SECTION A [40 MARKS]
ANSWER **ALL** QUESTION

Question 1

a) For each question, there are four alternatives A, B, C and D. Choose the correct alternative and circle it. DO NOT circle more than ONE alternative. If there is more than ONE circled alternative, NO score shall be awarded. **[25]**

i. Endosymbiotic theory states that eukaryotes evolved from the symbiotic relationship between different types of prokaryotes. Which of the cell organelles provides evidence for this theory?

A vacuole

B nucleoid

C chloroplast

D centrosome

ii. Which of the following best describes the function of parathyroid hormone (PTH) with regard to calcium ions (Ca^{2+}) homeostasis in the body?

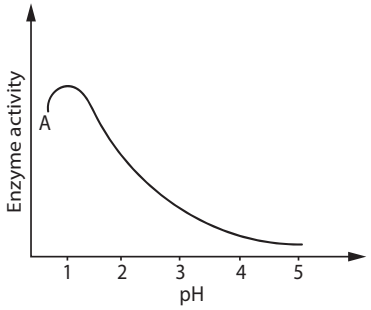
A PTH activates osteoblasts increasing Ca^{2+}concentration in the blood.

B PTH activates osteoclasts increasing Ca^{2+}concentration in the blood.

C PTH activates osteoblasts decreasing Ca^{2+}concentration in the blood.

D PTH activates osteoclasts decreasing Ca^{2+}concentration in the blood.

iii. The graph below shows the effect of pH on the enzymatic activity during digestion of food.



Enzyme A will most likely function in

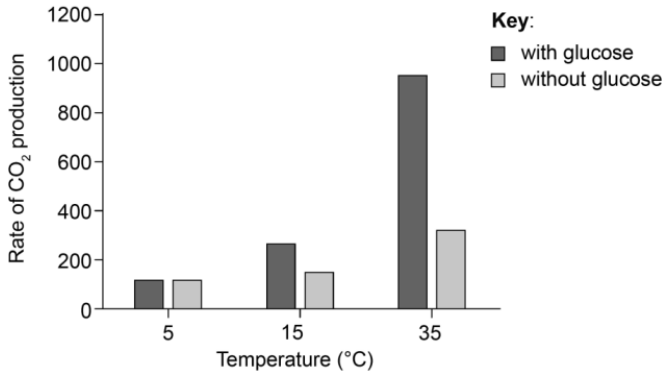
A mouth.

B stomach.

C large intestine.

D small intestine.

iv. Yeast cells were incubated at three different temperatures for five minutes with and without glucose, and the rate of CO_2 production was measured as shown in the graph.



From the results of this experiment, we can conclude that the rate of respiration

A remains constant.

B increases with temperature.

C increases with increase in CO_2 concentration.

D increases with increase in CO_2 concentration and temperature.

v. If the percentage of guanine in a DNA molecule was found to be 30%, then the percentage of adenine would be

A 20%.

B 30%.

C 50%.

D 70%.

vi. The base sequence of a section of antisense DNA strand and a tRNA anticodon, which could be used to translate the mRNA, is shown below.

Antisense strand: A-A-C-G-G-T-T-C-G-A-C-C tRNA **anticodon:** A-A-C

Which codon in the mRNA transcript would the tRNA anticodon bind during translation?

A 1^{st} codon

B 2^{nd} codon

C 3^{rd} codon

D 4^{th} codon

vii. Plants X, Y and Z belong to the same species and are grown under different coloured light for the same duration. Plant X is subjected to blue light, plant Y to green light and plant Z to orange light, respectively. If they only use chlorophyll *a* and *b* for photosynthesis, the expected order of plants from most growth to least growth would be

A X, Y and Z.

B X, Z and Y.

C Y, X and Z.

D Z, X and Y.

viii. How does the artificial selection of crops and ornamental plants affect the genotype frequency in a gene pool of the population?

A increases genetic diversity

B decreases genetic diversity

C maintains genetic diversity

D genetic diversity cannot be determined

ix. The table shows concentrations of K^+ and Na^+ inside and outside of a human nerve cell.

