CUET UG Performing Arts (320) - 2025 Question Paper with Solutions

Time Allowed : 1 Hour	Maximum Marks : 300	Total Questions : 75

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The test is of 1 hour duration.
2. The question paper consists of 75 questions. The maximum marks are 300.
3. 4 marks are awarded for every correct answer, and 1 mark is deducted for every wrong answer.

Q1. Which one of the following compounds inhibits the polymerization of tubulin to microtubules in animal cells?
(1) ATP
(2) Taxol
(3) Thymosin
(4) Vinblastine

Correct Answer: (4) Vinblastine

Solution:
Step 1: Understanding tubulin polymerization.
Microtubules are formed by the polymerization of - and -tubulin dimers. The dynamic equilibrium between polymerization and depolymerization is crucial for cell division and intracellular transport.

Step 2: Analyzing the options.
- ATP is an energy molecule and not a direct inhibitor of microtubule formation.
- Taxol stabilizes microtubules and prevents their depolymerization, rather than inhibiting polymerization.
- Thymosin binds to actin monomers and affects actin filament formation, not microtubules.
- Vinblastine binds to tubulin dimers and inhibits their polymerization into microtubules, thereby disrupting mitotic spindle formation during cell division.

Step 3: Conclusion.
Vinblastine acts as a mitotic inhibitor by preventing microtubule assembly.

Quick Tip

Remember: Vinblastine and Colchicine inhibit microtubule polymerization, whereas Taxol stabilizes microtubules.

Q2. Arrange the following elements in increasing order of their electronegativity according to the Pauling scale: C, Na, Be, and Br.
(1) Be, Na, C, Br
(2) Br, C, Na, Be
(3) Na, Be, C, Br
(4) Na, C, Be, Br

Correct Answer: (3) Na, Be, C, Br

Solution:
Step 1: Recall the concept of electronegativity.
Electronegativity increases from left to right in a period and decreases from top to bottom in a group.

Step 2: Comparing values (approx. on Pauling scale).
Na = 0.93, Be = 1.57, C = 2.55, Br = 2.96.

Step 3: Arranging in increasing order.
Na ¡ Be ¡ C ¡ Br.

Step 4: Conclusion.
The correct order is Na, Be, C, Br.

> **Quick Tip**
>
> Electronegativity generally increases across a period and decreases down a group in the periodic table.

Q3. Which one of the following is NOT a plant vascular tissue?
(1) Phloem
(2) Periderm
(3) Stele
(4) Xylem

Correct Answer: (2) Periderm

Solution:
Step 1: Understanding vascular tissues.
Vascular tissues are responsible for the transport of water, minerals, and nutrients in plants. The two main vascular tissues are xylem and phloem.

Step 2: Analyzing the options.
- Phloem and Xylem are vascular tissues.

- Stele represents the central vascular cylinder in roots and stems.
- Periderm, however, is a protective tissue that replaces the epidermis during secondary growth, not a vascular tissue.

Step 3: Conclusion.
Hence, Periderm is not a plant vascular tissue.

> **Quick Tip**
>
> Vascular tissues include xylem and phloem; protective tissues include periderm and epidermis.

Q4. A growing shoot of a germinating seedling encounters an underground obstacle. Which one of the following hormones elicits the 'triple response' to the underground obstacle?
(1) Auxin
(2) Cytokinin
(3) Ethylene
(4) Gibberellins

Correct Answer: (3) Ethylene

Solution:
Step 1: Understanding the triple response.
The triple response is observed when a seedling encounters mechanical stress or an obstacle while growing underground. The response includes:
(a) Inhibition of stem elongation,
(b) Thickening of the stem, and
(c) Horizontal growth of the shoot.

Step 2: Role of ethylene.
Ethylene induces this triple response, allowing the seedling to navigate around obstacles by modifying its growth pattern. Other hormones like auxin, cytokinin, and gibberellins do not induce this specific response.

Step 3: Conclusion.
Ethylene is the hormone responsible for the triple response in seedlings.

> **Quick Tip**
>
> Ethylene helps seedlings adjust their growth when encountering physical barriers underground.

Q5. Which one of the following pairs of antibodies contains 'J-chain' in their multimeric form?
(1) IgA and IgE
(2) IgA and IgM
(3) IgD and IgE
(4) IgD and IgG

Correct Answer: (2) IgA and IgM

Solution:
Step 1: Understanding J-chain function.
The J (joining) chain is a polypeptide that links immunoglobulin monomers into polymeric forms, such as dimers or pentamers.

Step 2: Immunoglobulins with J-chain.
- IgA is found as a dimer in mucosal secretions, connected by a J-chain.
- IgM exists as a pentamer in plasma, also linked by a J-chain.
- IgG, IgD, and IgE are monomeric and lack the J-chain.

Step 3: Conclusion.
Hence, the antibodies containing J-chain are IgA and IgM.

Quick Tip

Remember: IgA (dimeric) and IgM (pentameric) antibodies contain the J-chain that links their subunits.

Q6. Restriction enzymes that recognize the same nucleotide sequence but cleave at different positions are called:
(1) heterohypekomers
(2) isocaudomers
(3) isoschizomers
(4) neoschizomers

Correct Answer: (4) neoschizomers

Solution:
Step 1: Understanding restriction enzymes.
Restriction enzymes (endonucleases) recognize specific DNA sequences and cleave the DNA at or near these sites. Some enzymes recognize identical sequences but differ in where they cut the DNA strand.

Step 2: Classification of enzymes.
- **Isoschizomers:** Recognize and cut the same sequence at the same position.
- **Neoschizomers:** Recognize the same sequence but cut at a different site within that se-

quence.
- **Isocaudomers:** Recognize different sequences but generate the same cohesive ends.
- **Heterohypekomers:** This term is non-standard and incorrect.

Step 3: Conclusion.
Hence, enzymes that recognize the same sequence but cleave differently are called neoschizomers.

> Quick Tip
>
> Neoschizomers = same recognition site, different cleavage site; Isoschizomers = same recognition and cleavage site.

Q7. Which one of the following does NOT belong to the freshwater ecosystem?
(1) Estuary
(2) Lentic
(3) Lotic
(4) Wetland

Correct Answer: (1) Estuary

Solution:
Step 1: Classification of aquatic ecosystems.
Freshwater ecosystems include bodies of water with low salt concentration. They are broadly divided into:
- **Lentic systems:** Still water (lakes, ponds).
- **Lotic systems:** Flowing water (rivers, streams).
- **Wetlands:** Transitional zones between land and water, usually freshwater.

Step 2: Understanding estuaries.
Estuaries are coastal areas where freshwater from rivers meets seawater, leading to brackish conditions. Thus, they are not purely freshwater ecosystems.

Step 3: Conclusion.
Estuary does not belong to freshwater ecosystems because it has mixed salinity.

> Quick Tip
>
> Lentic = still water, Lotic = flowing water, Wetland = semi-aquatic, Estuary = brackish (not freshwater).

Q8. Which one of the following is transcribed by RNA polymerase III in eukaryotes?
(1) 18S rRNA

(2) 28S rRNA
(3) miRNA
(4) tRNA

Correct Answer: (4) tRNA

Solution:
Step 1: Overview of eukaryotic RNA polymerases.
Eukaryotes have three primary RNA polymerases:
- RNA polymerase I: Transcribes 28S, 18S, and 5.8S rRNA (ribosomal RNAs).
- RNA polymerase II: Transcribes mRNA and most snRNA and miRNA genes.
- RNA polymerase III: Transcribes tRNA, 5S rRNA, and some small RNAs.

Step 2: Identifying the correct answer.
tRNA genes are transcribed by RNA polymerase III, not RNA polymerase I or II.

Step 3: Conclusion.
Hence, tRNA is synthesized by RNA polymerase III.

Quick Tip

Remember: Pol I $\rightarrow$ rRNA (except 5S), Pol II $\rightarrow$ mRNA, Pol III $\rightarrow$ tRNA and 5S rRNA.

