

# BIOTECHNOLOGY

## PAPER 1 (THEORY)

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**Maximum Marks: 70**

**Time Allotted: Three Hours**

**Reading Time: Additional Fifteen Minutes**

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### Instructions to Candidates

1. You are allowed an **additional fifteen minutes** for **only** reading the question paper.
2. You must **NOT** start writing during reading time.
3. This question paper has **12 printed pages**.
4. There are **eighteen questions** in the paper. All questions are compulsory.
5. This paper is divided into **four sections: A, B, C and D**.
6. **Section A** has **twenty subparts**. Each question carries 1 mark.
7. While answering **Multiple Choice Questions** in Section A, you are required to **write only ONE option as the answer**.
8. **Section B** consists of *seven questions* each carrying 2 marks.
9. **Section C** consists of *seven questions* each carrying 3 marks.
10. **Section D** consists of *three questions* each carrying 5 marks.
11. **Internal choices** have been provided in *two questions in Section B, two questions in Section C* and in *two questions in Section D*.
12. **Diagrams should be drawn** wherever necessary using a **pencil** only.
13. The intended marks for questions are given in brackets [ ].

### Instruction to Supervising Examiner

Kindly read **aloud** the Instructions given above to all the candidates present in the examination hall.

*Note: The Specimen Question Paper in the subject provides a realistic format of the Board Examination Question Paper and should be used as a practice tool. The questions for the Board Examination can be set from any part of the syllabus, though the format of the Board Examination Question Paper will remain the same as that of the Specimen Question Paper. The weightage allocated to various topics, as given in the syllabus, will be strictly adhered to.*

## SECTION A – 20 MARKS

### Question 1

- (i) A geneticist observed very low recombination frequency between two genes. [1]  
She inferred that the genes were: **(Analyse)**
- (a) far apart.
  - (b) mutated.
  - (c) strongly linked.
  - (d) on different chromosomes.
- (ii) A buffer is an aqueous solution of: **(Recall)** [1]
- (P) weak acid and its conjugate base
  - (Q) strong acid and its conjugate base
  - (R) weak base and its conjugate acid
  - (S) strong base and its conjugate acid
- (a) Only (P) and (R)
  - (b) Only (Q) and (R)
  - (c) Only (P) and (S)
  - (d) Only (Q) and (S)
- (iii) Which of the following is the **MOST** important component of a cell for its life? [1]  
**(Understand)**
- (a) Nucleus
  - (b) Cytoplasm
  - (c) Mitochondria
  - (d) Golgi apparatus

- (iv) Study **Figure 1** shown below and answer the question that follows.

[1]

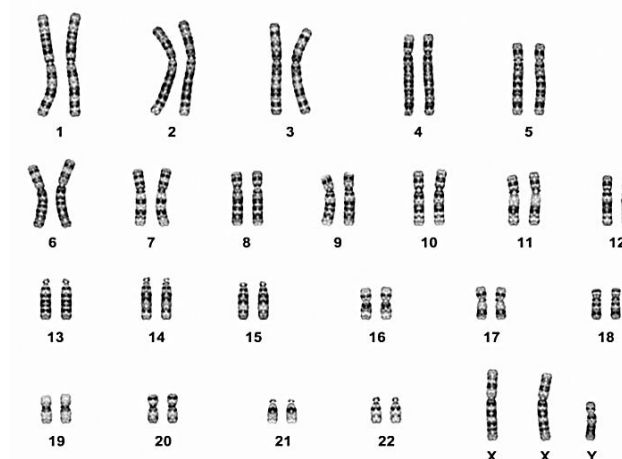


**Figure 1**

Identify the ploidy represented in the above figure.

(Apply)

- (a) Euploidy  
(b) Triploidy  
(c) Aneuploidy  
(d) Tetraploidy
- (v) A group of students was performing an experiment to determine the nature of three solutions P, Q and R by using pH paper. They dipped pH papers in the solution and observed the following final colours: [1]

| Solution | Final Colour of pH paper |
|----------|--------------------------|
| P        | Green                    |
| Q        | Light pink               |
| R        | Light blue               |

They concluded that the nature of the solutions was:

(Understand)

- (a) P: Acidic, Q: Basic, R: Neutral  
(b) P: Neutral, Q: Basic, R: Acidic  
(c) P: Basic, Q: Neutral, R: Acidic  
(d) P: Neutral, Q: Acidic, R: Basic

- (vi) Given below are two statements marked Assertion and Reason. Read both the statements carefully and choose the correct option. [1]