Ions	**Intracellular concentration (mM)**	**Extracellular concentration (mM)**
K^+	140	4
Na^+	12	145

From the data, we can infer that the nerve cell is at

A resting stage.

B depolarised stage.

C hypopolarised stage.

D hyperpolarised stage.

x. A person developed pancreatitis and had to undergo pancreatectomy, which involves the surgical removal of pancreas. What type of diet should the person take?

A low fat and low protein diet

B high fat and high protein diet

C low protein and low carbohydrate diet

D high protein and high carbohydrate diet

xi. Which of the following statements best describes the role of the juxtaglomerular apparatus in the kidneys?

A It produces hormones that control blood sugar levels.

B It regulates blood pressure and fluid balance in the body.

C It filters blood to remove waste products and excess water.

D It assists in the absorption of nutrients from the small intestine.

xii. The following is the process to synthesise proteins in retrovirus such as Corona virus.

I Translation of mRNA

II Transcription of mRNA

III Synthesis of DNA

IV Reverse transcription of RNA

Which of the following is the correct sequences?

A I → II → III → IV

B II → I → III → IV

C IV → II → III → I

D IV → III → II → I

xiii. According to Darwin's theory, the concept of "survival of the fittest" refers to the process by which

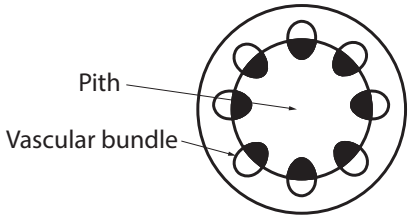
A individuals reproduce at the maximum rate and survive.

B strong individuals survive in the wild by predating on others.

C most intelligent individuals survive and reproduce in the wild.

D individuals with favourable traits adapt to the environment, survive and reproduce.

xiv. A student carried out an experiment to observe the section cutting of a certain part of a plant as shown below.



Which of the following did the student observe?

A dicot root

B dicot stem

C monocot root

D monocot stem

xv. How can sustainable management of natural resources contribute to social equity among people in Bhutan?

A Ignoring the needs and rights of indigenous people and community

B Prioritizing interest of certain segment of population and community

C Excluding marginalised group and communities from decision-making process

D Promoting equal access and fair distribution of resources to people and community

xvi. The colour of our hair or the patterns of our earlobes is influenced by the nature of proteins specified by the genes in our DNA. This is due to the

A shape and structure of DNA.

B formation of a double helix structure.

C packaging of DNA into nucleosomes.

D sequence and arrangement of base pairs in DNA.

xvii. Which of the following statement describes an example of a convergent evolution?

A evolution of wings in bats and birds

B evolution of beaks in Darwin's finches

C evolution of gills in fish and amphibians

D evolution of pentadactyl limbs in humans and whales

xviii. Plants offer a viable solution for addressing global warming. The mechanism within plants that supports this claim is the

A Krebs cycle.

B Calvin cycle.

C fruiting cycle.

D photoperiodic cycle.

xix. Bhutan faces various biodiversity challenges, including the issues of poaching and trafficking of wildlife and their parts. If you are tasked with regulating and curbing these illegal activities, which of the following strategies would be the most effective?

I. Allow defaulters to continue exploiting wildlife.

II. Enforce strict laws and penalties against offenders.

III. Raise awareness about the significance of biodiversity.

IV. Promote sustainable livelihood to reduce reliance on wildlife trade.

A I, II and III

B II and III

C IV, III and I

D III, IV and II

xx. The correct sequence of DNA fingerprinting is

A sample collection → amplification → electrophoresis → DNA extraction.

B sample collection → DNA extraction → electrophoresis → amplification.

C sample collection → electrophoresis → DNA extraction → amplification.

D sample collection → DNA extraction → amplification → electrophoresis.

xxi. The table below shows the bird species composition of two habitats.

Forest

Bird species	Abundance in percentage
House crow	7%
Little bunting	65%
Black bulbul	8%
Sparrow	20%

Wetland

Bird species	Abundance in percentage
River lapwing	27%
Sandpiper	25%
Cormorant	26%
Water pipit	22%

The habitat that is likely to be more resilient to changes in its environment is

A wetland as it contains greater diversity than forest.