Q9. Given the following sets:
$A = \{2, 4, 6, 8, 10, 12\}$
$B = \{8, 10, 12, 14, 16, 18\}$
$C = \{7, 8, 9, 10, 11, 12, 13\}$
Find $(A \cap B) \cup (B \cap C)$.
(1) {8, 10, 12, 14}
(2) {8, 10, 12}
(3) {7, 8, 10, 11, 12, 13, 14}
(4) {4, 6, 7, 8, 10, 11, 12, 13}

Correct Answer: (3) {7, 8, 10, 11, 12, 13, 14}

Solution:
Step 1: Find $A \cap B$.
Common elements of A and B = {8, 10, 12}.

Step 2: Find $B \cap C$.
Common elements of B and C = {8, 10, 11, 12, 13, 14}.

Step 3: Take the union of the two results.
$(A \cap B) \cup (B \cap C) = \{7, 8, 10, 11, 12, 13, 14\}$.

Step 4: Conclusion.
The correct result is $\{7, 8, 10, 11, 12, 13, 14\}$.

> Quick Tip
>
> Intersection () finds common elements; Union () combines all unique elements.

Q10. Rain is falling vertically with a speed of 40 m/s. Wind starts blowing with a speed of 16 m/s from west to east. How should a person, who is standing, hold his umbrella to avoid getting wet?
(1) At an angle of about 22° with vertical towards east
(2) At an angle of about 22° with vertical towards west
(3) At an angle of about 66° with vertical towards east
(4) At an angle of about 66° with vertical towards west

Correct Answer: (2) At an angle of about 22° with vertical towards west

Solution:
Step 1: Understanding the situation.
Rain falls vertically with a velocity of 40 m/s downward. Wind blows horizontally at 16 m/s from west to east.

Step 2: Relative velocity of rain w.r.t. person.
The person feels rain coming at an angle, given by:

$$\tan\theta = \frac{\text{horizontal velocity}}{\text{vertical velocity}} = \frac{16}{40} = 0.4$$

$$\theta = \tan^{-1}(0.4) \approx 21.8^\circ$$

Step 3: Direction of tilt.
Since wind blows from west to east, the rain appears to come from east. Thus, the umbrella should be tilted towards the west.

Step 4: Conclusion.
The umbrella must be held at approximately 22° with the vertical, towards the west.

> Quick Tip
>
> When wind blows, rain appears to come from the direction opposite to the wind's motion.

Q11. Which one of the following statements about the G1 checkpoint of the eukaryotic cell division cycle is INCORRECT?
(1) Cell assures the existence of favorable extracellular environment
(2) Cell assures the DNA has no damage
(3) Cell assures the damaged DNAs are directed for repair mechanism
(4) Cell assures complete replication of DNA

Correct Answer: (4) Cell assures complete replication of DNA

Solution:
Step 1: Understanding the G1 checkpoint.
The G1 checkpoint (also known as the restriction point) ensures that the cell is ready to enter the S phase. It verifies DNA integrity and checks for adequate nutrients and growth signals.

Step 2: Evaluating each statement.
- The G1 checkpoint indeed ensures a favorable extracellular environment and undamaged DNA.
- It can also trigger repair mechanisms for damaged DNA.
- However, checking for complete DNA replication is a function of the G2 checkpoint, not the G1 checkpoint.

Step 3: Conclusion.
Thus, the statement "Cell assures complete replication of DNA" is incorrect for the G1 checkpoint.

Quick Tip

G1 checkpoint checks DNA damage and environment; G2 ensures DNA replication; M checkpoint verifies spindle attachment.

Q12. Determine the correctness or otherwise of the following Assertion [a] and the Reason [r].
Assertion [a]: Nitric oxide is involved in transient paracrine and autocrine signaling.
Reason [r]: Nitric oxide is highly reactive, with a lifetime of few seconds, yet can diffuse freely across membranes.

(1) Both [a] and [r] are true and [r] is the correct reason for [a]
(2) Both [a] and [r] are true but [r] is not the correct reason for [a]
(3) Both [a] and [r] are false
(4) Only [a] is true but [r] is false

Correct Answer: (1) Both [a] and [r] are true and [r] is the correct reason for [a]

Solution:
Step 1: Role of nitric oxide (NO).

Nitric oxide acts as a signaling molecule in animals, especially in smooth muscle relaxation and neural signaling. It functions via paracrine and autocrine mechanisms because it diffuses locally and has a short half-life.

Step 2: Evaluating assertion and reason.
Both statements are correct — NO is transient and acts locally due to its high reactivity. Its ability to freely diffuse across membranes explains its paracrine and autocrine signaling nature.

Step 3: Conclusion.
Therefore, both [a] and [r] are true, and [r] correctly explains [a].

> **Quick Tip**
>
> NO is lipid-soluble, diffuses freely, and acts locally — a classic paracrine/autocrine messenger.

Q13. In mice, a trait is determined by a dominant allele Y and a recessive allele y. What proportion of the offspring from a $YY \times yy$ cross is expected to be homozygous recessive in the F1 generation?
(1) 0
(2) 0.25
(3) 0.5
(4) 1

Correct Answer: (1) 0

Solution:
Step 1: Determine the parental genotypes.
Parent 1 = YY (homozygous dominant)
Parent 2 = yy (homozygous recessive).

Step 2: Determine the F1 genotype.
Crossing $YY \times yy$ produces offspring with genotype Yy (heterozygous).

Step 3: Conclusion.
All F1 individuals are heterozygous (Yy), none are homozygous recessive (yy). Hence, the proportion of homozygous recessive individuals = 0.

> **Quick Tip**
>
> A cross between homozygous dominant and homozygous recessive parents yields 100

Q14. Match the molecules in Group I with the type of bonds present in them, in

Group II.

Group I	Group II
P) NaCl	1) Coordination bond
Q) H_2	2) Polar covalent bond
R) Pd–P bond in $Pd(PPh_3)_4$	3) Covalent bond
S) C–Cl bond in CH_3Cl	4) Ionic bond

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

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

Solution:
Step 1: Understanding the bond types.
- **NaCl:** Forms due to complete transfer of electrons → ionic bond.
- **H_2:** Bond due to equal sharing of electrons → covalent bond.
- **Pd–P bond:** A metal-ligand interaction where both electrons are provided by the ligand → coordination bond.
- **C–Cl bond in CH_3Cl:** Unequal sharing of electrons between C and Cl → polar covalent bond.

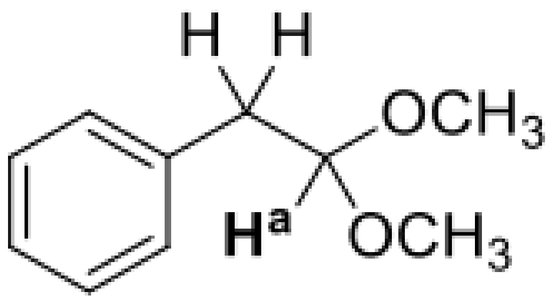
Step 2: Matching.
P–4, Q–3, R–1, S–2.

Step 3: Conclusion.
Thus, option (3) correctly represents the bond types.

Quick Tip

Coordination bonds form via lone pair donation; ionic via full transfer; covalent via equal sharing.

Q15. What is the splitting pattern of proton H^a of the following compound in its ^1H NMR spectrum?



(1) Doublet
(2) Doublet of doublet
(3) Multiplet
(4) Triplet

Correct Answer: (4) Triplet

Solution:
Step 1: Analyzing the structure.
The given proton H^a is attached to a carbon bearing two equivalent hydrogens (–CH_2 group).

Step 2: Applying the n + 1 rule.
For NMR splitting, a proton coupled to n equivalent neighboring protons appears as $n + 1$ peaks.
Here, H^a couples with two equivalent protons ($n = 2$), so the splitting pattern is a triplet.

Step 3: Conclusion.
Hence, proton H^a shows a triplet pattern in its ^1H NMR spectrum.

Quick Tip

In NMR, a proton coupled to n equivalent protons splits into $n + 1$ peaks — the $n + 1$ rule.