**Assertion:** Animal cells have more mitochondria than plant cells.

**Reason:** These cells need more energy as compared to plant cells.

(Understand)

- (a) Both Assertion and Reason are true, and Reason is the correct explanation for Assertion.
- (b) Both Assertion and Reason are true, but Reason is not the correct explanation for Assertion.
- (c) Assertion is true and Reason is false.
- (d) Both Assertion and Reason are false.
- (vii) Given below are two statements marked Assertion and Reason. Read both the statements carefully and choose the correct option. [1]

**Assertion:** Technological inventions and processes are not granted copyright.

**Reason:** Copyright protects the expression of creative works only.

(Understand)

- (a) Both Assertion and Reason are true, and Reason is the correct explanation for Assertion.
- (b) Both Assertion and Reason are true, but Reason is not the correct explanation for Assertion.
- (c) Assertion is true and Reason is false.
- (d) Both Assertion and Reason are false.
- (viii) How does independent assortment increase variation? (Understand) [1]
- (ix) Milk is maintained at around 37°C which results in proper curd formation, but significantly lower or higher temperatures do not. Justify the statement. [1]

(Analyse)

- (x) Study **Figure 2** shown below and answer the question that follows. [1]

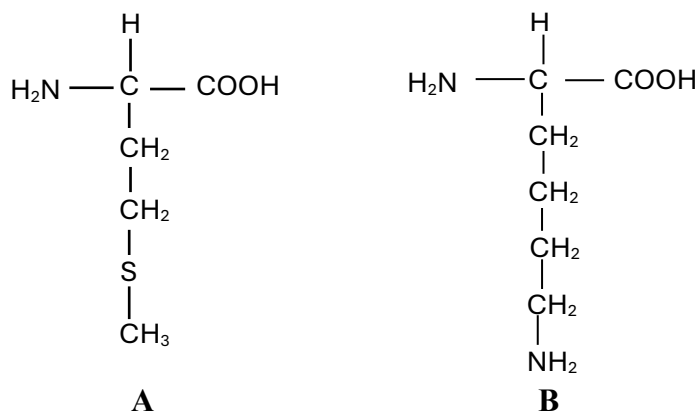


**Figure 2**

Identify biomolecules **A** and **B**.

(Understand)

- (xi) Vedika got her hair permed at a beauty salon changing her straight hair into curls. Identify the type of bond that underwent rearrangement within the hair protein and altered its structural organisation leading to the transformation in Vedika's hair. **[1]**  
(Understand)
- (xii) A male child suffering from haemophilia has only one allele of the gene. Write and define the term used to describe the condition evident in this haemophilic child. **[1]**  
(Recall)
- (xiii) Study the relation between the first two words and complete the analogy. **[1]**  
Biocon: Bengaluru :: Serum Institute of India: \_\_\_\_\_ **(Recall)**
- (xiv) Why is ribosome considered the second most important organelle of a living cell? **[1]**  
(Understand)
- (xv) Arrange the following events in the correct sequence of occurrence during a humoral immune response. **[1]**  
(Understand)  
P – Formation of memory B cells  
Q – Antigen exposure  
R – Differentiation into plasma cells  
S – Clonal expansion of activated B cells  
T – Production of antibodies
- (xvi) Answer the following questions:  
(a) Expand CCMB. **[1]**  
(b) Which autonomous organisation under the Department of Biotechnology (DBT) in India provides services and conducts research in DNA profiling? **[1]**  
(Recall)
- (xvii) The dividing meiocytes of a plant were observed under microscope with 20 pairs of chromatids at Prophase I stage. What is the chromosome number in its root tip cells? **[1]**  
(Apply)
- (xviii) Give a reason for each of the following statements:  
(a) During beer production, female hop flowers are added to the wort before fermentation. **[1]**  
(Understand)

- (b) The biomolecule shown below in **Figure 3B** is more stable than the one shown in **Figure 3A**. [1]  
(Analyse)

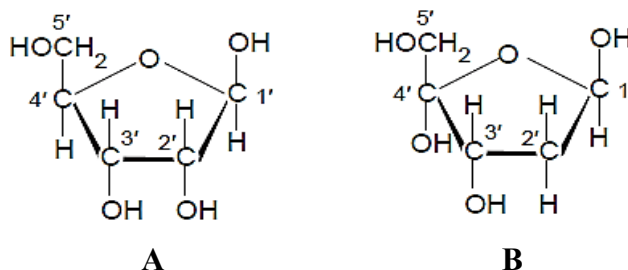


**Figure 3**

## SECTION B – 14 MARKS

### Question 2 [2]

- (i) A pharmaceutical scientist prepares a buffer in which the concentration of salt is  $\frac{1}{10}$ th of the concentration of acid. If the  $pK_a$  of the acid is 6, calculate the pH of the buffer. (Apply)

OR

- (ii) In a bioreactor, a buffer has a  $pK_a$  of 6. The desired pH of the buffer is 5, and the concentration of acid is 0.5 M. What will be the concentration of salt required to maintain the desired pH of the buffer? (Apply)

### Question 3

Study the cell organelle shown in **Figure 4** below and answer the questions that follow.

