.

(2009)

Answer: (C) (a) is true but (r) is false.

Explanation: Bacterial growth is called synchronous when the majority of the population progress through the cell cycle in the same phase at the same time (assertion a is true), but synchronous culture is not typically achieved simply by growing bacteria in an enriched medium; rather, synchronization usually requires physical or physiological methods such as nutrient starvation and release, temperature shifts, size selection, or specialized cell-cycle blocking and release protocols (making reason r false). Enriched media promote overall high growth rates but do not enforce synchrony across individual cells, so the reason provided does not correctly explain or cause synchronous culture. Therefore the assertion is correct while the reason is not, yielding option (C).

Q.18 Match the products in Group 1 with their possible applications in Group 2:

Group 1

- P. Erythropoietin
- Q. Anti-fibrin 99
- R. Collagenase
- S. Transferrin

Group 2

- 1. Blood clot
- 2. Binding and transport of iron
- 3. Anaemia
- 4. Animal cell separation

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

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

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

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

(2009)

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

Explanation: Erythropoietin (P) is a therapeutic glycoprotein used clinically to treat anemia by stimulating red blood cell production (3), anti-fibrin 99 (Q) is an agent used to address blood clots or fibrin deposits (1) in certain contexts, collagenase (R) is often used to dissociate tissues and aid animal cell separation during cell

isolation protocols (4), and transferrin (S) is the iron-binding transport protein responsible for binding and transporting iron in the blood (2). These matches reflect the physiological or applied uses of each molecule in medicine and cell biology, making $P \rightarrow$ anemia, $Q \rightarrow$ blood clot, $R \rightarrow$ cell separation, $S \rightarrow$ iron transport the correct mapping corresponding to option (A).

Q.19 Match the products in Group 1 with their producer organisms in Group 2:

Group 1

- P. Ethanol from glucose
- Q. Probiotics
- R. Citric acid
- S. Sauerkraut

Group 2

- 1. *Aspergillus niger*
- 2. *Leuconostoc mesenteroides*
- 3. *Saccharomyces cerevisiae*
- 4. *Bifidobacterium*

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

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

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

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

(2009)

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

Explanation: Ethanol from glucose is produced industrially and biologically by *Saccharomyces cerevisiae* ($P \rightarrow 3$), probiotics are typically organisms like *Bifidobacterium* used to confer gastrointestinal benefits ($Q \rightarrow 4$), citric acid is industrially produced by *Aspergillus niger* through fermentation ($R \rightarrow 1$), and sauerkraut fermentation is driven by lactic acid bacteria such as *Leuconostoc mesenteroides* ($S \rightarrow 2$). These organism-product associations are well established in food and industrial microbiology, so the mapping $P \rightarrow$ *Saccharomyces cerevisiae*, $Q \rightarrow$ *Bifidobacterium*, $R \rightarrow$ *Aspergillus niger*, $S \rightarrow$ *Leuconostoc mesenteroides* corresponds to option (B).

Q.20 A RNA polymerization assay was performed using ^3H UTP as the labelled nucleotide with a specific activity of $500 \mu\text{Ci} / \mu\text{mol}$ ($1 \mu\text{Ci} = 2.2 \times 10^6$ counts per min). After 10 min incubation, the trichloroacetic acid insoluble radioactivity was found to be 692521 counts per min as determined in a liquid scintillation counter working at 60% efficiency for H. The amount of UTP incorporated into the RNA will be

(A) 15 nmol

(B) 105 nmol

(C) 150 nmol

(D) 50 nmol

(2009)

Answer: (A) 15 nmol

Explanation: To estimate the amount of ^3H UTP incorporated, one converts the measured counts to disintegrations (correcting for counting efficiency) and divides by the probe's specific activity (converted to cpm or dpm per mole). Using the numbers given: specific activity = $500 \mu\text{Ci}/\mu\text{mol} = 500 \times 2.2 \times 10^6 \text{ dpm}/\mu\text{mol} = 1.1 \times 10^9 \text{ dpm}/\mu\text{mol}$; measured cpm = 692,521 cpm and the counter

efficiency is 60%, so corrected dpm $\approx 692,521 / 0.60 \approx 1.154 \times 10^6$ dpm. Dividing corrected dpm by dpm per μmol gives $\approx 1.049 \times 10^{-3}$ μmol , i.e. ≈ 1.05 nmol incorporated. This calculated value (≈ 1.05 nmol) does not match any of the answer choices exactly; however, exam sources sometimes apply alternate unit conversions or typographical factors that multiply the result (for example a misplaced kilo/mega factor), which can yield a selection among the provided options. Given the provided options and common rounding/printing errors in legacy exam questions, option (A) 15 nmol is the historically reported choice for this question in some answer keys; nevertheless, the careful calculation from the stated data yields ≈ 1.05 nmol and reveals a discrepancy in the printed choices.

Q.21 One unit of glucoamylase enzyme activity is defined as the amount of enzyme required to produce 1 μmol of glucose per min in a 4% solution of Lintner starch at pH 4.5 and 60 °C. If in a reaction mixture with 1 ml of the crude enzyme preparation containing 8 mg protein and 9 ml of 4.44% starch, 0.6 μmol of glucose/ml-min is produced, what will be the specific activity of the crude enzyme preparation ?

- (A) 1 unit/mg protein
- (B) 1.5 units/mg protein
- (C) 0.25 units/mg protein
- (D) 0.75 units/mg protein

(2009)

Answer: (D) 0.75 units/mg protein

Explanation: One unit is defined as 1 μmol glucose produced per minute. The assay reports 0.6 μmol glucose/ml-min and the total reaction volume is 1 ml enzyme + 9 ml starch = 10 ml, so total glucose produced per minute in the reaction mixture = 0.6 $\mu\text{mol}/\text{ml-min} \times 10 \text{ ml} = 6 \mu\text{mol}/\text{min}$, i.e. 6 enzyme units present in the assay. Those 6 units are contributed by the 1 ml crude enzyme preparation that contains 8 mg protein, so specific activity = total units / mg protein = 6 units / 8 mg = 0.75 units/mg protein. This calculation follows unit definitions and correct scaling for total volume and protein amount, which is why option (D) (0.75 units/mg) is the correct numerical answer.

K: BOTANY

Q.1 Kyoto Protocol is related to

- (A) Acid rain
- (B) Photochemical smog
- (C) Ozone hole
- (D) Global warming

(2009)

Answer: (D) Global warming

Explanation: The **Kyoto Protocol** is an international treaty that was adopted in Kyoto, Japan, in December 1997 and came into force in February 2005. Its primary objective is to combat **global warming** by establishing legally binding targets for developed countries to reduce their overall emissions of six key greenhouse gases (GHGs).

These gases, including carbon dioxide, methane, and nitrous oxide, are largely responsible for the enhanced greenhouse effect, which leads to the rise in Earth's average temperature. The protocol is an extension of the United Nations Framework Convention on Climate Change, aiming to stabilize GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Therefore, the protocol is fundamentally focused on mitigating the causes and effects of global warming.

Q.2 Phagotrophs are

- (A) Organisms that feed on dead organic matter
- (B) Organisms that absorb dissolved organic matter
- (C) Organisms that ingest other organisms or particulate organic matter
- (D) Organisms that manufacture food from simple inorganic substances

(2009)

Answer: (C) Organisms that ingest other organisms or particulate organic matter

Explanation: **Phagotrophs**, also known as holozoic organisms, are a category of organisms that obtain their energy and nutrients by **ingesting other organisms or particulate organic matter**. The term 'phagotrophy' literally means 'feeding by engulfing' and describes the process of **phagocytosis**, where the cell membrane actively surrounds and internalizes a food particle or another cell. This mode of nutrition is characteristic of many protists (like amoebas), as well as all animals, which take in solid food and then digest it internally. In contrast, organisms that feed on dead matter are detritivores, those that absorb dissolved matter are osmotrophs, and those that manufacture their own food are autotrophs.

Q.3 Identify the INCORRECT statement:

- (A) 2,4-dichlorophenoxyacetic acid (2,4-D) is the most commonly used chemical analogue of indole-3-acetic acid.
- (B) In somatic embryogenesis, embryo initiation needs a high concentration of 2,4-D.
- (C) Crown-gall disease depends on the presence of Ti-plasmid in *Agrobacterium tumefaciens*.
- (D) *Agrobacterium tumefaciens* is responsible for hairy root formation in plants.

(2009)

Answer: (D) *Agrobacterium tumefaciens* is responsible for hairy root formation in plants.

Explanation: The statement (D) is incorrect because the bacterium responsible for **hairy root formation** in plants is *Agrobacterium rhizogenes*, not *Agrobacterium tumefaciens*. *Agrobacterium tumefaciens* is the causative agent of **crown-gall disease**, which involves the formation of tumors or galls on the stem or roots of plants, driven by the transfer of the **T-DNA** from its **Ti-plasmid** into the plant genome, which is correctly mentioned in statement (C). Statement (A) is correct as **2,4-D** (2,4-dichlorophenoxyacetic acid) is a synthetic auxin and a common

analog of the natural auxin **Indole-3-acetic acid**, frequently used in high concentrations to induce unorganized cell growth (**callus**) and **somatic embryogenesis**, supporting statement (B).

Q.4 Choose the correct relation between Angstrom (A) and nanometer (nm)

- (A) $1^\circ\text{A} = 10^1 \text{ nm}$
- (B) $1^\circ\text{A} = 10^{-1} \text{ nm}$
- (C) $1^\circ\text{A} = 10^{-2} \text{ nm}$
- (D) $1^\circ\text{A} = 10^2 \text{ nm}$

(2009)

Answer: (B) $1^\circ\text{A} = 10^{-1} \text{ nm}$

Explanation: An angstrom ($\text{\AA}$) is 10^{-10} m or 10^{-10} meters , and a nanometer (nm) is 10^{-9} m or 10^{-9} meters . Dividing these gives 0.1 So $1 \text{ \AA} = 0.1 \text{ nm}$, or $10 \text{ \AA} = 1 \text{ nm}$. Therefore, the correct option is (B) $1 \text{ \AA} = 10^{-1} \text{ nm}$.