Q16. Which one of the following statements is correct about solute transport across membranes?
(1) Passive transporters decrease the activation energy and do not facilitate the transport of polar compounds
(2) The direction in which a charged solute tends to move spontaneously across a membrane does not depend on the electrical gradient across the membrane
(3) All ABC transporters do not have nucleotide binding domain
(4) P-type ATPases get reversibly phosphorylated as a part of transport cycle

Correct Answer: (4) P-type ATPases get reversibly phosphorylated as a part of transport cycle

Solution:
Step 1: Understanding types of membrane transport.
Transport across membranes can be passive (no energy required) or active (requires ATP). Active transporters are often classified as P-type, V-type, F-type ATPases, and ABC transporters.

Step 2: Analyzing options.
- (A) Passive transporters facilitate polar compound transport; hence, this is incorrect.
- (B) Charged solute movement depends on both concentration and electrical gradients; hence, false.
- (C) All ABC transporters possess a nucleotide-binding domain; hence, this is incorrect.
- (D) P-type ATPases undergo reversible phosphorylation during their transport cycle — for example, the Na/K-ATPase.

Step 3: Conclusion.
The correct statement is that P-type ATPases are reversibly phosphorylated during the transport process.

> **Quick Tip**
>
> P-type ATPases use ATP hydrolysis and undergo phosphorylation-dephosphorylation during each cycle.

Q17. Match the type of DNA repair mechanism in Group I with the enzyme(s) involved in Group II.

Group I	**Group II**
P) Mismatch repair	1) DNA glycosylase
Q) Base excision repair	2) UvrA, UvrB, UvrC, and UvrD
R) Nucleotide excision repair	3) RecA
S) Double strand break repair	4) MutL, MutS, and MutH

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

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

Solution:
Step 1: Understanding DNA repair mechanisms.
Different repair systems correct distinct types of DNA damage using specialized enzymes.

Step 2: Matching based on enzyme involvement.
- **Mismatch repair:** Uses MutL, MutS, and MutH to identify and correct replication errors.

- **Base excision repair:** Involves DNA glycosylase to remove damaged bases.
- **Nucleotide excision repair:** Uses UvrA, UvrB, UvrC, and UvrD to remove bulky adducts.
- **Double strand break repair:** Uses RecA protein for homologous recombination repair.

Step 3: Conclusion.
Correct pairing: P–4, Q–1, R–2, S–3.

Quick Tip

Remember: Mut proteins = mismatch repair; Uvr proteins = nucleotide excision repair; Glycosylase = base excision repair.

Q18. Tetracycline binds to the:
(1) 30S subunit and inhibits aminoacyl-tRNA binding
(2) 50S subunit and inhibits aminoacyl-tRNA binding
(3) 30S subunit and prevents codon:anticodon interactions
(4) 50S subunit and blocks exit of growing polypeptide chain

Correct Answer: (1) 30S subunit and inhibits aminoacyl-tRNA binding

Solution:
Step 1: Mechanism of tetracycline.
Tetracycline is a broad-spectrum antibiotic that acts by inhibiting protein synthesis in bacteria.

Step 2: Binding site and function.
It binds to the 30S ribosomal subunit and prevents the attachment of aminoacyl-tRNA to the A-site of the ribosome. This blocks elongation of the growing polypeptide chain.

Step 3: Conclusion.
Hence, tetracycline binds to the 30S subunit and inhibits aminoacyl-tRNA binding.

Quick Tip

Tetracycline $\rightarrow$ 30S subunit; Chloramphenicol $\rightarrow$ 50S (peptidyl transferase inhibition); Macrolides $\rightarrow$ 50S (translocation block).

Q19. In the 'Southern blot' technique, which of the following reagents is used to detect the presence of a desired DNA fragment?
(1) Ethidium bromide
(2) DNA probe
(3) Silver nitrate
(4) DNase

Correct Answer: (2) DNA probe

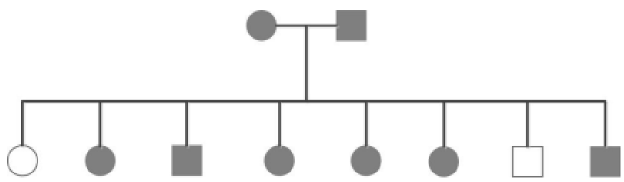
Solution:
Step 1: Understanding Southern blotting.
Southern blotting is a molecular biology technique used to detect a specific DNA sequence in a mixture. DNA fragments are separated by electrophoresis, transferred to a membrane, and hybridized with a labeled DNA probe.

Step 2: Function of the probe.
A complementary DNA probe binds to the target DNA sequence by base pairing and allows visualization (using radioactive or fluorescent labels).

Step 3: Conclusion.
DNA probes are used for detection, not ethidium bromide or silver nitrate, which are general stains.

> **Quick Tip**
>
> Southern blot $\rightarrow$ DNA detection; Northern $\rightarrow$ RNA detection; Western $\rightarrow$ Protein detection.

Q20. The pedigree given below shows individuals affected (shaded circles/rectangles) by chronic hypertension. Assuming 100% penetrance, the inheritance of this trait is:



(1) Autosomal dominant
(2) Autosomal recessive
(3) Sex-linked dominant
(4) Sex-linked recessive

Correct Answer: (1) Autosomal dominant

Solution:
Step 1: Analyze the pedigree.
In the given pedigree, the trait appears in every generation and affects both males and females equally. Each affected individual has at least one affected parent.

Step 2: Apply inheritance rules.
These features are typical of autosomal dominant inheritance, where only one copy of the mu-

tant allele is sufficient to express the trait.

Step 3: Eliminate other options.
- Autosomal recessive traits skip generations.
- Sex-linked traits usually affect males more frequently.

Step 4: Conclusion.
Hence, the mode of inheritance is autosomal dominant.

> Quick Tip
>
> Autosomal dominant traits appear in every generation; autosomal recessive traits can skip generations.

Q21. Which one of the following statements about photoproteins in plants is INCORRECT?
(1) Phytochromes are activated by red light
(2) Phytochromes are inactivated by far-red light
(3) Cryptochromes are sensitive to blue light
(4) Phototropins are insensitive to blue light

Correct Answer: (4) Phototropins are insensitive to blue light

Solution:
Step 1: Understanding plant photoreceptors.
Plants have three major classes of light-sensitive photoproteins — phytochromes, cryptochromes, and phototropins — that help them perceive and respond to light.

Step 2: Analyzing each option.
- Phytochromes detect red and far-red light. They are activated by red light and inactivated by far-red light.
- Cryptochromes detect blue light and control photomorphogenesis.
- Phototropins are also blue-light receptors involved in phototropism, chloroplast movement, and stomatal opening. Hence, the statement that phototropins are "insensitive to blue light" is incorrect.

Step 3: Conclusion.
Phototropins are sensitive to blue light; hence option (4) is incorrect.

> Quick Tip
>
> Phytochromes $\rightarrow$ red/far-red light; Cryptochromes Phototropins $\rightarrow$ blue light responses in plants.

Q22. Match the microorganisms in Group I with the human diseases in Group II.

Group I	**Group II**
P) *Treponema pallidum*	1) Sleeping sickness
Q) *Trypanosoma cruzi*	2) Whooping cough
R) *Trypanosoma gambiense*	3) Chagas disease
S) *Bordetella pertussis*	4) Syphilis

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

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

Solution:
Step 1: Identify the causative agents.
- *Treponema pallidum* causes Syphilis (a sexually transmitted disease).
- *Trypanosoma cruzi* causes Chagas disease (transmitted by reduviid bugs).
- *Trypanosoma gambiense* causes Sleeping sickness (spread by tsetse fly).
- *Bordetella pertussis* causes Whooping cough (a respiratory infection).

Step 2: Conclusion.
Correct match: P–4, Q–3, R–1, S–2.

Quick Tip

Remember: Treponema → Syphilis; Trypanosoma cruzi → Chagas; Trypanosoma gambiense → Sleeping sickness; Bordetella → Whooping cough.