B wetland as it contains more individuals than forest.

C forest as it contains more individuals than wetland.

D forest as it is primarily composed of a single species.

xxii. A gardener maintains the trees at a certain height through pruning. The scientific basis behind this is the removal of

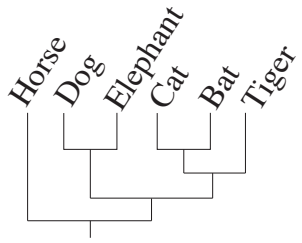
A apical meristem.

B lateral meristem.

C intercalary meristem.

D apical and intercalary meristem.

xxiii. The following phylogenetic tree shows the evolutionary relationships among six types of mammals.



According to this phylogenetic tree, tigers are more closely related to cats than to elephants because

A tigers share a common ancestor with elephant but not with cats.

B both tigers and cats are less closely related to their common ancestor.

C tigers share a more recent common ancestor with cats than with elephants.

D the branch of the phylogenetic tree with tiger is closer to the branch with elephants than to dogs.

xxiv. Plants are classified based on their ability to thrive in specific environments. If a plant possesses the following characteristics:

- *wide flat leaf blades*
- *large air spaces within its mesophyll tissues*
- *large leaves covered with a thick upper cuticle*

This type of adaptation would most likely occur in

A a water lily floating on water.

B a cactus growing in a cold and dry environment.

C an orchid hanging from a tree in a tropical forest.

D a pine tree growing in a hot and dry environment.

xxv. A population of species that resides on opposite sides of a river cannot mate with each other. This is called

A seasonal isolation.

B ecological isolation.

C behavioural isolation.

D physiological isolation.

b) Match each item under column A with the most appropriate item in column B. Write the correct alphabet under the 'answer' column in the space provided. **[5]**

Answer	Column A	Column B
	i. Occurs in mitochondrial matrix	a) neuromuscular junction
	ii. Conducts impulse towards cell body	b) endangered species
	iii. Massive production of smokes from factories	c) mutation theory
	iv. Introduction of invasive species	d) reduce, reuse and recycle
	v. Evolution of corona virus	e) dendrite
	vi. Occurs in inner membrane of mitochondria	f) climate change
	vii. Use and disuse of organs	g) Krebs cycle
	iii. Release of acetylcholine	h) Lamarckism
	ix. Species facing high risk of extinction	i) axon
	x. Sustainable consumption	j) climate action
		k) extinction
		l) electron transport chain
		m) vulnerable species

c) Fill in the blanks with an appropriate word(s). **[5]**

i.	The intervertebral discs of our spine contains tight and dense structure that cushion and absorb shock during movement. The structure described is _____.	
ii.	Some people experience the inability to control the release of urine, leading to involuntary leakage. This conditon is due to the weakening of _____.	
iii.	Haversian canals provide food and oxygen to the bone cells and are transversely connected by _____.	
iv.	Study of heritable changes in gene expression or cellular phenotype that occurs without alteration in the DNA sequence is termed as _____.	

v.	The process of accurately determining the sequential arrangement of nucleotides within a DNA molecule is known as _____.	
vi.	The ancient metabolic pathway that is common to both aerobes and anaerobes is _____.	
vii.	The route of glomerular filtrate on its path to a collecting duct of a nephron are Bowman's capsule, proximal tubule, loop of Henle and _____.	
viii.	The proboscis of butterflies, bees and mosquitoes are examples of _____organs in insects.	
ix.	The number of NADH molecules generated during each turn of the citric acid cycle is _____.	
x.	Southern blotting is a laboratory technique designed to precisely locate a particular sequence of _____ within an entire genome.	