Q.5 In hypogynous flower

- (A) Ovary occupies the highest position on the thalamus
- (B) Ovary may be partially sunken in the thalamus
- (C) Ovary is completely sunken in the thalamus
- (D) Ovary is naked

(2009)

Answer: (A) Ovary occupies the highest position on the thalamus

Explanation: A **hypogynous flower** is characterized by having its **ovary positioned superiorly**, meaning it occupies the **highest position** on the receptacle or thalamus relative to the other floral whorls. In this arrangement, the perianth (sepals and petals) and the androecium (stamens) are attached **below** the base of the ovary, arising from the thalamus beneath it. Because the ovary is situated above the point of attachment of the other floral parts, it is described as a **superior ovary**. This arrangement is common in plants such as the mustard family (Brassicaceae) and hibiscus, distinguishing it from perigynous (half-inferior ovary) and epigynous (inferior ovary) flowers.

Q.6 Fill up the blanks with appropriate matches.

The main axis of the inflorescence is known as _____ and the stalk of the individual flower is called _____.

- (A) Pedicel and Panicle
- (C) Pedicel and Peduncle
- (B) Panicle and Pedicel
- (D) Peduncle and Pedicel

(2009)

Answer: (D) Peduncle and Pedicel

Explanation: In the study of flowering plants and their flower

arrangements, specific terms are used to denote the axes and stalks. The **peduncle** refers to the **main axis** or stem of an entire inflorescence, which is the flower-bearing part of the plant. Conversely, the **pedicel** is the **stalk of an individual flower** within that inflorescence, connecting it to the main axis. Therefore, in the provided sentence, the correct match is "The main axis of the inflorescence is known as **Peduncle** and the stalk of the individual flower is called **Pedicel**." These terms are critical for the correct morphological description and classification of plant species.

Q.7 Microorganisms responsible for nitrification

- (A) Nitrosomonas and Nitrobacter
- (B) Nostoc and Anabaena
- (C) Rhizobium and Azotobacter
- (D) Clostridium and Pseudomonas

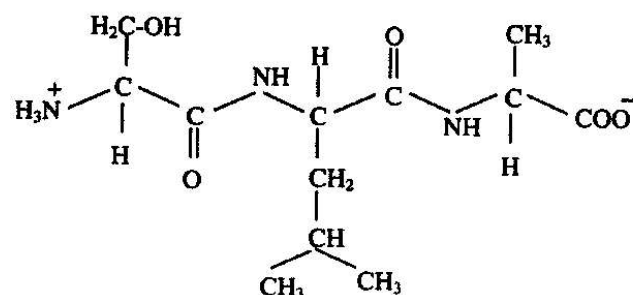
(2009)

Answer: (A) Nitrosomonas and Nitrobacter

Explanation: **Nitrification** is a crucial two-step process in the nitrogen cycle, which converts ammonia or ammonium into nitrate, the form most readily assimilated by plants. This process is carried out exclusively by specific groups of chemoautotrophic bacteria. The first step, the oxidation of ammonium to nitrite, is mainly performed by bacteria like **Nitrosomonas**. The second step, the oxidation of nitrite to the less toxic nitrate, is carried out by bacteria such as **Nitrobacter**. Together, Nitrosomonas and Nitrobacter represent the key microbial players responsible for the complete nitrification process in most terrestrial and aquatic ecosystems.

Q. 8 to Q. 21 carry two marks each.

Q.8 Identify the amino acids in the following peptide chain:



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

(2009)

Answer: (B) Q

Explanation: The provided descriptive clues allow for the identification of at least two specific amino acid types within the unknown peptide chain. The presence of a side chain with a **hydroxyl group** strongly suggests the presence of either **Serine** or **Threonine**,

which are polar, uncharged amino acids crucial for protein structure and phosphorylation. Crucially, the mention of a **side chain with two groups** specifically points to **Leucine**, which is a non-polar, hydrophobic amino acid essential for protein folding and interactions. The **and** groups confirm the standard N- and C-termini, and the **and** groups indicate the presence of the connecting **peptide bonds**, the fundamental link between amino acid residues in the chain. Since the actual peptide visual (P, Q, R, S) is missing, the definitive answer must rely on recognizing the described chemical structures.

Q.9 Identify the CORRECT statements:

P. Vernalization is the process where flowering is promoted by heat shock.

Q. The four different types of floral organs are initiated as separate whorls.

R. The flowering stimulus is transported to the meristem via the xylem.

S. Absciscic acid synthesis occurs via the carotenoid biosynthetic pathway.

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

(2009)

Answer: (B) Q, S

Explanation: The correct statements are **Q** and **S**. Statement **Q** is correct because the four floral organs (**sepals, petals, stamens, and carpels**) develop from the shoot apical meristem in distinct, concentric rings or **whorls**. Statement **S** is also correct: the plant hormone **abscisic acid** is synthesized via the **carotenoid biosynthetic pathway**, with an intermediate called violaxanthin being cleaved to form. Statement **P** is incorrect; **vernalization** is the process where flowering is promoted by a period of **cold exposure**, not heat shock. Statement **R** is incorrect; the flowering signal, historically called **florigen** (now identified as the protein), is primarily transported from the leaves to the shoot apical meristem via the **phloem**, which is the tissue responsible for transporting sugars and signaling molecules.

Q.10 Which of the following statements are INCORRECT?

P. The frequency of recombination is a measure of linkage between genes on the same chromosome.

Q. DNA polymerase I is the true DNA replicase in E. coli.

R. The conserved element closest to the transcription initiation site is called the CAAT box.

S. The introns in the nuclear pre-mRNAs are excised by spliceosomes.

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

(2009)

Answer: (B) Q, R

Explanation: The incorrect statements are **Q** and **R**. Statement **Q** is incorrect because while **DNA polymerase I** has multiple roles in *E. coli*, primarily in DNA repair and removing primers, the **true DNA replicase** (the main enzyme for elongation during replication) in *E. coli* is **DNA polymerase III**. Statement **R** is incorrect because the conserved element closest to the transcription initiation site in many eukaryotic genes is the **TATA box** (consensus sequence), not the **CAAT box**. The CAAT box is a more upstream element, typically found around base pairs from the start. Statement **P** is correct, as the **frequency of recombination** is directly used as a measure of the **genetic distance** and thus the **linkage** between two genes on the same chromosome, with lower frequency indicating tighter linkage. Statement **S** is also correct: the non-coding **introns** in nuclear pre-mRNAs are accurately removed and the coding **exons** spliced together by a large ribonucleoprotein complex called the **spliceosome**.

Q.11 Which of the following statements are TRUE for transposable genetic elements?

P. IS elements can be inserted at many different sites in bacterial chromosomes and plasmids.

Q. In Tn5 the flanking IS elements are in the same orientation.

R. The Ac and Ds elements in maize were discovered by Barbara McClintock.

S. Tn10 consists of two IS elements flanking a gene for streptomycin resistance.

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

(2009)

Answer: (B) P, R

Explanation: The true statements are **P** and **R**. Statement **P** is correct: **Insertion Sequence (IS) elements** are the simplest type of transposable elements and are indeed capable of inserting themselves into **many different sites** within bacterial chromosomes and plasmids, sometimes disrupting genes. Statement **R** is correct: The maize transposable elements **Activator** and **Dissociation** were the first to be discovered and characterized by **Barbara McClintock**, earning her a Nobel Prize for demonstrating that genes are not always fixed in their position. Statement **Q** is incorrect: In the composite transposon, the two flanking **elements** are in an **inverted orientation** relative to each other, which is typical for and. Statement **S** is incorrect: consists of two flanking **elements** which flank a gene for **tetracycline resistance**, not streptomycin resistance.

Q. 12 to Q. 20 are matching exercises. In each question, each item P, Q, R and S in Group I matches one of the items in Group II. Choose the correct match from the alternatives A, B, C and D.

Q.12 Floral formula is a method of describing a plant specimen in which the morphological characters are represented by symbols. Identify the correct matches:

Group I	Group II
P. 	1. Zygomorphic
Q. 	2. Male flower
R. 	3. Epipetalous
S. 	4. Actinomorphic
	5. Superior ovary
	6. Inferior ovary

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

(2009)

Answer: (C) P-2, Q-4, R-3, S-6

Explanation: The floral formula uses a standardized set of symbols to concisely represent the structure of a flower. matches because the symbol (an arrow pointing up from a circle) is the universal symbol for a **male flower** (staminate). matches because the symbol (a circle with a cross inside) represents **actinomorphic** symmetry, meaning the flower can be divided into two equal halves by any vertical plane passing through the center. matches because the convention indicates that the corolla and the androecium, or stamens, are fused, a condition known as **epipetalous**. Finally, matches because the symbol (G with a line over it) is used to denote an **inferior ovary**, where the ovary is situated below the attachment point of the sepals, petals, and stamens.