Q23. Which one of the following is correct in the case of conjugation of a high frequency recombination (Hfr) strain with an F^- strain of *E. coli*?
(1) Recombination frequency is high, F factor transfer frequency is low
(2) Recombination frequency is high, F factor transfer frequency is high
(3) Recombination frequency is low, F factor transfer frequency is high
(4) Recombination frequency is low, F factor transfer frequency is low

Correct Answer: (1) Recombination frequency is high, F factor transfer frequency is low

Solution:
Step 1: Understanding Hfr conjugation.
In Hfr strains, the F factor is integrated into the bacterial chromosome. During conjugation, chromosomal genes are transferred along with part of the F factor to the recipient cell.

Step 2: Consequence of conjugation.
Because the F factor is located within the chromosome, full transfer of the F plasmid is rare (hence, F factor transfer frequency is low). However, chromosomal recombination occurs at a high frequency.

Step 3: Conclusion.
Thus, in Hfr $\times F^-$ conjugation, recombination frequency is high but F factor transfer frequency is low.

> Quick Tip
>
> Hfr strains integrate F factor into chromosome $\rightarrow$ high recombination, low F factor transfer.

Q24. Determine the correctness or otherwise of the following Assertion [a] and Reason [r].
Assertion [a]: The cardiovascular organization called double circulation provides vigorous flow of blood to the brain, muscles, and other organs.
Reason [r]: The blood is pumped a second time after it loses pressure in the capillary beds of the lungs or skin.

(1) Both [a] and [r] are true and [r] is the correct reason for [a]
(2) Both [a] and [r] are true but [r] is not the correct reason for [a]
(3) Both [a] and [r] are false
(4) [a] is true but [r] is false

Correct Answer: (1) Both [a] and [r] are true and [r] is the correct reason for [a]

Solution:
Step 1: Understanding double circulation.
In vertebrates, double circulation means that blood passes through the heart twice in one complete circuit — once for oxygenation (pulmonary) and once for distribution (systemic).

Step 2: Analyzing the reason.
After losing pressure in the lungs' capillaries, blood returns to the heart and is pumped again to maintain high pressure, ensuring efficient supply to all tissues. Hence, both statements are true and [r] explains [a].

Step 3: Conclusion.
Double circulation ensures vigorous flow by re-pressurizing blood before systemic distribution.

Quick Tip

Double circulation → Pulmonary + Systemic; ensures efficient oxygen delivery and pressure maintenance.

Q25. The inability in humans to taste capsaicin resides in a single gene difference between two alleles P and p. The allele P for tasting is dominant over the nontasting allele. In a population of 400 individuals in Hardy-Weinberg equilibrium, 64 are nontasters. How many individuals are heterozygous for the gene?
(1) 64
(2) 128
(3) 144
(4) 192

Correct Answer: (4) 192

Solution:
Step 1: Identify known values.
Given that 64 out of 400 individuals are nontasters (recessive genotype pp):

$$q^2 = \frac{64}{400} = 0.16 \Rightarrow q = 0.4$$

Then, $p = 1 - q = 0.6$.

Step 2: Calculate heterozygous frequency.
Heterozygotes $= 2pq = 2(0.6)(0.4) = 0.48$.

Step 3: Calculate number of heterozygous individuals.

$$0.48 \times 400 = 192.$$

Hence, 192 individuals are heterozygous (Pp).

Quick Tip

Hardy–Weinberg law: $p^2 + 2pq + q^2 = 1$; where p^2 = dominant homozygotes, q^2 = recessive homozygotes, $2pq$ = heterozygotes.

Q26. A genetic linkage map represents the:
(1) relative locations of genes on a chromosome
(2) distribution of the mutational hotspots
(3) phylogenetic linkage among organisms
(4) accurate physical distances among loci

Correct Answer: (1) relative locations of genes on a chromosome

Solution:
Step 1: Understanding genetic linkage maps.
A genetic linkage map shows the order of genes and the relative distances between them on a chromosome, based on the frequency of recombination during meiosis.

Step 2: Key concept.
The closer two genes are, the lower their recombination frequency. The distances are measured in map units or centimorgans (cM), representing 1
Step 3: Conclusion.
Thus, a genetic linkage map represents the relative positions of genes, not their exact physical distances.

> **Quick Tip**
>
> Genetic maps indicate recombination-based distances; physical maps show actual DNA base pair distances.

Q27. Class II MHC molecules are NOT expressed by:
(1) B-cells
(2) dendritic cells
(3) macrophages
(4) T-cells

Correct Answer: (4) T-cells

Solution:
Step 1: Understanding MHC class II expression.
MHC class II molecules are present on antigen-presenting cells (APCs), such as B-cells, macrophages, and dendritic cells. These molecules present processed antigen peptides to helper T-cells (CD4).

Step 2: Evaluating the options.
T-cells recognize antigens through their T-cell receptors but do not express MHC class II molecules. They instead express MHC class I molecules.

Step 3: Conclusion.
Hence, class II MHC molecules are not expressed by T-cells.

> **Quick Tip**
>
> MHC I $\rightarrow$ all nucleated cells; MHC II $\rightarrow$ only professional antigen-presenting cells.

Q28. Which one of the following enzymes is required to ensure the replication of a negative-sense or negative-strand RNA virus?
(1) DNA-dependent RNA polymerase
(2) DNA polymerase
(3) RNA-dependent DNA polymerase
(4) RNA-dependent RNA polymerase

Correct Answer: (4) RNA-dependent RNA polymerase

Solution:
Step 1: Understanding negative-sense RNA viruses.
Negative-sense RNA viruses have genomes complementary to mRNA. To replicate, they must synthesize a positive-sense RNA strand first, which acts as a template for protein synthesis.

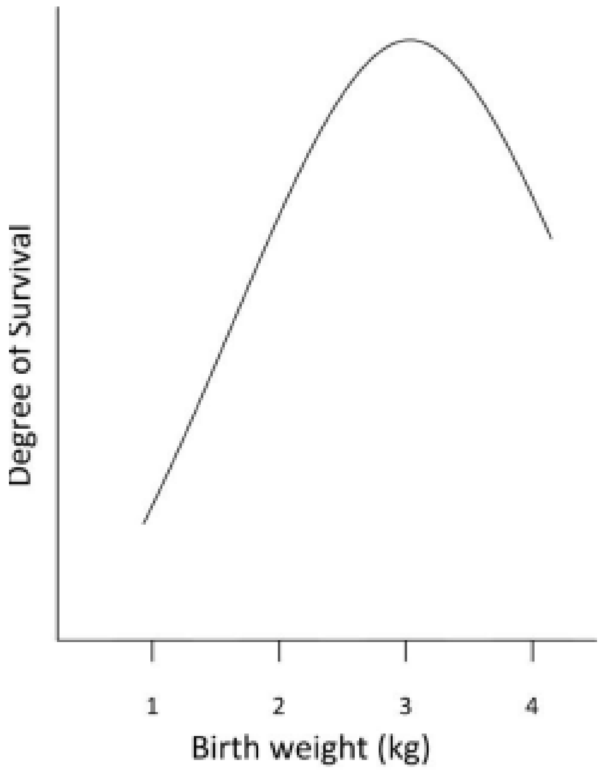
Step 2: Role of enzyme.
The enzyme RNA-dependent RNA polymerase (RDRP) catalyzes the synthesis of complementary RNA from an RNA template. This enzyme is not found in host cells; thus, the virus must carry it within its virion.

Step 3: Conclusion.
Replication of negative-strand RNA viruses requires RNA-dependent RNA polymerase.

Quick Tip

Positive-sense RNA $\rightarrow$ acts as mRNA; Negative-sense RNA $\rightarrow$ requires RDRP for conversion to mRNA.

Q29. The relationship between birth weight and degree of survival (log[$\frac{\text{survivors}}{\text{non-survivors}}$]) in 6908 human births is shown below. The mode of selection for birth weight is:



(1) directional
(2) disruptive
(3) diversifying
(4) stabilizing

Correct Answer: (4) stabilizing

Solution:
Step 1: Understanding the graph.
The curve shows maximum survival at an intermediate birth weight, while both very low and very high weights correspond to lower survival rates.

Step 2: Type of selection.
Stabilizing selection favors intermediate phenotypes by selecting against extremes. This maintains the population around an optimal average trait value.