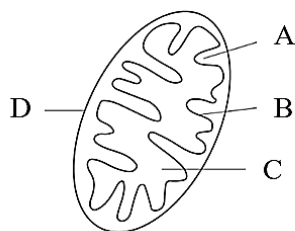


**Figure 4**

- (i) Mention the number of membranes shown above. Relate them to the labels that represent them. [1]  
(Understand)
- (ii) State *two* structural features that enable the organelle to act semi-autonomous in a cell. [1]  
(Understand)

#### Question 4

The table given below compares two types of adaptive immune responses, **A** and **B** in human body.

| Feature        | Response A                                                    | Response B                                  |
|----------------|---------------------------------------------------------------|---------------------------------------------|
| Mode of Action | Antibodies in the body fluid and blood act against pathogens. | T-cells destroy infected or abnormal cells. |
| Targets        | Extracellular pathogens (such as bacteria, viruses in fluids) | Virus-infected and cancer cells             |

Based on the information given, answer the following questions:

- (i) Identify and name the two responses. (Understand) [1]
- (ii) How does Response B help Response A? (Understand) [1]

#### Question 5

During a biotechnology experiment, Daniel and Aarti performed Gram staining on two unknown bacterial samples. Daniel observed purple cells, whereas Aarti observed pink cells.

- (i) How do the cell wall structures of the two bacteria differ causing the difference in the colour retention? (Understand) [1]
- (ii) Why did the bacteria in Daniel's experiment retain the purple crystal violet stain, whereas the bacteria in Aarti's experiment lost it during alcohol wash? (Understand) [1]

#### Question 6

A cell oscillates between different phases of the cell cycle and passes through checkpoints before progressing to the next phase.

Identify the checkpoints where the following are examined:

- (i) Cell size, nutrients and DNA damage (Understand) [1]
- (ii) Proper alignment and attachment of spindle fibres (Understand) [1]

#### Question 7

[2]

Some cells of a bacterial population survive antibiotic treatment. These cells carry small, self-replicating DNA molecules.

Identify these DNA molecules and explain how they provide an advantage to the bacteria.

(Understand)

### Question 8

- (i) Study carefully the structure of a chemical shown in **Figure 5** below and answer the questions that follow.

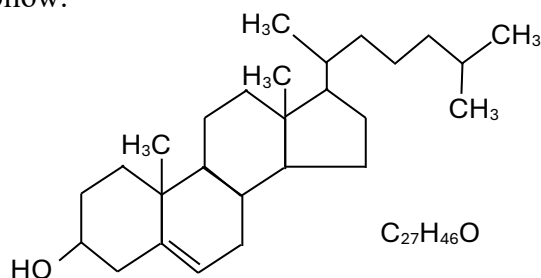


**Figure 5**

- (a) Identify the biomolecule and classify it as a type of lipid. **(Understand)** [1]  
 (b) Analyse its role in chemical coordination in humans. **(Analyse)** [1]

**OR**

- (ii) **Figure 6** represents a process of separation of proteins based on their pI values. Protein A stops at pI = 4.5, B stops at pI = 6.0 and C stops at pI = 8.5.