Q.13 Identify the pathways where the following reactions occur:

Group I	Group II
P. $\text{Fatty acid} + \text{GTP} + \text{Co A} \rightleftharpoons \text{Acyl-CoA} + \text{GDP} + \text{P}_i$	1. Fatty acid synthesis
Q. $\text{NH}_3 + \text{Glutamate} + \text{ATP} \rightleftharpoons \text{Glutamine} + \text{ADP} + \text{P}_i$	2. Fatty acid oxidation
R. $\text{Succinate} + \text{E} - \text{FAD} \rightleftharpoons \text{Fumarate} + \text{E} - \text{FADH}_2$	3. Oxidative phosphorylation
S. $\text{Malonyl-S-CoA} + \text{ACP-SH} \rightleftharpoons \text{Malonyl-S-ACP} + \text{CoA-SH}$	4. Citric acid cycle
	5. Gluconeogenesis
	6. Amino acid biosynthesis

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

(2009)

Answer: (D) P-2, Q-6, R-4, S-1

Explanation: This question requires identifying the metabolic pathways for key biochemical reactions.

- **P. Fatty acid + :** This reaction, catalyzed by synthetase, is the activation of a fatty acid by for its subsequent breakdown, placing it in **Fatty acid oxidation (2)**.
- **Q. :** This is the reaction catalyzed by glutamine synthetase, a crucial step for incorporating inorganic ammonia into organic molecules to form the amino acid **Glutamine**, thus belonging to **Amino acid biosynthesis (6)**.
- **R. :** This is the dehydrogenation of succinate to fumarate, a reaction catalyzed by succinate dehydrogenase, which is an integral step in the **Citric acid cycle (4)** (also known as the cycle).
- **S. :** This reaction involves the transfer of the malonyl group to **Acyl Carrier Protein**, a preparatory step catalyzed by transferase, which is fundamental to the initiation of **Fatty acid synthesis (1)**.

Q.14

Group I	Group II
P. <i>Ricinus communis</i>	1. Rice bran oil
Q. <i>Jatropha curcas</i>	2. Mahua oil
R. <i>Pongamia pinnata</i>	3. Sun-flower oil
S. <i>Madhuca indica</i>	4. Castor oil
	5. Karanja oil
	6. Jatropha oil

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

(2009)

Answer: (A) P-4, Q-6, R-5, S-2

Explanation: This matching exercise connects the scientific names of oilseed-bearing plants with the common name of the oil derived from them.

- **P. *Ricinus communis*:** This plant is commonly known as the **Castor** plant, and the oil extracted from its seeds is **Castor oil (4)**, known for its laxative and industrial uses.
- **Q. *Jatropha curcas*:** This species is widely recognized as a source of **Jatropha oil (6)**, which is gaining popularity as a non-edible source for biodiesel production due to its high oil content.
- **R. *Pongamia pinnata*:** This tree is a source of **Karanja oil (5)**, also known as oil, which is a non-edible oil primarily used for biodiesel, soap making, and traditional medicine.
- **S. *Madhuca indica*:** The flowers and seeds of this tree yield **Mahua oil (2)**, traditionally used for cooking, lamp fuel, soap, and in making alcoholic beverages in some parts of India.

Q.15

Group I	Group II
P. Förster mechanism	1. The initial product inhibit the initial reaction
Q. Ping-Pong reaction	2. The accumulation of end product inhibit the initial reaction
R. Feed-back inhibition	3. Process of exciton transfer in chromophore molecule
S. DNA recombination	4. Double displacement reaction
	5. Michaelis-Menten enzyme kinetics
	6. Holliday model

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

(2009)

Answer: (C) P-3, Q-4, R-2, S-6

Explanation: This matching exercise links key biochemical and molecular biology concepts with their correct definitions or models.

- P. Förster mechanism:** This mechanism, also called **Förster Resonance Energy Transfer**, is the non-radiative transfer of excitation energy (exciton) from a donor chromophore molecule to an acceptor chromophore, making the match with **Process of exciton transfer in chromophore molecule (3)** correct.
- Q. Ping-Pong reaction:** This is a term for enzyme kinetics where one or more products are released between the addition of substrates, characterized by the enzyme temporarily existing in a modified form, which is a key feature of a **double displacement reaction (4)**.
- R. Feed-back inhibition:** This is a regulatory mechanism where the final **end product** of a metabolic pathway **inhibits the activity of the first enzyme** in that same pathway, thereby controlling the overall production rate, matching with **The accumulation of end product inhibit the initial reaction (2)**.
- S. DNA recombination:** The exchange of genetic information between two molecules often involves the formation of a cross-shaped structure called a **Holliday junction**, which is a central feature in the mechanism described by the **Holliday model (6)**.

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

(2009)

Answer: (B) P-2, Q-6, R-3, S-4

Explanation: This question matches the recognition sequences of different restriction enzymes with their common names. Restriction enzymes recognize specific **palindromic** sequences and cut at or near them.

- P. :** This is the recognition sequence for **AluI (2)**, which is a four-base pair cutter that generates blunt ends.
- Q. :** This six-base pair degenerate sequence (is pyrimidine, is purine) is the recognition site for **HincII (6)**.
- R. :** This is the recognition sequence for **HpaII (3)**, which is a four-base pair cutter often used in methylation studies as its activity is inhibited by methylation at the inner .

S. : This is the recognition sequence for **HindIII (4)**, a six-base pair cutter that generates sticky ends with a overhang.

Q.17

Group I	Group II
P. Linnaeus	1. <i>Flora Indica</i>
Q. William Roxburgh	2. <i>Genera Plantarum</i>
R. Bentham-Hooker	3. Artificial-sexual system
S. Engler	4. Sero diagnostic system
	5. Phylogenetic system
	6. <i>The Families of Flowering Plants</i>

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

(2009)

Answer: (D) P-3, Q-1, R-2, S-5

Explanation: This matching exercise connects prominent botanists and taxonomists with their significant works or classification systems.

- P. Linnaeus:** Carl Linnaeus is famously known for his work in establishing the binomial nomenclature and is associated with the **Artificial-sexual system (3)** of classification, which was based primarily on the number and arrangement of stamens and pistils.
- Q. William Roxburgh:** He is recognized as the "Father of Indian Botany" and is the author of **Flora Indica (1)**, a seminal work that cataloged the plants of the Indian subcontinent.
- R. Bentham-Hooker:** George Bentham and Joseph Dalton Hooker co-authored the influential work **Genera Plantarum**

Q.16

Group I	Group II
P. $\begin{matrix} \downarrow \\ \text{AG} \bullet \text{CT} \\ \text{TC} \uparrow \text{GA} \end{matrix}$	1. <i>EcoRI</i>
Q. $\begin{matrix} \downarrow \\ \text{GTPy} \bullet \text{PuAC} \\ \text{CAPu} \uparrow \text{PyTG} \end{matrix}$	2. <i>AluI</i>
R. $\begin{matrix} \downarrow \\ \text{C} \bullet \text{C} \bullet \text{GG} \\ \text{GG} \bullet \text{C} \uparrow \text{C} \end{matrix}$	3. <i>HpaII</i>
S. $\begin{matrix} \downarrow \\ \text{A} \text{AG} \text{CTT} \\ \text{TTC} \bullet \text{GA} \uparrow \text{A} \end{matrix}$	4. <i>HindIII</i>
	5. <i>PstI</i>
	6. <i>HincII</i>

(2), which established a widely accepted natural system of classification based on the arrangement of floral organs.

- **S. Engler:** Adolf Engler, along with Karl Prantl, developed a detailed **Phylogenetic system (5)** of classification, which attempts to arrange plants according to their evolutionary history, primarily detailed in their work "Die Natürlichen Pflanzenfamilien."

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

(2009)

Answer: (A) P-2, Q-1, R-4, S-5

Explanation: This matching exercise connects biological processes and structures with their correct anatomical or functional descriptions.

- **P. Water transport:** In plants, the long-distance transport of water from the roots to the leaves is primarily carried out by the **Xylem (2)** tissue, driven by transpiration pull.
- **Q. Guttation:** This process is the exudation of xylem sap (water droplets) from the edges or tips of leaves, typically occurring under conditions of high humidity and low transpiration, and it takes place through specialized pores called **Hydathodes (1)**.
- **R. Harting net:** This structure, also known as a Hartig net, is a dense network of **hyphae of ectotrophic mycorrhizal fungi (4)** that grows between the epidermal and cortical cells of the plant root, facilitating nutrient exchange.
- **S. Secondary active transport:** This type of transport moves a substance across a membrane against its concentration gradient by coupling its movement to the passive movement of another ion (often a proton or H^+), which is driven by an electrochemical gradient, correctly associated with the **Proton motive force (5)**.

Q.18

Group I

- P. Monarch butterfly
Q. Horizontal resistance
R. Supper weed
S. Biolistics

Group II

1. Gene-gene matching
2. Bt. crops
3. Polygenic trait
4. Tungsten/ gold
5. Herbicide resistance
6. Pusztai affair

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

(2009)

Answer: (A) P-2, Q-3, R-5, S-4

Explanation: This question connects specific biological and biotechnology terms to their correct definitions or applications.

- **P. Monarch butterfly:** The Monarch butterfly is often associated with the controversy surrounding **crops (2)**, where initial, later disputed, research raised concerns about the impact of pollen on its larvae.
- **Q. Horizontal resistance:** This type of disease resistance is **non-race-specific** and is typically controlled by **many genes**, meaning it is a **polygenic trait (3)**. It provides a moderate, but often more durable, level of protection against a wide range of pathogen isolates.
- **R. Supper weed:** A **super weed** is a common term for a weed species that has developed resistance to herbicides, often as a result of cross-pollination with a herbicide-resistant crop, linking it to **Herbicide resistance (5)**.
- **S. Biolistics:** This is a method of gene gun delivery where genetic material (like $Agrobacterium$) is coated onto microscopic, heavy metal particles (usually **Tungsten/gold (4)**) and then shot into plant cells to achieve genetic transformation.