d) Circle the appropriate letter T for True and F for False against each statement. [5]

i.	Prokaryotic cells exhibit highly developed structures that are specialized to perform specific functions, in contrast to eukaryotic cells which possess less intricate structures. **(T / F)**	
ii.	The presence of Tibetan mastiffs, Bhuti sheepdogs, and Damchis (dogs) in Bhutan is an example of species diversity. **(T / F)**	
iii.	Our age-old traditions and cultures, such as *sokdam*, which includes the prohibition of killing animals and selling meat, contributes to the conservation of our environment. **(T / F)**	
iv.	The Royal government of Bhutan regulates the collection of *Cordyceps sinensis* to prevent the extinction of this fungal species. **(T / F)**	
v.	Researchers can manipulate the plasmid found in bacterial cells for laboratory purposes such as genetic engineering. **(T / F)**	
vi.	One of the recommended strategies to mitigate human-wildlife conflict in Bhutan is to feed wildlife animals along the national highways. **(T / F)**	
vii.	*Thermus aquaticus* is used in polymerase chain reaction because this species of bacteria is heat tolerant. **(T / F)**	

viii.	Species dominance refers to the occurrence of different types of species in equal number relative to one another. **(T / F)**	
ix.	Connecting link can be interpreted as intermediate between living and non-living as exemplified by bacteria. **(T / F)**	
x.	Wetlands are considered as highly productive aquatic ecosystems, yet the benefits derived from them are not regarded as ecological services. **(T / F)**	

SECTION B [60 MARKS]

ATTEMPT **ANYSIX** QUESTIONS

Question 2

a) What is reflex action? **[1]**

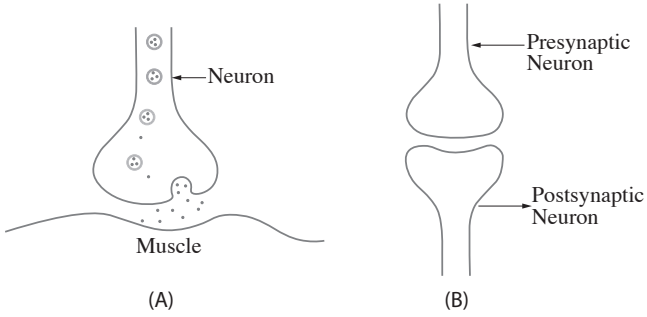
b) i. Does the efficiency of a cell always depend on its size? Give **ONE** reason. **[1]**

ii. How would you scientifically convince your friend that not all prokaryotic organisms such as bacteria are inherently harmful and pathogenic? **[1]**

c) i. Explain the assimilation of the end products of protein digestion. **[1]**

ii. Antacids are prescribed when a person suffers from heartburn or indigestion problems. Justify giving **ONE** reason. **[1]**

d) i. How are the processes that take place at A different from B? Provide **TWO** points. **[2]**



ii. Socio-economic developments have led to habitat fragmentation and decrease in forest cover. To address this pressing issue, propose any **THREE** strong solutions. **[3]**

Question 3

a) i. The table below shows the codon on mRNA and amino acids. **[1]**

Codon on mRNA	Amino acid
UCG	serine
UCU	serine
UUA	leucine
UAA	stop
AUG	methionine

Using the information given in the table, write the peptide chain encoded by an mRNA sequence given below.

5'AUG-UCU-UUA-UAA-3'

ii. Classify the terms listed below as either a part of "transcription" or "translation". **[2]**

1. Ribosome
2. Nucleus
3. RNA polymerase
4. Aminoacyl-synthetase

Transcription	Translation

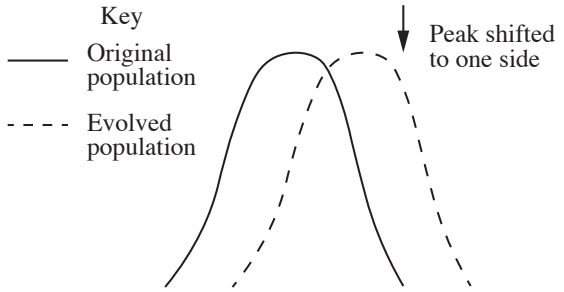
b) Human Genome Project (HGP) was carried out from 1990–2003 which was one of the most ambitious and important scientific endeavors in human history. Evaluate any **TWO** successes and limitations of HGP. **[2]**

c) i. Write the balanced chemical equation for photolysis. **[1]**

ii. Differentiate between photosystem I and photosystem II based on the absorption of light wavelength. **[1]**

d) i. Explain **ONE** significance of fossils in understanding the evolution of organisms. **[1]**