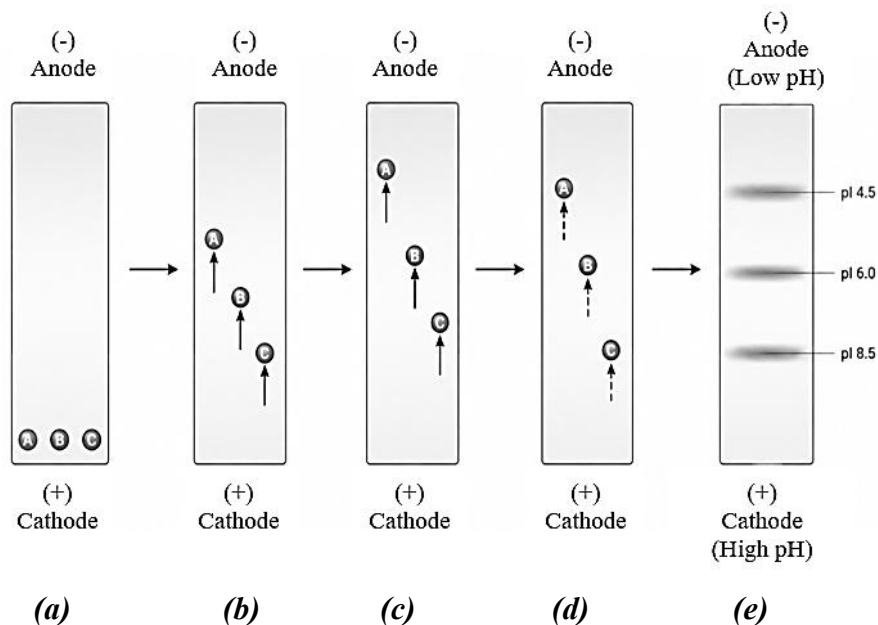


**Figure 6**

- If a fourth protein has a pI of 7.0, predict and draw its final position in the pH gradient by modifying **Figure 6 (e)**. Give a reason for your answer. **(Apply)** [2]

## SECTION C – 21 MARKS

### Question 9

During fermentation, a bacterium produces only lactic acid, while another one produces lactic acid, ethanol and CO<sub>2</sub> from glucose.

- (i) Identify the *two* types of fermentation performed by the bacteria. (Understand) [2]
- (ii) Write the chemical reaction of the latter process. (Apply) [1]

### Question 10

- (i) Answer the following questions:
  - (a) What does recombination frequency indicate about the linkage between two genes? (Understand) [1]
  - (b) Two gene pairs show recombination frequencies of 20% and 4% respectively. Which pair is more closely linked? Give a reason. (Analyse) [2]

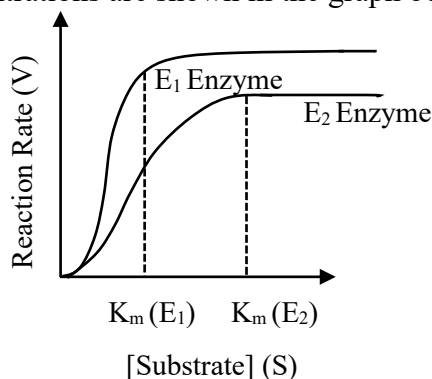
**OR**

- (ii) Answer the following questions:
  - (a) State the importance of COV in gene mapping. (Recall) [2]
  - (b) Construct a gene map based on the table given below, indicating the order and distance among five genes - A, B, C, D and E. (Analyse) [1]

| Crossover between genes | D-C | A-B | B-D | A-C | A-D | D-E |
|-------------------------|-----|-----|-----|-----|-----|-----|
| % Crossover Value       | 21  | 8   | 24  | 3   | 32  | 11  |

### Question 11

Kim and Joe are comparing two enzymes, E<sub>1</sub> and E<sub>2</sub>, for use in an industrial process. Both enzymes catalyse the same reaction under identical conditions. Their reaction rates at different substrate concentrations are shown in the graph below.



Based on the above graph, identify the enzyme that:

- (i) has a higher substrate affinity. Justify your answer. (Evaluate) [1]
- (ii) reaches saturation faster. How does this influence its industrial use? (Analyse) [2]

### Question 12

Sohail is analysing a cell suspension to obtain information about the cells before using them in an experiment. He needs to separate specific cell populations, determine the cell concentration, and check whether the cells are viable.

Briefly explain the techniques that Sohail would use to:

- (i) selectively isolate specific cells having a specific surface marker. (Understand) [1]
- (ii) determine the number of cells present in a known volume of suspension. (Understand) [1]
- (iii) distinguish viable cells from non-viable cells. (Understand) [1]

### Question 13

A one-year-old child born to consanguineous parents shows delayed body development, recurrent seizures, reduced social interaction, microcephaly and has musty smelling urine.

- (i) Identify the metabolic disorder in the child. Which enzyme deficiency causes this disorder? Explain the function of this enzyme. (Understand) [2]
- (ii) Suggest a dietary approach that would help manage the child's condition. (Apply) [1]

### Question 14

Two samples of a patient's serum, P and Q, are tested using a diagnostic method in which a specific antigen–antibody interaction takes place through an enzyme linked antibody. After the test, a strong colour develops in Sample P, while no colour develops in Sample Q.