Step 3: Conclusion.
The observed pattern represents stabilizing selection, common in traits like birth weight where extremes reduce fitness.

Quick Tip

Stabilizing selection favors the mean; directional favors one extreme; disruptive favors both extremes.

Q30. Match the recombinant DNA products in Group I with their applications in Group II.

Group I	Group II
P) Tissue plasminogen activator	1) Emergency treatment of heart attack
Q) Erythropoietin	2) Treatment of anemia
R) Superoxide dismutase	3) Prevents tissue damage
S) Interferon	4) Stimulates cells to inhibit viral replication

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

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

Solution:
Step 1: Identifying the recombinant products and their functions.
- **Tissue plasminogen activator (tPA):** Dissolves blood clots — used for emergency heart attack treatment.
- **Erythropoietin:** Stimulates red blood cell production — used to treat anemia.
- **Superoxide dismutase:** Protects tissues from oxidative damage — prevents tissue injury.
- **Interferon:** Stimulates antiviral responses in cells — inhibits viral replication.

Step 2: Conclusion.
Correct match: P–1, Q–2, R–3, S–4.

Quick Tip

tPA $\rightarrow$ heart attack; Erythropoietin $\rightarrow$ anemia; Superoxide dismutase $\rightarrow$ prevents oxidative damage; Interferon $\rightarrow$ antiviral defense.

Q31. Which of the following statement(s) is/are correct about telophase?
(1) Daughter chromosomes are yet to form
(2) New nuclear envelope starts to reassemble
(3) Division of cytoplasm begins
(4) Nuclear membrane disappears

Correct Answer: (2) and (3)

Solution:
Step 1: Understanding telophase.
Telophase is the final stage of mitosis where daughter chromosomes reach opposite poles, and the cell prepares to divide its cytoplasm.

Step 2: Evaluating each statement.
- (A) Incorrect — Daughter chromosomes have already formed during anaphase.
- (B) Correct — The nuclear envelope begins to re-form around each set of chromosomes.
- (C) Correct — Cytokinesis (division of cytoplasm) begins during telophase.
- (D) Incorrect — The nuclear membrane reappears, not disappears, in telophase.

Step 3: Conclusion.
Thus, the correct statements about telophase are (2) and (3).

> **Quick Tip**
>
> Remember: Telophase = "T" for "Two nuclei" — nuclear envelope reappears and cytokinesis begins.

Q32. The characteristic morphological change(s) in cells undergoing apoptosis is/are:
(1) Formation of blebs on cell surface
(2) Swelling and bursting of cells
(3) Collapse of the cytoskeleton
(4) Condensation and fragmentation of nuclear chromatin

Correct Answer: (1), (3), and (4)

Solution:
Step 1: Understanding apoptosis.
Apoptosis, or programmed cell death, is a controlled cellular process involving morphological and biochemical changes that prevent inflammation.

Step 2: Analyzing features.
- (A) Correct — Formation of membrane blebs is a hallmark of apoptosis.
- (B) Incorrect — Swelling and bursting occur in necrosis, not apoptosis.
- (C) Correct — Cytoskeletal collapse occurs as the cell shrinks.
- (D) Correct — Nuclear chromatin condenses and fragments during apoptosis.

Step 3: Conclusion.
Therefore, the correct options are (A), (C), and (D).

> **Quick Tip**
>
> Apoptosis: blebbing, shrinkage, chromatin condensation. Necrosis: swelling and lysis.

Q33. A species of fish living in a lake are separated by drying up of the lake into two separate lakes. After several hundreds of years of separation, the two groups

are unable to mate. These groups are now considered to be different:
(1) communities
(2) organisms
(3) populations
(4) species

Correct Answer: (4) species

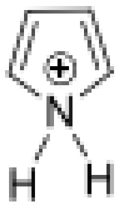
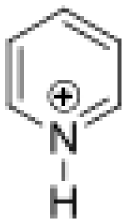
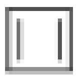
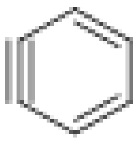
Solution:
Step 1: Concept of speciation.
When populations of the same species become geographically isolated, they stop interbreeding and evolve independently. Over time, reproductive isolation results in the formation of new species.

Step 2: Analyzing the situation.
The inability of the two fish groups to mate indicates reproductive isolation — the key criterion for defining distinct species under the biological species concept.

Step 3: Conclusion.
Hence, the two groups are now considered different species.

> **Quick Tip**
>
> Geographical isolation → Reproductive isolation → Speciation (Allopatric speciation).

Q34. Which of the following compound(s) is/are aromatic?

(A)	
(B)	
(C)	
(D)	

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

Correct Answer: (2) and (4)

Solution:
Step 1: Aromaticity rules.
According to Hückel's rule, a compound is aromatic if it is planar, cyclic, conjugated, and has $(4n + 2)$ electrons.

Step 2: Analyze each compound.
- Compound A (pyrrole-like): aromatic due to delocalized electrons including the lone pair on N (6 electrons).

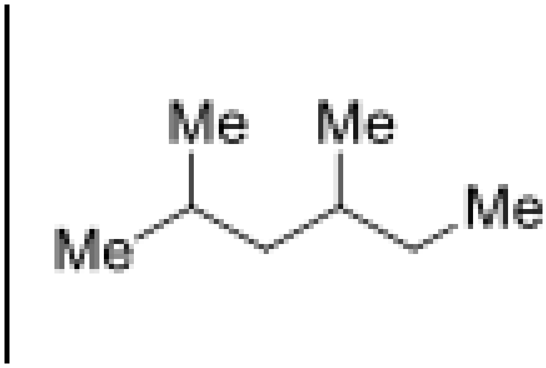
- Compound B (pyridine): aromatic (6 electrons from conjugated bonds).
- Compound C (cyclobutadiene): anti-aromatic (4 electrons).
- Compound D (benzene): aromatic (6 electrons).

Step 3: Conclusion.
Hence, the aromatic compounds are (B) and (D).

Quick Tip

Aromatic compounds follow the (4n + 2) electron rule — examples: benzene, pyridine, pyrrole.

Q35. Which of the following statement(s) is/are correct for the given compound?



(1) It can have a maximum of four stereoisomers
(2) It can have a maximum of two stereoisomers
(3) It is a chiral compound
(4) It is an achiral compound

Correct Answer: (2) and (3)

Solution:
Step 1: Understanding the structure.
The molecule contains two chiral carbon atoms, each attached to four different groups.

Step 2: Calculating possible stereoisomers.
Theoretically, for n chiral centers, the number of stereoisomers = 2^n. Here $n = 2$, so possible stereoisomers = 4. However, due to symmetry, a meso form reduces the number to 2 active stereoisomers.

Step 3: Chirality.
The compound lacks a plane of symmetry and is therefore chiral.

Step 4: Conclusion.
Hence, the compound can have two stereoisomers and is chiral.

Quick Tip

For n chiral centers, max stereoisomers $= 2^n$. Meso compounds reduce this count.

Q36. Which of the following is/are essential feature(s) of high-fidelity DNA polymerases used in polymerase chain reaction (PCR)?
(1) 5→3 exonuclease activity
(2) Endonuclease activity
(3) 3→5 exonuclease activity
(4) Optimum temperature for activity 72 °C

Correct Answer: (3) and (4)

Solution:
Step 1: Understanding high-fidelity DNA polymerases.
High-fidelity DNA polymerases, such as Pfu polymerase, possess proofreading ability, ensuring accurate DNA synthesis during PCR.

Step 2: Evaluating each activity.
- (A) Incorrect — 5→3 exonuclease activity is for DNA repair or primer removal, not proofreading.
- (B) Incorrect — Endonuclease activity cuts internal bonds and is undesirable in PCR.
- (C) Correct — 3→5 exonuclease activity enables proofreading, removing mismatched nucleotides.
- (D) Correct — The polymerase must function at high temperatures (around 72 °C) for effective DNA amplification.

Step 3: Conclusion.
Thus, essential features are (3) and (4).

Quick Tip

High-fidelity polymerases combine thermostability with 3→5 exonuclease proofreading to minimize mutation errors.