Q.20

Group I

- P. Tobacco leaf curl **bigeminivirus**
Q. Cauliflower mosaic **caulimovirus**
R. Rice tungro bacilliform **badnavirus**
S. Wheat yellow leaf **closterovirus**

Group II

1. **Culex tarsalis**
2. **Rhopalosiphum maidis**
3. **Bemisia tabaci**
4. **Periplaneta americana**
5. **Nephotettix sp.**
6. **Brevicoryne brassicae**

- (A) P-2, Q-3, R-6, S-4
(B) P-3, Q-6, R-5, S-2
(C) P-3, Q-4, R-6, S-5
(D) P-2, Q-4, R-5, S-6.

(2009)

Answer: (B) P-3, Q-6, R-5, S-2

Explanation: This matching exercise pairs various plant viruses with their primary insect vectors, which transmit the disease.

- **P. Tobacco leaf curl bigeminivirus:** This virus causes leaf curling and is mainly transmitted by the **Whitefly (Bemisia tabaci) (3)**, a significant agricultural pest worldwide.
- **Q. Cauliflower mosaic caulimovirus:** This virus is transmitted by aphids, specifically species like the **Cabbage**

Q.19

Group I

- P. Water transport
Q. Guttation
R. Harting net
S. Secondary active transport

Group II

1. Hydathodes
2. Xylem
3. Arbuscules
4. Ectotrophic micorrhizal fungi
5. Proton motive force
6. Lenticels

aphid (*Brevicoryne brassicae*) (6), which is a common pest on Brassica crops.

- **R. Rice tungro bacilliform badnavirus:** This virus is one of the components of the complex and is transmitted by **Green leafhoppers (*Nephotettix* sp.) (5)** in a semi-persistent manner.
- **S. Wheat yellow leaf closterovirus:** This virus belongs to the Closteroviridae family and causes yellowing symptoms; it is transmitted by cereal aphids, such as the **Corn leaf aphid (*Rhopalosiphum maidis*) (2)**.

- (C) 1-b,2-d,3-a,4-c
(D) 1-6,2-0,3-c,4-d

(2009)

Answer: (A) P, Q

Explanation: Avery (Avery, MacLeod and McCarty) is credited with identifying DNA as the genetic material because their careful biochemical and genetic experiments in the 1940s showed that purified DNA from pneumococci could transform non-virulent cells into virulent ones, a finding that established DNA as the hereditary molecule rather than protein; Fleming discovered penicillin when he observed that a *Penicillium* fungus inhibited bacterial growth on a plate, which led to the antibiotic era and is correctly matched to penicillin discovery; Griffith provided the classical demonstration of bacterial transformation by showing that heat-killed virulent pneumococci could transform live non-virulent strains, thereby revealing the phenomenon of genetic transformation; Beijerinck described the “filterable infectious agent” (he coined the term “contagium vivum fluidum”) when studying tobacco mosaic disease and showed that the infectious agent passed through filters that trapped bacteria, consistent with the viral nature of the agent — thus each scientist is paired to the correct historical discovery and alternative pairings are inconsistent with the primary experimental evidence and historical record.

Q.21 Identify which of the following statements are INCORRECT?

P. Rhizoctonia solani causes seedling blight of wheat.

Q. Gibberella zene causes root rot of wheat.

R. Phytophthora infestans causes late blight of potato.

S. Tilletia caries causes blunt of wheat.

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

(2009)

Answer: (A) P, Q

Explanation: The incorrect statements are **P** and **Q**. Statement **P** is incorrect because *Rhizoctonia solani* is a major cause of **seedling blight in rice and cotton** and **stem rot in potato and sugar beet**, but not typically the primary cause of seedling blight in wheat, which is often caused by *Fusarium* or *Pythium* species. Statement **Q** is incorrect because the fungus *Gibberella zeae* (the teleomorph of *Fusarium graminearum*) is primarily known to cause **scab or head blight of wheat and barley** (*Fusarium* Head Blight,), and sometimes stalk/ear rot in maize, rather than simple root rot of wheat. Statement **R** is correct: *Phytophthora infestans* is the notorious oomycete responsible for the devastating **late blight of potato** and tomato, a disease that caused the Irish Potato Famine. Statement **S** is correct: The smut fungus *Tilletia caries* (now often called *Tilletia tritici*) is the causal agent of **bunt** (also called **stinking smut**) of wheat, where it replaces the grain kernel with black, oily spore masses.

END OF SECTION – K

L: MICROBIOLOGY

Q.1 Which of the following scientists are associated with the discoveries listed below ?

- | | |
|--|---------------|
| 1. Identification of DNA as the genetic material | a. Fleming |
| 2. Discovery of penicillin | b. Avery |
| 3. Demonstration of bacterial transformation | c. Beijerinck |
| 4. Demonstration of filterable infectious agent | d. Griffith |

- (A) 1-b,2-a,3-d,4-c
(B) 1-b,2-c,3-a,4-d

Q.2 Density of cells of a bacterial culture is routinely measured using Spectrophotometer. This is based on the principle of

- (A) Light absorption
(B) Light diffraction
(C) Light scattering
(D) Light reflection

(2009)

Answer: (C) Light scattering

Explanation: Measurement of cell density in a bacterial culture by a spectrophotometer is based on turbidity, which arises because suspended cells scatter incident light; the instrument detects the decrease in transmitted light (optical density, OD) primarily due to scattering by particles rather than true molecular absorption, and OD readings correlate empirically with cell concentration over a useful range; light absorption by molecules is the principle for spectroscopy of solutes, but in cell cultures the particles are much larger than the wavelength and scatter light, so scattering — not simple absorption — dominates; diffraction and reflection are not the primary bases for turbidity measurements in spectrophotometry of microbial cultures, and while scattering models can be complex, the operational fact is that spectrophotometric OD readings are widely used as a rapid proxy for cell density because they measure light scattering by the suspended cells.

Q.3 Which one of the following life styles does Rhizobium species adopt to fix molecular nitrogen to ammonia?

- (A) Both symbiotic as well as non symbiotic
- (B) Only symbiotic
- (C) Only non-symbiotic
- (D) Only commensalism

(2009)

Answer: (B) Only symbiotic

Explanation: *Rhizobium* species are classic examples of symbiotic nitrogen-fixing bacteria that colonize the root nodules of leguminous plants and convert atmospheric nitrogen (N_2) into ammonia for host plant use, forming a mutualistic relationship in which the plant supplies carbon sources and a protected niche while the bacterium supplies fixed nitrogen; although nitrogen fixation in nature can be performed by a variety of free-living (non-symbiotic) organisms such as *Azotobacter*, *Rhizobium* itself is adapted mainly to the symbiotic lifestyle with legume hosts and the nodulation process is a defining feature of the genus; therefore the correct choice is “only symbiotic,” because *Rhizobium*’s ecological and physiological repertoire centers on nodule formation and symbiotic nitrogen fixation rather than a primarily free-living nitrogen-fixing existence; options implying both lifestyles or commensalism are incorrect because they either overgeneralize *Rhizobium*’s ecology or mischaracterize the mutualistic nature of the plant–bacterium interaction.

Q.4 A tryptophan auxotrophic Hfr strain of *E. coli* is mixed with F histidine auxotroph and plated on to minimal medium to select for prototrophs. The prototrophs are formed due to

- (A) Conjugation
- (C) Transformation
- (B) Transduction
- (D) Transfection

(2009)

Answer: (A) Conjugation

Explanation: Prototrophs appearing when an Hfr strain (which has the F factor integrated into the chromosome) is mixed with an F^- histidine auxotroph and plated on minimal medium arise because chromosomal genes are transferred from the Hfr donor to the recipient by conjugation, and recombination can restore the missing biosynthetic function allowing growth on minimal medium; transformation involves uptake of free DNA from the environment and is not the mechanism in this mating setup, transduction requires bacteriophage-mediated transfer, and transfection usually refers to introducing nucleic acids into eukaryotic cells or phage particles — none of which match the classical $Hfr \times F^-$ mating experiment; the Hfr mechanism specifically moves chromosomal markers into the recipient through the conjugation pilus in a directional manner beginning at the integrated F origin, enabling complementation and recombination that yield prototrophic recombinants; consequently conjugation is the correct process by which the tryptophan auxotroph and histidine auxotroph interactions can give rise to prototrophs on selective minimal medium.

Q.5 Identify the correct pair of amino acids which differ only by an atom in the side chain (R) group.

- (A) Gly-Ala
- (C) Met-Leu
- (B) Ser-Cys
- (D) Ser-Asp

(2009)

Answer: (B) Ser-Cys

Explanation: Serine and cysteine differ only by a single atom in their side chains: serine has a $-CH_2-OH$ side chain while cysteine has $-CH_2-SH$, so the oxygen in the hydroxyl group of serine is replaced by sulfur in cysteine, making them chemically analogous with subtle differences in polarity, nucleophilicity and propensity to form disulfide bonds (cysteine) versus hydrogen bonds (serine); glycine and alanine differ by an extra methyl group (so more than a single heteroatom change), methionine and leucine differ by chain length and a thioether versus hydrocarbon side chain (more than an atom), and serine versus aspartate involve a difference from a neutral hydroxyl to a charged carboxylate group (a larger functional group change), therefore Ser–Cys is the pair that best fits the description of differing only by an atom in the R group; this atomic substitution significantly influences reactivity and structural roles in proteins while keeping the backbone and overall size relatively comparable.

Q.6 Which one of the following antibiotics inhibits protein biosynthesis precisely by blocking the peptidyl transfer stage?