- (i) What inference can be drawn about samples P and Q from the above test? (Understand) [1]
- (ii) Explain how the enzyme linked to antibody enables detection of the target molecule. (Analyse) [2]

### Question 15

- (i) Answer the following questions:
  - (a) Provide *two* arguments explaining how a complete and clear disclosure fulfils the criteria for patent protection. (Analyse) [2]
  - (b) What is the purpose of the claims in a patent application? (Understand) [1]

**OR**

- (ii) Answer the following questions:
  - (a) Success in laboratory trials alone is not sufficient to justify environmental release of a genetically modified organism. Justify the statement. (Evaluate) [2]
  - (b) Which Indian regulatory body is involved in approving the environmental release of Genetically Modified Organism? (Recall) [1]

## SECTION D – 15 MARKS

### Question 16

- (i) With respect to cell cycle and cell division in somatic and germinal cells, answer the following questions.
- (a) Which process accounts for the formation of two daughter cells from one parent cell? [1]  
(Recall)
- (b) Draw a well labelled diagram representing a cell cycle in a germinal cell. [3]  
(Create)
- (c) Distinguish between the cell cycle and cell division of somatic and germinal cells related to chromosomal behaviour. [1]  
(Analyse)

OR

- (ii) With respect to cell cycle and cell division in pollen mother cell, answer the following questions.
- (a) Comment on the difference in chromosomal behaviour in zygotene and pachytene stages of cell division in a pollen mother cell. [1]  
(Analyse)
- (b) Draw a graph representing the C-Value in different stages of cell cycle of a pollen mother cell. [3]  
(Create)
- (c) What would be the consequences of failure of apoptosis on normal cell division and tissue growth? [1]  
(Apply)

### Question 17

Study **Figure 7** below and answer the questions that follow.

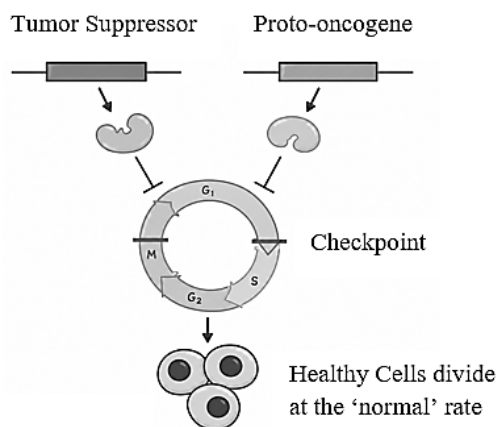


**Figure 7**

(Source: Dr Zara Wood, Copyright 2024)

- (i) How does a tumour-suppressor gene regulate the cell cycle? [1]  
(Understand)

- (ii) Differentiate between a *proto-oncogene* and an *oncogene*. (Understand) [1]
- (iii) Explain the regulation of the cell cycle by proto-oncogenes. How can their mutation lead to the transformation of normal cells into malignant cells? [3]

(Analyse)

### Question 18

- (i) Dr. Chitra, Dr. Jacob, and Dr. Aftab work on microbial, plant tissue and animal cell cultures, respectively. They use different culture media and observe differences in growth, differentiation and consistency.

Answer the following questions based on the above scenario.

- (a) Dr. Chitra obtains better bacterial growth with the medium that contains no chemically synthesised nutrients. What does this suggest about her choice of culture medium? [1]  
(Analyse)
- (b) Dr. Jacob needs a medium for vigorous plant tissue growth. Why would MS media be a better choice for Dr. Jacob than White's media? [2]  
(Analyse)
- (c) Dr. Aftab uses FBS as a supplement during his animal cell culture. Justify his choice. [1]  
(Evaluate)
- (1) Expand FBS and state from where it is derived. [1]  
(Recall)

OR

- (ii) A research team in a biotechnology laboratory maintains mammalian cell lines for research and long-term storage. It uses DMEM for cell culture and DMSO with liquid nitrogen for cryopreservation. The team observes reduced viability after thawing and occasional contamination of freshly prepared media.

Based on the above information, answer the following questions.