Q37. Which of the following option(s) represent(s) the evolutionary relationship between the bird and bat wings as structures for flying?
(1) analogous
(2) convergence
(3) divergence
(4) homologous

Correct Answer: (1) and (2)

Solution:

Step 1: Understanding the structures.

Bird and bat wings serve a similar function (flight) but have different structural origins — birds have feathers, bats have membranous skin.

Step 2: Type of evolution.

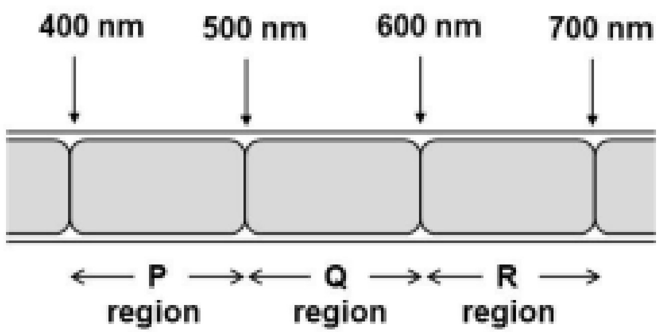
Such structures with similar function but different origin are called **analogous structures**, and they arise through **convergent evolution**.

Step 3: Conclusion.

Hence, the relationship is both analogous and an example of convergent evolution.

Quick Tip
Homologous $\rightarrow$ common origin, may differ in function. Analogous $\rightarrow$ common function, different origin.

Q38. Different segments of a photosynthetic filamentous alga are exposed to different wavelengths of light as shown below. After a period of time, bacteria known to migrate towards high oxygen concentration are spread on the surface of the alga. Which region(s) of the alga will have maximum bacterial congregation?



(1) P and R
(2) P and Q
(3) Only P
(4) Only Q

Correct Answer: (1) P and R

Solution:

Step 1: Light absorption in photosynthesis.

Photosynthetic pigments, mainly chlorophylls, absorb light most efficiently in blue (400–450 nm) and red (650–700 nm) regions of the spectrum.

Step 2: Oxygen evolution.
Photosynthesis releases oxygen, especially in regions where light absorption is high. Therefore, high oxygen concentration will be near wavelengths where absorption is maximum — blue and red.

Step 3: Analyzing regions.
- P region (400 nm) → blue light → high oxygen.
- R region (700 nm) → red light → high oxygen.

Step 4: Conclusion.
Bacteria will accumulate in regions P and R.

> Quick Tip
>
> Photosynthesis peaks in blue and red wavelengths — minimal in green due to poor absorption.

Q39. Hyperventilation (breathing rapidly and deeply) causes which of the following event(s) in the arterial blood?
(1) Decrease in CO_2 concentration
(2) Decrease in proton concentration
(3) Increase in pH
(4) Increase in O_2 concentration

Correct Answer: (1), (2), and (3)

Solution:
Step 1: Understanding hyperventilation.
Rapid breathing expels CO_2 faster than it is produced, leading to a decrease in arterial CO_2 concentration (hypocapnia).

Step 2: pH change mechanism.
CO_2 reacts with water to form carbonic acid (H_2CO_3), which dissociates into H and $HCO_3{}^-$. Lower CO_2 reduces H ions, thus decreasing proton concentration and increasing blood pH (respiratory alkalosis).

Step 3: Oxygen level.
O_2 concentration may not increase significantly because hemoglobin is already near saturation under normal conditions.

Step 4: Conclusion.
Therefore, (A), (B), and (C) are correct.

Quick Tip

$CO_2 \downarrow \rightarrow$ H $\downarrow \rightarrow$ pH $\uparrow$. Hyperventilation leads to respiratory alkalosis.

Q40. Which of the given statement(s) about synthetic oligonucleotides is/are correct?

(1) Chemical synthesis extends the DNA chain from 3→5 end
(2) They can be utilized for site-directed mutagenesis
(3) Chemical synthesis extends the DNA chain from 5→3 end
(4) They can be utilized as radiolabeled probes

Correct Answer: (1), (2), and (4)

Solution:
Step 1: Understanding synthetic oligonucleotide synthesis.
Oligonucleotides are short single-stranded DNA molecules synthesized chemically using the **phosphoramidite method**. The synthesis proceeds in the 3→5 direction, opposite to biological DNA replication.

Step 2: Applications.
- (B) Used in site-directed mutagenesis to introduce specific mutations.
- (D) Used as radiolabeled probes in hybridization techniques such as Southern blotting.

Step 3: Elimination of incorrect option.
(C) is incorrect because chemical synthesis proceeds 3→5, not 5→3.

Step 4: Conclusion.
Correct statements are (A), (B), and (D).

Quick Tip

Chemical oligonucleotide synthesis: 3→5 direction; DNA replication: 5→3 direction.

Q41. The net number of molecule(s) of NADH formed from one molecule of glucose in glycolysis under aerobic conditions is/are ______.
Correct Answer: 2.0

Solution:
Step 1: Understanding glycolysis.
In glycolysis, one molecule of glucose ($C_6H_{12}O_6$) is broken down into two molecules of pyruvate. During this process, NAD^+ is reduced to NADH.

Step 2: Identifying NADH-producing steps.

At the step catalyzed by **glyceraldehyde-3-phosphate dehydrogenase**, each molecule of glyceraldehyde-3-phosphate generates one NADH. Since two molecules of glyceraldehyde-3-phosphate are formed per glucose, two NADH molecules are produced.

Step 3: Conclusion.
Hence, the net number of NADH molecules formed during glycolysis under aerobic conditions is 2.0.

> Quick Tip
>
> Glycolysis produces: 2 ATP (net) + 2 NADH + 2 Pyruvate per glucose molecule.

Q42. The number of possible unique combination(s) of linear tetrapeptides that can be made from four different amino acids using each amino acid only once in the chain is/are ______.
Correct Answer: 24.0

Solution:
Step 1: Understanding the problem.
We have 4 different amino acids, and each can occupy one position in a tetrapeptide sequence. The order of arrangement matters because sequence determines structure and function.

Step 2: Using permutations.
The number of unique sequences $= 4! = 4 \times 3 \times 2 \times 1 = 24$.

Step 3: Conclusion.
Hence, 24 unique linear tetrapeptides can be formed.

> Quick Tip
>
> For n distinct amino acids forming a linear chain: total peptides = n!.

Q43. Among i-BuNH_2, NH_3, Me_2NH, EtNH_2, the number of compound(s) more basic than MeNH_2 is/are ______.
Correct Answer: 3.0

Solution:
Step 1: Understanding basicity of amines.
Basicity depends on electron-donating ability of alkyl groups and the availability of the nitrogen lone pair for protonation.

Step 2: Comparison.
- NH_3: least basic (no alkyl groups).

- $MeNH_2$: more basic due to +I effect of methyl.
- $EtNH_2$: stronger base (greater +I effect).
- i-$BuNH_2$ and Me_2NH: both have greater alkyl substitution, enhancing basicity.

Step 3: Conclusion.
i-$BuNH_2$, $EtNH_2$, and Me_2NH are more basic than $MeNH_2$. Hence, the number of compounds = 3.

Quick Tip

Basicity of amines: tertiary ¿ secondary ¿ primary ¿ ammonia (in gas phase). Solvent effects can alter this order in water.

Q44. Among K^+, Li^+, Rb^+, Cs^+, the number of cation(s) having ionic radii more than Na^+ is/are ______.
Correct Answer: 3.0

Solution:
Step 1: Concept of ionic radius.
Ionic radius increases down the group as the principal quantum number increases. In Group 1 elements: Li^+ ¡ Na^+ ¡ K^+ ¡ Rb^+ ¡ Cs^+.

Step 2: Comparison.
- Li^+: smaller than Na^+.
- K^+, Rb^+, Cs^+: all larger than Na^+.

Step 3: Conclusion.
Thus, 3 cations (K^+, Rb^+, Cs^+) have larger ionic radii.

Quick Tip

Down a group, ionic size increases due to addition of electron shells despite similar charge.