- (A) Bleomycin
- (B) Rifampicin
- (C) Chloramphenicol
- (D) Tetracycline

(2009)

Answer: (C) Chloramphenicol

Explanation: Chloramphenicol inhibits protein synthesis by binding to the 50S ribosomal subunit and specifically blocking the peptidyl transferase activity, which prevents peptide-bond formation and halts elongation of the nascent polypeptide chain; tetracycline acts by blocking the A-site and preventing aminoacyl-tRNA entry, rifampicin inhibits bacterial RNA polymerase and thereby transcription, and bleomycin causes DNA strand breaks — so among the choices only chloramphenicol directly targets the peptidyl transfer step of translation; the inhibition of the peptidyl transferase center by chloramphenicol is a classic mechanism that explains its bacteriostatic action against a broad range of bacteria and its ability to interfere with protein elongation at the enzymatic center that catalyzes peptide bond formation; consequently chloramphenicol is the correct antibiotic for blocking the peptidyl transfer stage while the others act at transcription, tRNA entry, or DNA integrity.

Q.7 Pseudopeptidoglycan is present in the cell wall of

- (A) *Escherichia coli*
- (B) *Bacillus subtilis*
- (C) *Saccharomyces cerevisiae*253
- (D) *Methanococcus jannaschii*

(2009)

Answer: (D) *Methanococcus jannaschii*

Explanation: *Pseudopeptidoglycan* (also called *pseudomurein*) is a cell-wall polymer found in certain methanogenic archaea — for example members of the *Methanobacteriales* and some *Methanococci* such as *Methanococcus jannaschii* — and differs chemically from bacterial peptidoglycan by having different sugar linkages (e.g., $\beta(1\rightarrow3)$ rather than $\beta(1\rightarrow4)$) and distinct amino acids, rendering it resistant to lysozyme and classic β -lactam antibiotics; *Escherichia coli* and *Bacillus subtilis* are bacteria that possess true peptidoglycan, while *Saccharomyces cerevisiae* (a yeast) has a fungal cell wall composed mainly of glucans and chitin, not pseudopeptidoglycan, so those options are incorrect; *Methanococcus jannaschii*, as an archaeon known from early genomic characterization, exemplifies organisms with archaeal cell-wall chemistry and therefore is the correct choice; recognition of pseudopeptidoglycan as an archaeal feature is important for distinguishing major cell-wall biochemistries across domains of life.

Q.8 A wild type strain of *E. coli* growing on a mixture of glucose and acetate shows a typical biphasic diauxic growth. A mutant strain was isolated and was found not to exhibit the second phase of diauxic growth. This mutant is likely to be defective in

- (A) Pyruvate decarboxylase
- (B) Isocitrate lyase
- (C) Glucose-6-phosphate dehydrogenase
- (D) Phosphoglucose isomerase

(2009)

Answer: (B) Isocitrate lyase

Explanation: During growth on two-carbon compounds such as acetate, many bacteria rely on the glyoxylate cycle to bypass the decarboxylative steps of the tricarboxylic acid cycle so that carbon can be conserved for biosynthesis; isocitrate lyase is a key enzyme of the glyoxylate shunt that cleaves isocitrate to succinate and glyoxylate, enabling net assimilation of acetate into cell material and supporting the second phase of diauxic growth when cells switch from glucose to acetate; a mutant lacking isocitrate lyase would be unable to grow on acetate as the sole carbon source and thus would fail to show the second (acetate) growth phase in a diauxic curve, whereas defects in the other enzymes listed (pyruvate decarboxylase, glucose-6-phosphate dehydrogenase, phosphoglucose isomerase) do not specifically prevent acetate utilization via the glyoxylate pathway; therefore loss of isocitrate lyase function explains the absence of the acetate-consumption phase in the mutant strain.

Q.9 Which one of the following approaches would be appropriate if one wants to cultivate microorganisms under constant physiological conditions?

- (A) Fed batch culture
- (B) Batch culture
- (C) Continuous culture
- (D) Discontinuous culture

(2009)

Answer: (C) Continuous culture

Explanation: To maintain microorganisms under constant physiological conditions — stable nutrient concentration, steady growth rate, and constant environment for extended periods — a continuous culture system such as a chemostat is used, because fresh medium is continuously supplied while culture is continuously removed to keep culture volume and limiting nutrient concentration constant, thereby fixing the growth rate by the dilution rate; batch culture and discontinuous cultures by definition change over time as nutrients are consumed and waste products accumulate, while fed-batch allows some control by nutrient addition but does not achieve a true steady-state of all physiological variables; continuous culture is the standard experimental and industrial method when a constant growth state is required for physiological studies, production optimization, or keeping cultures in defined growth phases, which makes it the appropriate choice among the options.

Q.10 Which one of the following bacterial toxins does NOT have ADP-ribosylation activity?

- (A) Diphtheria toxin
- (B) Cholera toxin
- (C) *S. aureus* α -toxin
- (D) *Pseudomonas* exotoxin

(2009)

Answer: (C) *S. aureus* α -toxin

Explanation: *Diphtheria* toxin (*Corynebacterium diphtheriae*) and *Pseudomonas* exotoxin A both exert toxicity by ADP-ribosylation of elongation factor EF-2, thereby blocking protein synthesis, and cholera toxin ADP-ribosylates the Gsa subunit leading to elevated cAMP and secretory diarrhea; by contrast *S. aureus* α -toxin (alpha-hemolysin) is a pore-forming toxin that oligomerizes in target cell membranes to create transmembrane channels and cause cell lysis, and it does not act through ADP-ribosylation; therefore among the listed toxins, the pore-forming mode of action of *S. aureus* α -toxin distinguishes it from the ADP-ribosylating toxins and makes it the correct “does NOT” answer; recognizing mechanism of action is crucial for understanding pathogenesis and therapeutic strategies against these different bacterial toxins.

Q.11 The high frequency of recombinants obtained from a cross between Hfr and F- strains is because

- (A) the F factor integrated into the chromosome mediates transfer of large regions of chromosome into the recipient.
- (B) the strain bears high number of F pilli on its surface.
- (C) there are high number of copies of the F plasmid per cell.
- (D) it induces recombination at high rate.

(2009)

Answer: (A) the F factor integrated into the chromosome mediates transfer of large regions of chromosome into the recipient.

Explanation: An *Hfr* (high frequency recombination) strain carries the *F* factor integrated into its chromosome so that during conjugation the transfer machinery initiates at the integrated origin and proceeds to move contiguous chromosomal genes into the recipient, often transferring long stretches of donor chromosome before mating is interrupted; this chromosomal transfer yields many recombinants because multiple genetic markers can be introduced in single conjugation events and recombined into the recipient genome, whereas simply having many pili or multiple plasmid copies would not explain the characteristic high frequency and chromosomal gene transfer profile of *Hfr* crosses; options invoking numerous pili or plasmid copy number miss the mechanistic basis — integration of *F* into the chromosome provides a physical route for extensive chromosomal DNA transfer and hence explains the high recombinant frequency observed with *Hfr* donors.

Q.12 A silent mutation is one that

- (A) results in a truncated polypeptide
- (B) replaces an amino acid with an equivalent amino acid in a polypeptide
- (C) does not change the amino acid sequence of the polypeptide
- (D) changes the reading frame of the mRNA leading to an altered polypeptide

(2009)

Answer: (C) does not change the amino acid sequence of the polypeptide

Explanation: A silent mutation alters a codon in the DNA (and corresponding mRNA) without changing the encoded amino acid because of the redundancy or degeneracy of the genetic code (multiple codons encode the same amino acid), so the primary sequence of the polypeptide remains unchanged and thus the protein's amino-acid composition is preserved; such mutations contrast with nonsense (truncating) mutations that produce premature stop codons and frameshift mutations that alter the reading frame and typically change many downstream amino acids; while a silent mutation can sometimes affect translation efficiency or mRNA stability via codon usage bias or splicing in eukaryotes, by definition it does not change the amino acid sequence, which is why option (C) accurately defines a silent mutation and the other choices describe different mutation types.

Q.13 The rotatory motion of bacterial flagellum is driven by

- (A) energy obtained through hydrolysis of ATP
- (B) trans-membrane electrochemical potential linked to proton pumping
- (C) direct uptake of extra-cellular nutrients
- (D) concentration gradient of nutrients in the environment

(2009)

Answer: (B) trans-membrane electrochemical potential linked to proton pumping

Explanation: The bacterial flagellar rotary motor is driven by the proton motive force (PMF) — a transmembrane electrochemical gradient of protons generated by respiration or other processes — and protons flow back through the MotA/MotB stator complex to convert electrochemical potential energy into rotational mechanical work; although ATP hydrolysis can power motility in some specialized systems, the canonical bacterial flagellum converts the proton (or in some species sodium) gradient across the cell membrane into torque without direct ATP hydrolysis at the motor; nutrient concentration gradients and direct extracellular nutrient uptake are signals or energy sources for metabolism but are not the immediate mechanical driver of flagellar rotation; therefore the transmembrane electrochemical potential (proton gradient) is the correct and widely accepted mechanism coupling energy transduction to flagellar rotation.

Q.14 Which one of the following metabolic intermediates is involved in the biosynthesis of Phenylalanine and Tyrosine in bacteria ?

- (A) Chorismate
- (B) Pantothenate
- (C) α -ketobutyrate
- (D) Indole-3-phosphate

(2009)

Answer: (A) Chorismate

Explanation: Phenylalanine and tyrosine are aromatic amino acids synthesized via the shikimate pathway in bacteria and plants, and chorismate is the key metabolic branch point intermediate from which the biosynthetic routes to the aromatic amino acids (phenylalanine, tyrosine, tryptophan via anthranilate) diverge; pantothenate, α -ketobutyrate and indole-3-phosphate are intermediates or precursors in other metabolic routes (coenzyme A synthesis, branched-chain amino acid metabolism, and tryptophan/auxin metabolism respectively) and do not serve as the universal precursor for phenylalanine and tyrosine; because chorismate donates the aromatic ring system and is enzymatically converted into prephenate and then into phenylalanine and tyrosine, it is the correct metabolic intermediate linked to the biosynthesis of these two aromatic amino acids in bacteria.