- (a) The thawed cells show poor recovery. What does this indicate about the effectiveness of the cryopreservation process? [1]  
(Analyse)
- (b) Contamination is detected despite sterilisation. Which aspect of media preparation should the team investigate first? [1]  
(Analyse)
- (c) Comment on the effectiveness of DMEM in maintaining and preserving mammalian cell lines. [2]  
(Evaluate)
- (d) What is the role of liquid nitrogen in cryopreservation? [1]  
(Recall)



# BIOTECHNOLOGY

## PAPER 1

### (THEORY)

#### ANSWER KEY

#### SECTION A– 20 MARKS

##### Question 1

- (i) (c) strongly linked. [1]
- (ii) (a) Only (P) and (R) [1]
- (iii) (b) Cytoplasm [1]
- (iv) (c) Aneuploidy [1]
- (v) (d) P: Neutral, Q: Acidic, R: Basic [1]
- (vi) (a) Both Assertion and Reason are true, and Reason is correct explanation of Assertion. [1]
- (vii) (a) Both Assertion and Reason are true, and Reason is correct explanation of Assertion. [1]
- (viii) Independent assortment increases variation by random distribution of maternal and paternal chromosomes into gametes. [1]
- (ix) 37°C is the optimum temperature for *Lactobacillus* growth that leads to curdling of milk while lower or higher temperature either inactivates or kills the bacteria. [1]
- (x) These are amino acids. A: Methionine; B: Lysine [1]
- (xi) Disulfide bonds (Rearrangement of these bonds changes hair shape from straight to curly.) [1]
- (xii) It illustrates hemizygosity, a condition in which an individual has only one allele of a particular gene, as it is a X-linked gene in human males who have only one chromosome (XY). [1]
- (xiii) Biocon: Bengaluru :: Serum Institute of India: Pune [1]
- (xiv) Ribosomes are crucial because they synthesise proteins required for cell structure and function. [1]
- (xv)  $Q \rightarrow S \rightarrow R \rightarrow T \rightarrow P$  [1]  
Antigen exposure  $\rightarrow$  Clonal expansion of activated B cells  $\rightarrow$  Differentiation into plasma cells  $\rightarrow$  Production of antibodies  $\rightarrow$  Formation of memory B cells.
- (xvi) (a) Centre for Cellular and Molecular Biology [1]  
(b) Centre for DNA Fingerprinting and Diagnostics (CDFD) [1]
- (xvii) Chromosome number in root tip cells = 20 chromosomes (since root cells are diploid =  $2n = 20$ ) [1]

- (xviii) (a) Female hop flowers are added to the wort mainly to provide flavour and aroma to the beer. [1]
- (b) Deoxyribose sugar does not have reactive hydroxyl group (–OH) [1] while ribose sugar has reactive hydroxyl group (–OH).

## SECTION B – 14 MARKS

### Question 2

[2]

- (i) Using Henderson–Hasselbalch equation:

$$pH = pK_a + \log \frac{[Salt]}{[Acid]}$$

$$pH = 5 + \log \left( \frac{1}{100} \right)$$

$$pH = 5 + \log (10^{-2}) = 5 - 2 = 3$$

OR

- (ii) Using Henderson–Hasselbalch equation:

$$pH = pK_a + \log \frac{[Salt]}{[Acid]}$$

$$5 = 6 + \log \frac{[Salt]}{0.5}$$

$$-1 = \log \frac{[Salt]}{0.5}$$

$$\log 10^{-1} = \log \frac{[Salt]}{0.5}$$

$$[Salt] = 10^{-1} \times 0.5$$

$$[Salt] = 0.5 \times 0.1 = 0.05 \text{ M}$$

### Question 3

- (i) The organelle has two membranes, represented by B (inner membrane) and D (outer membrane). [1]
- (ii) The organelle is semi-autonomous because it contains its own DNA and ribosomes, enabling it to synthesise some of its proteins and replicate independently. [1]

### Question 4

- (i) Response A – Humoral immune response mediated by B-lymphocytes; [1]  
Response B – Cell-mediated immune response mediated by T – lymphocytes.
- (ii) The Helper T – lymphocytes of Cell-mediated immune response, convert the B – lymphocytes into plasma cells that produce antibodies. [1]

### Question 5

- (i) In Daniel's experiment, the Gram-positive bacterium has a thick peptidoglycan cell wall, whereas the Gram-negative bacterium in case of Aarti, has a thin peptidoglycan layer and an outer membrane. [1]
- (ii) Daniel's bacteria retained the crystal violet stain because the thick peptidoglycan layer traps the crystal violet-iodine complex during alcohol treatment. Aarti's bacteria had a thin peptidoglycan layer, and alcohol disrupted the outer membrane, allowing the crystal violet-iodine complex to be removed. They then take up the counterstain (safranin) and appear pink. [1]

### Question 6

- (i) G1 (G1/S) checkpoint ensures cell size, nutrients, and DNA damages before DNA replication. [1]
- (ii) M – checkpoint (Metaphase) ensures correct alignment of chromosomes and spindle attachment before separation. [1]