Q45. Among the five fragments given below:
CH_2–CH_3, CH_3–CH_3, CH_3–CH_2–CH_2, CH_2=CH–$CH_2{}^+$, $[CH_3–CH_2–CH_3]^+$,
the number of fragment(s) accelerated to the analyzer tube in a mass spectrometer with electron ionization is/are ______.
Correct Answer: 2.0

Solution:
Step 1: Understanding electron ionization.
In electron ionization, neutral molecules are bombarded with high-energy electrons, producing positively charged ions (cations or radical cations). Only positively charged species are accel-

erated toward the analyzer.

Step 2: Analyzing fragments.
Among the given species, only those with a positive charge (CH_2=CH–CH_2^+ and $[CH_3–CH_2–CH_3]^+$) are accelerated. Neutral and radical species are not.

Step 3: Conclusion.
Hence, 2 fragments are accelerated to the analyzer tube.

> **Quick Tip**
>
> In mass spectrometry, only positively charged ions are detected — neutral and radical fragments are not.

Q46. A restriction endonuclease has a recognition site of 3 bases. Assuming random arrangement of nucleotides, the probability that this endonuclease will cut a piece of DNA is ______ (rounded off to three decimal places).
Correct Answer: 0.016

Solution:
Step 1: Concept.
Each base pair in DNA can be A, T, G, or C, i.e., there are 4 possible bases at each position. For a 3-base recognition site, the total number of possible base combinations is:

$$4^3 = 64$$

Step 2: Probability calculation.
The probability of the enzyme recognizing a specific 3-base sequence = $\frac{1}{4^3} = \frac{1}{64}$.

Step 3: Conversion to decimal.

$$\frac{1}{64} = 0.015625 \approx 0.016$$

Step 4: Conclusion.
Hence, the probability that the enzyme will cut a random DNA segment is approximately 0.016.

> **Quick Tip**
>
> For a recognition site of n bases, probability = $\frac{1}{4^n}$.

Q47. A massless ideal spring is hanging vertically. A sphere of mass 500 g, suspended from the spring, stretches the spring from its initial position by 50 cm when it reaches equilibrium. The force constant of the spring is ______ N m^{-1}. (Use g = 10 m s^{-2})
Correct Answer: 10.0

Solution:
Step 1: Understanding equilibrium.
At equilibrium, the restoring force of the spring equals the weight of the mass.

$$kx = mg$$

Step 2: Substitute given values.
$m = 0.5\,\text{kg}$, $g = 10\,\text{m/s}^2$, $x = 0.5\,\text{m}$

$$k = \frac{mg}{x} = \frac{0.5 \times 10}{0.5} = 10\,\text{N/m}$$

Step 3: Conclusion.
Hence, the spring constant $k = 10.0\,\text{N/m}$.

Quick Tip

At equilibrium: $kx = mg$. The extension is directly proportional to the weight.

Q48. Whales can dive undersea to depths of 2 km. The pressure on the whale at this depth (ignoring atmospheric pressure) is ______ $\times$ 10^6 Pa. (Density of seawater = 1 g cm^{-3} and g = 10 m s^{-2})
Correct Answer: 20.0

Solution:
Step 1: Pressure due to fluid column.
Pressure $= \rho g h$

Step 2: Substitute values.

$$\rho = 1\,\text{g/cm}^3 = 1000\,\text{kg/m}^3, \quad g = 10\,\text{m/s}^2, \quad h = 2\,\text{km} = 2000\,\text{m}$$
$$P = 1000 \times 10 \times 2000 = 2 \times 10^7\,\text{Pa}$$

Step 3: Express in $\times 10^6$ Pa.

$$P = 20 \times 10^6\,\text{Pa}$$

Step 4: Conclusion.
The pressure on the whale is 20.0×10^6 Pa.

Quick Tip

Hydrostatic pressure increases linearly with depth: $P = \rho g h$.

Q49. The order of the differential equation $\frac{d^3y}{dx^3} + 2\frac{d^2y}{dx^2} - 3\frac{dy}{dx} + 6x^4y = 0$ is ______.
Correct Answer: 3.0

Solution:
Step 1: Definition.
The **order** of a differential equation is the highest derivative of the dependent variable present in the equation.

Step 2: Identify the highest derivative.
The highest derivative term is $\frac{d^3y}{dx^3}$.

Step 3: Conclusion.
Hence, the order of the given differential equation is 3.

Quick Tip

Order = highest derivative; degree = highest power of that derivative (if equation is polynomial in derivatives).

Q50. The value of $\lim_{x\to -3} \frac{2x+6}{x+3}$ is ______.
Correct Answer: 2.0

Solution:
Step 1: Simplify the expression.

$$\frac{2x+6}{x+3} = \frac{2(x+3)}{x+3}$$

Step 2: Cancel common terms.
For $x \neq -3$, the $(x+3)$ terms cancel, giving $f(x) = 2$.

Step 3: Apply the limit.

$$\lim_{x\to -3} 2 = 2$$

Step 4: Conclusion.
Hence, the limit equals 2.0.

> **Quick Tip**
> Always simplify before applying a limit; removable discontinuities often simplify easily.

Q51. The G° and K_{eq} values of ATP hydrolysis are -32.34 kJ moL^{-1} and 4.6 × 10 respectively. The G° and K_{eq} values of enzymatic hydrolysis of glucose-6-phosphate to glucose and phosphate are -13.18 kJ moL^{-1} and 203.8, respectively. The G° value of the reaction of glucose-6-phosphate formation from glucose and ATP by hexokinase is ______ kJ moL^{-1} (rounded off to two decimal places). [All reactions are carried out at pH 7.0 and 25°C.]
Correct Answer: -19.16 kJ moL^{-1}

Solution:
Step 1: Write the given reactions.
1. ATP hydrolysis: ATP + H_2O → ADP + P
G° = -32.34 kJ moL^{-1}

2. Glucose-6-phosphate hydrolysis: Glucose-6-phosphate + H_2O → Glucose + P
G° = -13.18 kJ moL^{-1}

Step 2: Write the desired reaction (reverse of 2 + 1).
Glucose + ATP → Glucose-6-phosphate + ADP

Step 3: Apply thermodynamic relation.
For the coupled reaction: G° = G° + (-G°)

Step 4: Substitute values.
G° = (-32.34) + (+13.18) = -19.16 kJ moL^{-1}

Step 5: Conclusion.
Hence, G° for glucose-6-phosphate formation is -19.16 kJ moL^{-1}.

> **Quick Tip**
> In coupled biochemical reactions, the total G° is the algebraic sum of individual G° values.

Q52. K_m and V_{max} of an enzyme preparation are 5 M and 30 M min^{-1} respec-

tively. Considering K_i value of competitive inhibitor is 60 M, the velocity (V) of this enzyme-catalyzed reaction in the presence of 200 M substrate and 600 M competitive inhibitor is ______ M min^{-1} (rounded off to two decimal places).
Correct Answer: 23.55 M min^{-1}

Solution:
Step 1: Write the Michaelis-Menten equation for competitive inhibition.

$$V = \frac{V_{max}[S]}{K_m(1 + \frac{[I]}{K_i}) + [S]}$$

Step 2: Substitute the given values.

$$V_{max} = 30, \quad [S] = 200, \quad K_m = 5, \quad [I] = 600, \quad K_i = 60$$

$$V = \frac{30 \times 200}{5(1 + \frac{600}{60}) + 200}$$

Step 3: Simplify.

$$V = \frac{6000}{5(11) + 200} = \frac{6000}{255} = 23.53 \approx 23.55\,\text{M}\ min^{-1}$$

Step 4: Conclusion.
Thus, the enzyme velocity (V) = 23.55 M min^{-1}.

Quick Tip

In competitive inhibition, apparent K_m increases, but V_{max} remains unchanged.