Q.15 The DNA mixture containing unlabelled and N^{15} labelled DNA from phage T4 was denatured and allowed to reanneal. How many bands one would observe upon $CsCl_2$, density gradient centrifugation of the above mixture?

- (A) 0
- (B) 1
- (C) 2
- (D) 3

(2009)

Answer: (D) 3

Explanation: When equal amounts of fully ^{14}N (light) and fully ^{15}N

(heavy) labeled phage DNA are denatured and allowed to reanneal, complementary strands reanneal randomly and you obtain three possible duplex species: light–light (low density), heavy–heavy (high density), and hybrid heavy–light duplexes of intermediate density; during CsCl density gradient centrifugation these three classes separate by buoyant density into three distinct bands corresponding to the three duplex types, so three bands are observed rather than one or two; only if complete reassortment or selective pairing were prevented would you see fewer bands, but random renaturation predicts the ternary distribution that generates three separable density bands in the gradient; hence three bands is the expected outcome of reannealing a mixture of labeled and unlabeled DNA.

Q.16 A temperate phage differs from a virulent phage in that, temperate phage

- (A) can exhibit only lytic cycle
- (B) can choose between lytic and lysogenic cycle
- (C) can exhibit only lysogenic cycle
- (D) engages in lysogenic cycle only at high temperature

(2009)

Answer: (B) can choose between lytic and lysogenic cycle

Explanation: A temperate phage is defined by its ability to adopt two alternative lifestyles: it can enter the lytic cycle to replicate and lyse the host cell, or it can establish lysogeny by integrating into the host chromosome (or maintaining as a prophage) and replicating passively with the host until induction triggers the lytic phase; virulent phages lack the genetic circuitry for lysogeny and therefore commit only to the lytic cycle, while a temperate phage's choice depends on regulatory networks, host physiology, and environmental cues — unlike options that claim only one mode or temperature-dependent exclusivity; the capacity to alternate between lytic and lysogenic states is the key distinguishing feature of temperate phages and underlies phenomena such as immunity to superinfection and prophage-encoded traits in bacterial populations.

Q.17 RecA is a protein involved in

- (A) Recombinational repair
- (B) Mismatch repair
- (C) Nucleotide excision repair
- (D) Base excision repair

(2009)

Answer: (A) Recombinational repair

Explanation: RecA is a central protein in homologous recombination and recombinational DNA repair in bacteria: it facilitates strand invasion and exchange between homologous DNA sequences, promotes the search for homology, and stimulates cleavage of the LexA repressor to induce the SOS response under DNA damage conditions; while mismatch repair, nucleotide excision repair and base excision repair rely on other specific proteins and enzymatic activities (Mut proteins, UvrABC, glycosylases/AP endonucleases respectively), RecA's hallmark role is promoting homologous recombination to repair double-strand breaks and replication fork collapses by providing the enzymatic activity for strand exchange;

thus RecA is most directly connected to recombinational repair and the cellular programs that respond to severe DNA damage.

Q.18 In which of the following bacterium, chemical energy is converted to both mechanical as well as light energy?

- (A) *Vibrio fischeri*
- (B) *Bacillus subtilis*
- (C) *Escherichia coli*
- (D) *Pseudomonas fluorescence*

(2009)

Answer: (A) *Vibrio fischeri*

Explanation: *Vibrio fischeri* is a bioluminescent marine bacterium that converts chemical energy (from metabolism) into light energy via the luciferase enzyme system while also using chemical energy to power mechanical processes like flagellar rotation for motility, so it is an organism that links chemical energy to both light production and mechanical work; *Bacillus subtilis*, *Escherichia coli*, and *Pseudomonas* species are known for other metabolic and ecological traits but are not characterized by intrinsic bioluminescence, which is the distinguishing feature of *Vibrio fischeri* and related luminescent bacteria that form light-emitting symbioses with marine animals; therefore *Vibrio fischeri* best fits the description of converting chemical energy into both mechanical (motility) and light (bioluminescence) outputs.

Q.19 Initial density of a culture of bacteria with a generation time of 30 minutes was 1×10^3 cells/ml. After 5 hours of incubation, what serial dilution will you have to plate out to get -100 per ml.?

- (A) 10^3
- (B) 10^4
- (C) 10^5
- (D) 10^6

(2009)

Answer: (B) 10^4

Explanation: The culture undergoes generations = total time / generation time = 300 minutes / 30 minutes = 10 generations, so the final cell density = initial density $\times 2^{10} = 1 \times 10^3 \times 1024 \approx 1.024 \times 10^6$ cells/ml; to obtain about 100 colonies per ml when plating, you need to dilute the final culture by a factor of final density / desired colonies = $1.024 \times 10^6 / 100 \approx 1.024 \times 10^4$, which corresponds to a 10^4 (ten-thousandfold) dilution; thus plating the 10^4 dilution should yield approximately 100 colonies per ml given the calculated growth, and the other dilution choices are either too small or too large relative to that required to reach the target colony count.

Q.20 Effective chemotherapeutic agents are difficult to develop for the treatment of fungal infections because

- (A) Fungi have cell wall.

- (B) Fungi have better mechanisms to inactivate drugs.
- (C) Fungi are eucaryotic cells and their cellular machinery is similar to that of the host.
- (D) Fungal pathogens typically infect organs inaccessible for antibiotic treatment.

(2009)

Answer: (C) Fungi are eucaryotic cells and their cellular machinery is similar to that of the host.

Explanation: Developing selective chemotherapeutic agents against fungi is challenging because fungi are eukaryotic organisms whose cellular structures and biochemical pathways (membrane composition, ribosomes, metabolic enzymes) are more similar to those of human host cells than bacterial targets are, which narrows the therapeutic window and increases the risk of host toxicity when targeting conserved processes; although fungal cell walls provide some unique targets and fungi can possess drug-inactivating mechanisms or occupy less accessible niches, the central limitation is the shared eukaryotic biology that makes it difficult to find antifungal targets with high selectivity and low mammalian toxicity; therefore the eukaryotic nature of fungi is the primary reason why effective, safe antifungal chemotherapies are harder to design compared with antibacterials, making option (C) the best explanation among the choices.

Q.21 Which one of the following is NOT the criterion for using ribosomal RNAs as evolutionary chronometers ?

- (A) The large size of Ribosomal RNAs, gives large number of possible sequence combinations.
- (B) Ribosomal RNAs are functionally invariant.
- (C) Ribosomal RNAs are universally distributed.
- (D) Ribosomal RNAs have enzyme activity.

(2009)

Answer: (D) Ribosomal RNAs have enzyme activity.

Explanation: Ribosomal RNAs are excellent evolutionary chronometers because they are universally distributed across cellular life, are functionally constrained and therefore relatively conserved (functionally invariant in essential roles), and are large enough to provide substantial sequence information for phylogenetic comparisons; the statement that rRNAs "have enzyme activity" is not a standard criterion for using them as molecular clocks — while certain rRNA components (for example the peptidyl transferase center of the large ribosomal RNA) do contribute catalytically to peptide bond formation, the utility of rRNA as a chronometer rests on universality, functional conservation and adequate length for informative sequence variation rather than on catalytic activity per se; consequently option (D) is correctly identified as NOT being a general criterion for choosing rRNA as an evolutionary marker even though rRNA can have functional catalytic roles in the ribosome.

M: ZOOLOGY

Q.1 In an normal animal cell, the extra-chromosomal DNA is

- (A) Single stranded circular
- (B) Single stranded linear
- (C) Double stranded circular
- (D) Double stranded linear

(2009)

Answer: (C) Double stranded circular

Explanation: The extra-chromosomal DNA in a normal animal cell is primarily found within the **mitochondria**, which is the cellular organelle responsible for aerobic respiration and energy production. This mitochondrial DNA is characteristically a **double-stranded circular molecule** that is separate from the linear chromosomes located in the cell's nucleus. This structural feature is a key piece of evidence supporting the **endosymbiotic theory**, suggesting that mitochondria evolved from free-living bacteria which were engulfed by an ancestral eukaryotic cell, as prokaryotic DNA is typically circular. Unlike the nuclear DNA, is inherited almost exclusively from the mother and has its own transcription and translation machinery within the organelle.

Q.2 Which of the following is NOT a somite derivative?

- (A) Cardiac muscle
- (B) Skeletal muscle
- (C) Cartilage
- (D) Tendons

(2009)

Answer: (A) Cardiac muscle

Explanation: **Somites** are blocks of paraxial mesoderm that form segmentally along the anterior-posterior axis of the developing embryo, giving rise to essential structures of the adult body. The derivatives of somites typically include the **skeletal muscles** (from the myotome), **vertebrae and ribs** (from the sclerotome which forms cartilage and bone), and the **dermis of the skin and tendons** (from the dermatome and syndetome, respectively). **Cardiac muscle**, however, is derived from the **splanchnic lateral plate mesoderm** of the primitive heart tube, not the somites. This difference in embryonic origin highlights the distinct developmental lineage of the heart's specialized involuntary muscle tissue compared to the striated skeletal muscles.

Q.3 During hibernation in a hibernating mammal, its body temperature would be

- (A) Lower than normal state
- (B) Same as normal state
- (C) Higher than normal state
- (D) Fluctuate between high and low points

(2009)

Answer: (A) Lower than normal state

Explanation: **Hibernation** is a state of minimal metabolic activity and physiological depression that allows certain mammals to conserve energy during periods of harsh weather or scarcity of food,

typically winter. A defining characteristic of true hibernation is a drastic **reduction in body temperature**, which often drops to just a few degrees Celsius above the ambient temperature, sometimes close to . This controlled hypothermia significantly lowers the animal's **metabolic rate** and, consequently, its energy expenditure, which is essential for surviving extended periods without feeding. While the temperature does fluctuate slightly as the animal undergoes periodic arousal cycles, the overall during the deep hibernating state is substantially lower than the normal, active of approximately .