### Question 7

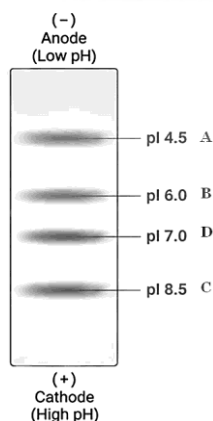
These extra-chromosomal DNA molecules are plasmids. They carry antibiotic-resistance genes, which enable some bacteria to survive in the presence of antibiotics. [2]

### Question 8

- (i) (a) The biomolecule is cholesterol. It is a steroid (derived) lipid. [1]
- (b) It forms the steroid hormones such as cortisol, aldosterone, testosterone, oestrogen, progesterone etc. [1]

OR

- (ii) [2]



In isoelectric focusing, a protein migrates through the pH gradient until it reaches the position where  $\text{pH} = \text{pI}$  and its net charge becomes zero.

## SECTION C – 21 MARKS

### Question 9

- (i) Homofermentation: Glucose is converted into only lactic acid, producing no gas. [2]  
Heterofermentation: Glucose produces lactic acid, ethanol, and CO<sub>2</sub>, resulting in mixed end products.
- (ii) Reaction: Glucose → Lactic acid + Ethanol + CO<sub>2</sub> ↑ [1]  
$$\text{C}_6\text{H}_{12}\text{O}_6 \rightarrow \text{C}_3\text{H}_6\text{O}_3 + \text{C}_2\text{H}_5\text{OH} + \text{CO}_2 \quad \uparrow$$

### Question 10

- (i) (a) Recombination frequency indicates the degree of linkage between two genes. A lower frequency indicates closer linkage. [1]  
(b) The pair showing 4% recombination is more closely linked. A lower recombination frequency indicates that the genes are closer together on the chromosome. [2]
- OR**
- (ii) (a) COV (Crossover frequency) indicates the frequency of crossing over between genes. It is used to estimate the relative distance between genes on a chromosome. A higher COV generally indicates a greater distance between the genes. [2]  
(b) Gene order: (distance in cm) [1]  
A---- 3cM---- C---- 5cM---- B----24cM ---- D----11cM ----E

### Question 11

- (i) Enzyme E<sub>1</sub> has higher substrate affinity because it has a lower K<sub>m</sub> than E<sub>2</sub>. (lower K<sub>m</sub> indicates greater affinity for the substrate). [1]
- (ii) Enzyme E<sub>1</sub> reaches saturation faster because it achieves nearly the maximum reaction rate at a lower substrate concentration. Therefore, it is more suitable for industrial processes where less substrate is required to achieve a high reaction rate. [2]

### Question 12

- (i) FACS (Fluorescence-Activated Cell Sorting). It uses fluorescently labelled antibodies to identify and selectively isolate cells with a specific surface marker. [1]
- (ii) Haemocytometer. In this technique, the cells are counted under a microscope in a known volume to determine the cell concentration. [1]
- (iii) Trypan Blue exclusion test: the viable cells exclude the dye and remain unstained, while non-viable cells take up the dye and appear blue. [1]

### Question 13

- (i) Disorder: Phenylketonuria (PKU) or Phenylpyruvic Idiocy (PPI) [2]  
Enzyme: Phenylalanine hydroxylase. This enzyme converts phenylalanine into tyrosine reducing the accumulation of phenylalanine and formation of tyrosine that acts as precursor to many hormones, neurotransmitters and pigments.
- (ii) The child should be given a low-phenylalanine diet to prevent its accumulation, and adequate tyrosine supplements should also be provided. [1]

### Question 14

- (i) Sample P is positive for the target molecule as it gives strong colour, while Sample Q is negative. [1]
- (ii) The enzyme-linked antibody binds specifically to the target antigen. When the appropriate substrate is added, the enzyme catalyses a reaction producing a colour change. The intensity of the colour indicates the presence of the target molecule. [2]