Q53. The heat required to convert 2 kg of water at 20°C in a calorimeter to steam at 100°C and at atmospheric pressure (1 atm) is ______ kJ. (Specific heat capacity of water = 4.2 kJ kg^{-1} K^{-1} and latent heat of steam = 2256 kJ kg^{-1}.)
Correct Answer: 5184 kJ

Solution:
Step 1: Calculate total heat.
Total heat (Q) = heat to raise temperature + heat to vaporize

$$Q = mc\Delta T + mL$$

Step 2: Substitute values.

$$m = 2\,\text{kg}, \quad c = 4.2\,\text{kJ/kg·K}, \quad \Delta T = 100 - 20 = 80\,\text{K}, \quad L = 2256\,\text{kJ/kg}$$

$$Q = (2)(4.2)(80) + (2)(2256)$$

$$Q = 672 + 4512 = 5184\,\text{kJ}$$

Step 3: Conclusion.
Hence, the total heat required is 5184 kJ.

Quick Tip

Always include both sensible heat (mcΔT) and latent heat (mL) when phase change occurs.

Q54. An electron is accelerated from rest through a potential difference of 200 V. The de Broglie wavelength associated with this electron is ______ nm. (Rounded off to two decimal places) (Planck's constant = 6.6 × 10^{-34} J·s, 1 eV = 1.6 × 10^{-19} J, mass of an electron = 9.1 × 10^{-31} kg)
Correct Answer: 0.087 nm

Solution:
Step 1: Formula for de Broglie wavelength.

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2meV}}$$

where $h = 6.6 \times 10^{-34}\,$J·s, $m = 9.1 \times 10^{-31}\,$kg, $e = 1.6 \times 10^{-19}\,$C, $V = 200\,$V.

Step 2: Substitute the values.

$$\lambda = \frac{6.6 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times 200}}$$

Step 3: Simplify.

$$\lambda = \frac{6.6 \times 10^{-34}}{\sqrt{5.824 \times 10^{-47}}} = \frac{6.6 \times 10^{-34}}{7.63 \times 10^{-24}} = 8.65 \times 10^{-11}\,\text{m}$$

Step 4: Convert to nanometers.

$$8.65 \times 10^{-11}\,\text{m} = 0.0865\,\text{nm} \approx 0.087\,\text{nm}$$

Step 5: Conclusion.
Thus, the de Broglie wavelength of the electron is 0.087 nm.

Quick Tip

The de Broglie wavelength decreases with increasing accelerating voltage: $\lambda \propto \frac{1}{\sqrt{V}}$.

Q55. Given data consists of distinct values of x_i occurring with frequencies f_i. The mean value for the data is ______. (rounded off to one decimal place)

x_i	5	6	8	10
f_i	8	10	10	12

Correct Answer: 7.5

Solution:
Step 1: Formula for mean of discrete data.

$$\bar{x} = \frac{\sum f_i x_i}{\sum f_i}$$

Step 2: Compute the products.

x_i	f_i	$f_i x_i$
5	8	40
6	10	60
8	10	80
10	12	120
Total	40	300

Step 3: Substitute in the formula.

$$\bar{x} = \frac{300}{40} = 7.5$$

Step 4: Conclusion.
Hence, the mean of the data is 7.5.

Quick Tip

The arithmetic mean gives the central tendency of frequency data: $\bar{x} = \frac{\sum f_i x_i}{\sum f_i}$.

Q56. A random variable X and its probability distribution is given below. The value of P(X 5) is ______. (rounded off to one decimal place)

X	0	1	2	3	4	5
P(X)	0	k	2k	3k	6k	8k

Correct Answer: 0.6

Solution:
Step 1: Total probability equals 1.

$$\sum P(X) = 1$$

$$0 + k + 2k + 3k + 6k + 8k = 20k = 1$$

$$k = \frac{1}{20} = 0.05$$

Step 2: Compute P(X 5).

$$P(X5) = P(0) + P(1) + P(2) + P(3) + P(4) + P(5)$$
$$P(X5) = 0 + 0.05 + 0.1 + 0.15 + 0.3 + 0.4 = 1.0$$

Step 3: Check interpretation (P(X ¡ 5)).
If the question means $P(X < 5)$, then:

$$P(X < 5) = P(0) + P(1) + P(2) + P(3) + P(4) = 0.6$$

Step 4: Conclusion.
Thus, $P(X < 5) = 0.6$.

> Quick Tip
>
> In probability distributions, ensure that all probabilities sum to 1 before calculating specific cumulative values.

Q57. A protein solution of 1 M has transmission of 40% at 280 nm, when measured in a 1 cm cuvette using a UV-Visible spectrophotometer. The transmission of the same solution, when measured using a 2 cm cuvette is ______ %. (rounded off to the nearest integer)

Correct Answer: 16%

Solution:
Step 1: Apply Beer-Lambert law.

$$A = \varepsilon c l$$

where $A = -\log_{10}(T), \quad T = \frac{I}{I_0}$.

Step 2: Compute absorbance for 1 cm path.
For 40% transmission:

$$A_1 = -\log_{10}(0.4) = 0.398$$

Step 3: For 2 cm cuvette (double path length).

$$A_2 = 2 \times A_1 = 0.796$$

Step 4: Compute new transmission.

$$T_2 = 10^{-A_2} = 10^{-0.796} = 0.159 \approx 15.9\%$$

Step 5: Conclusion.
Hence, the transmission through a 2 cm cuvette is approximately 16%.

Quick Tip

According to Beer-Lambert law, absorbance increases linearly with path length, while transmission decreases exponentially.

Q58. If a bacterial culture with a doubling time of 30 minutes starts with two cells, then the number of cells after 4 hours are ______.
Correct Answer: 512

Solution:
Step 1: Formula for exponential growth.

$$N = N_0 \times 2^n$$

where N_0 = initial number of cells and n = number of generations.

Step 2: Compute number of generations.

$$n = \frac{\text{total time}}{\text{doubling time}} = \frac{4 \times 60}{30} = 8$$

Step 3: Compute final population.

$$N = 2 \times 2^8 = 2 \times 256 = 512$$

Step 4: Conclusion.
Hence, after 4 hours, there will be 512 cells.

Quick Tip

In microbial growth, the total population doubles with each generation: $N = N_0 2^{(t/T_d)}$.

Q59. The rate of transcription in a bacterium is 50 nucleotides/min and the average molecular weight of an amino acid is 110 Da. Time taken for synthesis of the mRNA of a protein with molecular weight of 110 kDa is ______ min. (rounded off to one decimal place)

Correct Answer: 60.0 min

Solution:
Step 1: Relate protein size to number of amino acids.
Molecular weight of protein = 110 kDa = 110 000 Da.
Average molecular weight of 1 amino acid = 110 Da.

$$\text{Number of amino acids} = \frac{110000}{110} = 1000$$

Step 2: Relate amino acids to nucleotides in mRNA.
Each amino acid is encoded by 3 nucleotides (codon):

$$\text{Number of nucleotides in mRNA} = 1000 \times 3 = 3000$$

Step 3: Calculate time required for transcription.
Rate of transcription = 50 nucleotides per minute

$$\text{Time} = \frac{3000}{50} = 60 \text{ min}$$

Step 4: Conclusion.
Therefore, the time for mRNA synthesis is **60.0 min.**

> Quick Tip
>
> A protein with n amino acids requires 3n nucleotides for its mRNA; total transcription time = (nucleotides / transcription rate).

Q60. Consider a first-order reaction A → B. The initial concentration of A is 100 mol L^{-1} and the value of first-order rate constant is 0.01 min^{-1}. The concentration of A after 10 min of reaction is ________ mol L^{-1} (rounded off to one decimal place).

Correct Answer: 90.5 mol L^{-1}

Solution:
Step 1: Use the integrated rate law for a first-order reaction.

$$[A] = [A_0]e^{-kt}$$

Step 2: Substitute the values.

$$[A_0] = 100, \quad k = 0.01, \quad t = 10 \text{ min}$$
$$[A] = 100e^{-0.01\times10} = 100e^{-0.1}$$

Step 3: Simplify.

$$e^{-0.1} = 0.9048$$
$$[A] = 100 \times 0.9048 = 90.48 \approx 90.5 \text{ mol } L^{-1}$$

Step 4: Conclusion.
Hence, the concentration of A after 10 minutes is **90.5 mol L^{-1}.**

> Quick Tip
>
> For first-order reactions, concentration decays exponentially with time as [A] = $[A_0]\ e^{-kt}$.