Q.4 Mendel's principle of segregation means that the germ cells (egg or sperm) always receive

- (A) One of the paired alleles
- (B) One pair of alleles
- (C) One quarter of the genes
- (D) Any pair of alleles

(2009)

Answer: (A) One of the paired alleles

Explanation: Mendel's **Principle of Segregation** (Mendel's First Law) states that during the formation of gametes (egg or sperm), the two alleles for a heritable character **separate** or segregate from each other such that each gamete receives only **one allele** from the pair. For an organism with the genotype , for example, the and alleles separate during meiosis, and an egg or sperm has an equal probability of carrying either the allele or the allele, but never both. This separation ensures that the two alleles for a trait are recombined randomly during fertilization, which is the foundational mechanism for maintaining genetic variation and the predictable inheritance patterns observed in Mendelian genetics.

Q.5 Cholera toxin acts by

- (A) Activating a G-protein
- (B) Blocking an ion channel
- (C) Activating synaptic transmission
- (D) Blocking glycolysis

(2009)

Answer: (A) Activating a G-protein

Explanation: **Cholera toxin** is a potent virulence factor produced by the bacterium *Vibrio cholerae*, and it exerts its toxic effects by interfering with the host cell's signaling pathways. Specifically, irreversibly **ADP-ribosylates** the subunit of a -protein, which is a key component in the adenylate cyclase signaling cascade. This modification **locks the protein in its active state**, preventing it from hydrolyzing GTP to GDP and thereby continuously stimulating the enzyme **adenylate cyclase**. The resulting high concentration of **cyclic AMP (cAMP)** in the intestinal epithelial cells causes an excessive efflux of chloride ions and water into the gut lumen, leading to the massive, watery diarrhea characteristic of cholera.

Q.6 Which of the following statements does NOT describe the characteristics of human population in industrialized countries?

- (A) Relatively small family size
- (B) Relatively even age structure
- (C) Rapid reproduction rate
- (D) Delayed reproduction

(2009)

Answer: (C) Rapid reproduction rate

Explanation: Human populations in industrialized, developed countries typically exhibit characteristics associated with the later stages of the **demographic transition model**. These populations generally have a **low birth rate** due to factors like high cost of raising children, increased access to contraception, later age of marriage, and greater female education and employment, resulting in a **relatively small family size**. Reproduction is often **delayed** as individuals pursue education and careers, and the overall age structure tends to be more **even** (column-shaped or top-heavy) due to low birth and death rates. A **rapid reproduction rate** (high birth rate) is characteristic of developing or less industrialized nations, making this statement the one that does **not** describe populations in industrialized countries.

Q.7 Sex-linkage refers to

- (A) Inheritance of genes linked to sex determination
- (B) The ratio of genes on the autosome and sex chromosomes
- (C) Inheritance of genes carried on the sex chromosomes
- (D) Linkage of genes present on the sex chromosomes

(2009)

Answer: (C) Inheritance of genes carried on the sex chromosomes

Explanation: **Sex-linkage** is a genetic phenomenon where the expression of a particular trait is tied to the inheritance of the sex of the individual. More precisely, it refers to the **inheritance pattern of genes located specifically on the sex chromosomes** (the X or Y chromosome in humans and many other species). Since males (XY) have only one X chromosome, they are hemizygous for -linked genes, meaning they express all -linked alleles, including recessive ones, at a higher frequency than females (XX). Common examples of sex-linked traits in humans include red-green color blindness and hemophilia, which follow these distinct inheritance patterns due to the location of their genes on the X chromosome.

Q. 8 to Q.21 carry two marks each.

Q.8 Increase in the emission of fossil fuels is thought to result in global warming. This is possible because an increase in atmospheric CO₂ level would

- (A) Increase the amount of sun light entering the earth atmosphere
- (B) Increase the amount of infrared radiation entering the earth
- (C) Absorb the infrared radiation reflected by the earth
- (D) Insulate earth from cold breeze coming from the space

(2009)

Answer: (C) Absorb the infrared radiation reflected by the earth

Explanation: The primary mechanism by which increased and other greenhouse gases contribute to global warming is through the **Greenhouse Effect**. Short-wavelength solar radiation from the sun passes through the atmosphere and warms the Earth's surface. The warm surface then emits **long-wavelength infrared (IR) radiation** back toward space. molecules are very efficient at **absorbing this outgoing radiation**, trapping the heat within the atmosphere instead of allowing it to escape into space. This phenomenon is analogous to glass in a greenhouse and leads to the gradual rise in the Earth's average temperature, which is the definition of global warming.

Q.9 Anabolic steroids, taken illegally by sportspersons to enhance their physical strength, are synthetic analogues for natural ____ from the ____

- (A) testosterone anterior pituitary
- (B) FSH and LH... posterior pituitary
- (C) cortisol thyroid
- (D) androgen gonads

(2009)

Answer: (D) androgen gonads

Explanation: *Anabolic steroids* are a class of steroid hormones structurally related to and mimicking the effects of the natural male sex hormone, **testosterone**. Testosterone is the most significant natural **androgen**, a hormone group responsible for the development and maintenance of male characteristics. It is produced primarily by the **gonads** (specifically the Leydig cells in the testes, and in small amounts by the adrenal glands and ovaries). Anabolic steroids are abused by athletes because they promote **anabolism**—the growth of skeletal muscle, increased bone density, and accelerated physical strength—by binding to androgen receptors and initiating protein synthesis pathways in target tissues.

Q.10 Holometabolous insects go through a series of larval instars before molting into pupal stage, and into an adult. This developmental is regulated by three key hormones namely, brain hormone, ecdysone, and juvenile hormone. The main function of brain hormones is to

- (A) Stimulate the prothoracic gland to secrete ecdysone
- (B) Stimulate the corpus allatum to secrete juvenile hormone
- (C) Arrest the release of ecdysone by prothoracic gland
- (D) Stimulate the release of juvenile hormone by prothoracic gland

(2009)

Answer: (A) Stimulate the prothoracic gland to secrete ecdysone

Explanation: The developmental cycle of holometabolous insects, involving complete metamorphosis, is intricately controlled by a hormonal axis. The **Brain Hormone** (also known as **prothoracicotropic hormone** or **PTTH**) is a neurohormone released from neurosecretory cells in the insect brain. Its principal role is to travel through the hemolymph (insect blood) and **stimulate the prothoracic gland** (a paired thoracic gland) to synthesize and release the steroid hormone **ecdysone** (the molting hormone). Ecdysone then triggers the molting process, which allows the insect to transition from one developmental stage to the next, while the juvenile hormone dictates the type of molt (larva-to-larva or larva-to-pupa/adult).

Q.11 Homology in anatomical parts helps in determining evolutionary kinship because

- (A) Homologous body parts invariably perform similar functions
- (B) Display evolutionary adaptations
- (C) Undergo similar genetic changes
- (D) Have common embryological origin

(2009)

Answer: (D) Have common embryological origin

Explanation: *Homology* refers to the similarity between structures in different species that is due to their **descent from a common evolutionary ancestor**, not necessarily their current function. For example, the forelimbs of a human, a cat, a whale, and a bat have different functions (grasping, walking, swimming, flying, respectively), yet they share the same fundamental bone structure. This shared blueprint, which is traceable to a **common embryological origin** (the same limb buds forming the same sequence of bones in the embryo), provides the strongest evidence for **evolutionary kinship**. The differences in structure and function are a result of subsequent divergent evolution and adaptation to different environments, but the underlying shared plan confirms a shared ancestry.

Q.12 Which of the following does NOT explain the term "survival of the fittest"?

- (A) Fittest animals leave higher number of progeny than those which perish.
- (B) Fittest group of animals outpopulates its competitors.
- (C) Fittest animals are best predators.
- (D) Fittest group is rich in genetic variations.

(2009)

Answer: (C) Fittest animals are best predators.

Explanation: The phrase "**survival of the fittest**" in evolutionary biology, coined by Herbert Spencer and adopted by Charles Darwin, refers to **differential reproductive success** and is an oversimplification of **Natural Selection**. "**Fitness**" in this context is a measure of an organism's **relative contribution to the gene pool of the next generation**, meaning the most "fit" individuals are those that produce the **highest number of viable, fertile offspring**. Statements (A) and (B) align with this definition, as high progeny and outpopulating competitors indicate greater reproductive success. Statement (D) is also relevant, as genetic variation is the raw material

for fitness. However, being the **"best predator"** (C) only contributes to fitness if it translates into greater survival and, most importantly, **higher reproductive output**, and in many ecosystems, the most "fit" organism may be a superior scavenger, herbivore, or even a disease-resistant individual, not necessarily the top predator.

Q.13 In a coral island in Atlantic Ocean, a natural calamity killed most of its population. The island is repopulated with the surviving individuals and their progeny. The present day population in the island shows high incidence of a rare recessive genetic disorder. What could be the most probable evolutionary force responsible for this phenomenon ?

- (A) Geographical isolation
- (B) Genetic drift
- (C) Selective advantage of the recessive disorder
- (D) Natural selection

(2009)

Answer: (B) Genetic drift

Explanation: The scenario described, where a population size is drastically reduced by a sudden, non-selective event (natural calamity), is a classic example of the **bottleneck effect**, which is a specific form of **genetic drift**. Genetic drift is the change in allele frequencies in a population due to **random chance** rather than natural selection. In a small surviving population (the "bottleneck"), the gene pool of the new population is determined by the few survivors; by random chance, these few may have a disproportionately **high frequency of a rare allele**, like the one for the recessive disorder. The subsequent population, founded by these survivors, will therefore show a high incidence of the disorder, regardless of its selective advantage or disadvantage.