### Question 15

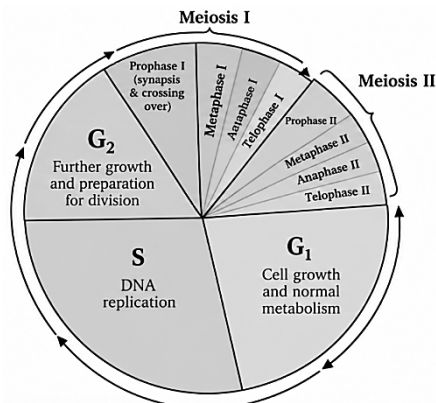
- (i) (a) An application with complete and clear disclosure fulfils the criteria for patent protection because: [2]
- it provides sufficient technical details for the invention to be examined for novelty and patentability.
  - it enables a person skilled in the field to understand and reproduce the invention accurately.
- (b) Claims define the scope of protection sought by the patent. They specify all the aspects of the invention that are legally protected. [1]
- OR**
- (ii) (a) Success in the laboratory alone is insufficient because the GMO must undergo biosafety and environmental risk assessment to determine its possible effects on human health, biodiversity and the environment before release. [2]
- (b) The Genetic Engineering Appraisal Committee (GEAC) is the Indian regulatory body involved in approving the environmental release of GM organisms. [1]

## SECTION D – 15 MARKS

### Question 16

- (i) (a) The process is mitosis, in which the root cells which are somatic cell divides to form two genetically identical daughter cells. [1]

- (b) [3]



*(Candidates are expected to diagrammatically show two meiotic phases.)*

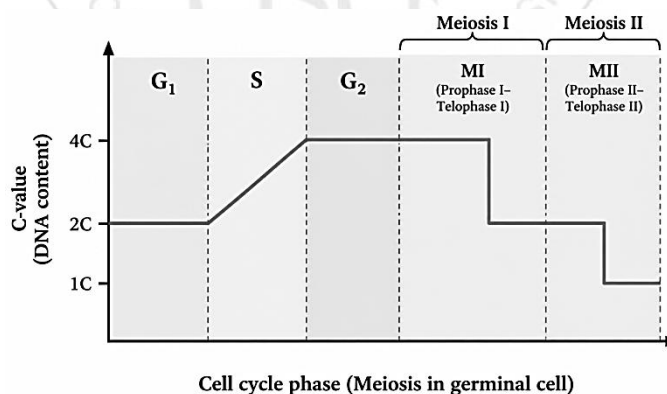
- (c) In mitosis, chromosomes separate only once without pairing of homologous chromosomes. On the other hand, homologous chromosomes pair and undergo crossing over in meiosis, followed by two successive divisions. [1]

OR

- (a) Zygotene: Homologous chromosomes undergo synapsis and form bivalents. [1]

Pachytene: Chromosomes become thicker and shorter, and crossing over occurs between non-sister chromatids.

- (b) [3]



*(Candidates are expected to draw a graph clearly representing the C-Value in different stages of cell cycle of a pollen mother cell.)*

- (c) Failure of apoptosis would prevent abnormal cells from being eliminated, leading to abnormal tissue growth and tumour formation. [1]

### Question 17

- (i) A tumour-suppressor gene produces proteins that slow or stop cell division at checkpoints, allowing damaged cells to be repaired or removed. [1]
- (ii) Proto-oncogene: It normally promotes controlled cell growth and division while an oncogene is a mutated or overactive proto-oncogene that promotes uncontrolled cell division. [1]
- (iii) Proto-oncogenes promote normal cell growth and division, while tumour-suppressor genes restrict cell division. Mutations in these genes can cause uncontrolled cell proliferation, leading to malignant tumour formation. [3]

### Question 18

- (i) (a) Better microbial growth indicates that the culture medium selected by Dr. Chitra has naturally occurring nutritional requirements for the microbes to show faster and proper growth (chemically synthesised nutrients may cause negative effect on their proper growth). [1]
- (b) MS medium contains higher and well-balanced concentrations of mineral salts and nutrients, making it suitable for vigorous plant tissue growth. [2]
- (c) Dr. Aftab's choice is correct as FBS provides growth factors, proteins, hormones, lipids and nutrients needed for animal cell growth in the culture medium. [1]
- (1) Foetal Bovine Serum. It is derived from the blood of bovine foetus obtained from the pregnant cattle. [1]

**OR**

- (ii) (a) Poor recovery indicates that the cryopreservation process was not fully effective, resulting in reduced cell viability after thawing. [1]
- (b) The laboratory should first check the sterilisation procedure and handling of the media for possible sources of contamination. [1]
- (c) DMEM (Dulbecco's Modified Eagle Medium) contains amino acids, vitamins, glucose, inorganic salts and other components. Hence its effectiveness is determined by the amount in which it is used to maintain suitable culture conditions. A suitable amount would make it effective while a less amount would render it ineffective. [2]
- (d) Liquid nitrogen provides very low temperature of  $-196^{\circ}\text{C}$ . At this temperature, the cell remains at zero metabolic rate. [1]