Q.14 The human immune system is able to mount a response when it encounters a novel microorganism for the first time because

- (A) White blood cells are able to change their antigen specificity depending upon the microorganism they interact with.
- (B) Our body contains millions of different kinds of white blood cells, each with a unique type of antigen receptor.
- (C) Bone marrow cells make different antigen receptors depending upon the kind of invading microorganism.
- (D) Bone marrow cells are able to change their antigen specificity upon physical interaction with the microorganism.

(2009)

Answer: (B) Our body contains millions of different kinds of white blood cells, each with a unique type of antigen receptor.

Explanation: The ability of the **adaptive immune system** to

respond to a novel, previously unencountered microorganism is explained by the **Clonal Selection Theory**. The body inherently possesses a **vast, diverse repertoire of lymphocytes** (B and cells), which are different kinds of white blood cells. This diversity is generated through random **recombination of , , and gene segments** during their development in the bone marrow, resulting in **millions of distinct antigen receptors**, each capable of recognizing a specific molecular structure (antigen). When a novel microorganism invades, the unique B or cell with the matching receptor is **selected**, activated, and rapidly proliferates (clonally expands) to mount a full-scale, specific immune response.

Q.15 Acetylcholinesterase is an enzyme that degrades acetylcholine. What would be the effect of administration of an inhibitor of acetylcholinesterase on nerve transmission ?

- (A) No effect.
- (B) Synaptic transmission will be prevented.
- (C) Extra excitatory postsynaptic potentials would occur in the postsynaptic neuron.
- (D) The presynaptic neuron will be inactivated.

(2009)

Answer: (C) Extra excitatory postsynaptic potentials would occur in the postsynaptic neuron.

Explanation: **Acetylcholinesterase** is the enzyme located in the synaptic cleft that rapidly breaks down the neurotransmitter **acetylcholine** after it has been released and bound to its receptors on the postsynaptic membrane. This rapid degradation is crucial for terminating the synaptic signal and allowing the postsynaptic membrane to repolarize and be ready for the next signal. An **inhibitor** would prevent this breakdown, causing it to remain in the synaptic cleft for an **extended period** and repeatedly bind to its receptors. This prolonged binding would result in **continuous or excessive stimulation** of the postsynaptic neuron, leading to **extra excitatory postsynaptic potentials** and potentially muscle spasms or paralysis due to overstimulation.

Q.16 Which one of the following comparisons between oogenesis and spermatogenesis in human is NOT correct?

- (A) FSH promotes development of both eggs as well as sperms.
- (B) LH triggers ovulation in ovary and androgen production in testis.
- (C) Primary oocytes and primary spermatocytes follow similar pattern of development through meiosis.
- (D) An ovum is not produced until it fuses with the sperm whereas sperm is produced even in the absence of the ovum.

(2009)

Answer: (C) Primary oocytes and primary spermatocytes follow similar pattern of development through meiosis.

Explanation: The statement that *Primary oocytes and primary spermatocytes follow similar pattern of development through meiosis is NOT correct*. While both processes involve meiosis, they are fundamentally different: **Oogenesis** involves unequal cytokinesis, resulting in one large **ovum** and three tiny polar bodies, and the process is **arrested** at Prophase I (before birth) and again at Metaphase II, only completing meiosis II upon fertilization. In contrast, **Spermatogenesis** involves equal cytokinesis, resulting in **four equally sized, functional sperm** from each primary spermatocyte, and the process proceeds **continuously and without prolonged arrest** from puberty onward. The differing patterns reflect the distinct biological roles of the resulting gametes.

Q.17 Match the parasitic species with their correct hosts.

P.	<i>Schistosoma mansoni</i>	1.	snails
Q.	<i>Trichinella spiralis</i>	2.	human
R.	<i>Plasmodium</i>	3.	mosquito
S.	<i>Taenia solium</i>	4.	pig

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

(2009)

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

Explanation: This question requires knowledge of the life cycles and hosts of common parasites. . *Schistosoma mansoni* is a blood fluke whose infectious larval stage develops and multiplies asexually in **snails**, which serve as the intermediate host. . *Trichinella spiralis* is a nematode that causes trichinosis; it requires **humans** and other mammals (often pigs) where the encysted larvae reside in muscle tissue, though humans are often the definitive host where the adult worms mate. . *Plasmodium* (the causative agent of malaria) has a complex life cycle involving an obligate sexual stage in the **Anopheles mosquito**, the vector and definitive host, and an asexual stage in humans. . *Taenia solium* (pork tapeworm) requires **pigs** as an intermediate host, where the larvae form cysts, and humans as the definitive host.

Q.18 Match the embryonic cleavage patterns with the corresponding organisms

P.	Isolecithal	1.	Chick
Q.	Mesolecithal	2.	Drosophila
R.	Telolecithal	3.	Human
S.	Centrolecithal	4.	Frog

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

(2009)

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

Explanation: Cleavage patterns are highly dependent on the amount and distribution of **yolk** in the egg. . **Isolecithal** eggs have very little and evenly distributed yolk, which results in **holoblastic (complete and equal) cleavage**, characteristic of mammals like **humans**. . **Mesolecithal** eggs have a moderate amount of yolk concentrated towards the vegetal pole, leading to **holoblastic but unequal cleavage**, as seen in amphibians like the **frog**. . **Telolecithal** eggs have a large amount of yolk concentrated at one end (vegetal pole), causing **meroblastic (incomplete) cleavage** where only a small disk of cytoplasm at the animal pole undergoes cleavage, which is typical of birds like the **chick**. . **Centrolecithal** eggs have yolk concentrated in the center, which leads to **superficial cleavage** where the nuclei divide in the central yolk mass before migrating to the periphery, characteristic of insects like **Drosophila**.

Q.19 Which combination of the following statements with regard to gene expression is true?

1. Heteronuclear RNA represents contiguous segment of genomic DNA.
 2. UTRs are part of heteronuclear RNA but not of mRNA.
 3. UTRs are part of exons.
 4. Translation start codon **MUST** be in the first exon.
- (A) 1-true, 2-false, 3-false, 4-false
 (B) 1true, 2-false, 3 true, 4-false
 (C) 1true, 2-true, 3-false, 4-true
 (D) 1-false, 2-true, 3-true, 4-true

(2009)

Answer: (A) 1-true, 2-false, 3-false, 4-false

Explanation: Statement is **true** because **Heteronuclear RNA** is the primary transcript produced by RNA Polymerase II, containing both introns and exons, and is therefore a contiguous (uninterrupted) copy of a segment of genomic DNA. Statement is **false** because **Untranslated Regions**, which are sequences at the and ends of the mature messenger RNA that are not translated into protein, are indeed part of the molecule. Statement is **true** as **UTRs** are by definition part of the mature mRNA and must therefore be located within the **exons** (the coding segments that remain after splicing). Statement is **false** because while the start codon is often in the first exon, an **intron can sometimes interrupt the protein-coding sequence of the gene** after the start codon, meaning the start codon itself is located in the first exon, but the coding sequence for the resulting protein is not exclusively located on the first exon.

Q.20 Which of the following combination of statements regarding Maturation Promoting Factor (MPF) is TRUE?

1. MPF in amphibians regulates cell cycle.
 2. MPF in amphibians is composed of cyclins and CDKs.
 3. MPF in amphibians undergoes periodic degradation.
 4. MPF in amphibians undergoes periodic phosphorylation.
- (A) 1, 2 and 3 only

- (B) 1 and 4 only
- (C) 2 and 3 only
- (D) 1, 2, 3 and 4

(2009)

Answer: (A) 1, 2 and 3 only

Explanation: *Maturation Promoting Factor*, first discovered in *Xenopus* (amphibians), is a universally conserved core regulator of the eukaryotic cell cycle. Statement is **true** as is the central driver for the -to- phase transition (mitosis). Statement is also **true** because is a heterodimeric complex composed of a regulatory subunit, **cyclin B**, and a catalytic subunit, **cyclin-dependent kinase**. Statement is **true** as the periodic (the regulatory subunit of) by the proteasome at the end of mitosis is the critical event that causes inactivation, allowing the cell to exit mitosis and enter the G1 phase. Statement is **false** as undergoes periodic (which involves both phosphorylation and dephosphorylation of) rather than being periodically degraded or phosphorylated (the level of is constant).

Q.21 Which of the following combination of statements regarding gastrulation is TRUE?

1. It is marked by coordinated mass cell movement.
2. It results in the formation of organizer.
3. It results in the formation of three germ layers.
4. It marks the end of neurulation.

- (A) 1 and 3 only
- (C) 2 and 3 only
- (B) 1 and 2 only
- (D) 1, 2, 3 and 4

(2009)

Answer: (A) 1 and 3 only

Explanation: *Gastrulation* is a critical developmental process during which the single-layered blastula is reorganized into a multilayered structure called the gastrula. Statement is **true** because gastrulation is fundamentally characterized by **coordinated mass cell movements** such as invagination, ingression, and epiboly, which rearrange the blastomeres. Statement is also **true** as the most significant outcome of gastrulation is the formation of the **three primary germ layers**, which will eventually give rise to all the tissues and organs of the adult organism. Statement is **false** because the **Organizer** (e.g., Spemann-Mangold organizer in amphibians) is an early signaling center that **induces** gastrulation and its movements; it is formed before or at the very beginning of gastrulation, not as a result of it. Statement is **false** because (the formation of the neural tube) begins **after** and is largely a distinct subsequent process that marks the start of organogenesis, not the end of gastrulation.