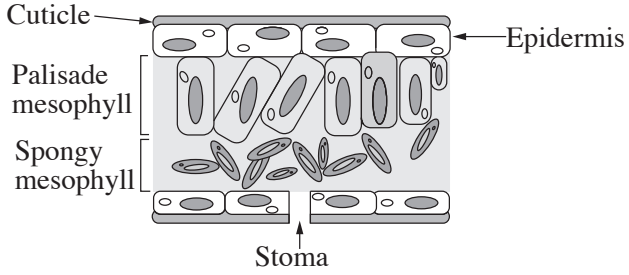
ii. Identify the type of natural selection shown by the graph and provide **ONE** reason to support your answer. **[2]**



Question 4

a) How is biodiversity in Bhutan connected with economic, social and spiritual values? **[3]**
Mention **ONE** point each.

b) Study the figure and answer the questions that follows.



i. Identify the type of tissue system represented by the figure. **[1]**

ii. Distinguish between palisade and spongy mesophyll based on the occurrence of chloroplast. **[1]**

c) i. Which treatment, haemodialysis or peritoneal dialysis, would be a better choice for kidney patients? Why? **[1]**

ii. Evaluate the measures implemented by the government to address human-wildlife conflicts in Bhutan. Discuss any **TWO** points. **[2]**

d) If the recessive allele *b* occurs with a frequency of 0.6 in a population of yak at Hardy-Weinberg equilibrium, what will be the frequency of heterozygous individuals? **[2]**

Question 5

a) i. Give **TWO** examples of the application of cellular respiration in real life. **[1]**

ii. Analyze the impact of the absence of oxygen on the efficiency of the electron transport chain. Write **TWO** points. **[2]**

b) i. The varicella-zoster virus (VZV) is responsible for causing chickenpox. Based on the information provided in the table, what conclusions can we infer regarding the genetic material of VZV? **[1]**

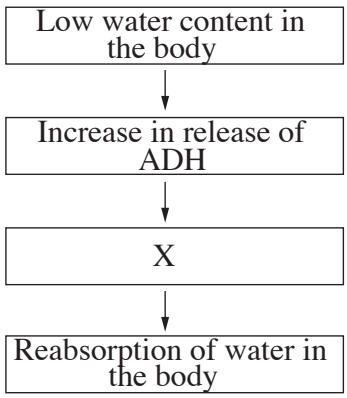
Nucleotide	% of VZV genome
Adenine	27
Cytosine	23
Thymine	27
Guanine	23

ii. Neuron A transmits a nerve impulse at the rate of 3m/sec and neuron B transmits nerve impulse at the rate of 45m/sec. Examine the difference between neurons A and B by stating **ONE** reason. **[1]**

c) i. Humans select desirable traits in plants and animals, and these traits are perpetuated in future generations. Give **ONE** example of such selections. **[1]**

ii. Quadrat sampling is widely used for sampling plant diversity. Mention **TWO** precautions that must be taken when using it. **[2]**

d) i. Study the flow chart and infer the part labelled X. **[1]**



ii. Suppose a catastrophic event occurs, randomly causing a substantial reduction in both the population size and genetic diversity of a large group of organism A, leaving only a few individuals. In light of genetic drift, analyze the effects on allele frequencies between the original population and its descendants. **[1]**

Question 6

a) i. State **ONE** benefit of prosthetics. **[1]**

ii. What would happen if the cartilaginous matrix gets calcified? **[1]**

b) Discuss how the absence of companion cells would affect the sieve tube elements in plants. **[2]**

c) i. Mention **ONE** potential way in which CRISPR, the gene editing tool, could be utilized to enhance human well-being. **[1]**

ii. The table below shows the length of 3 different fragments of DNA in basepairs (bp). If gel electrophoresis were carried out, which one would travel the farthest? Justify your answer. **[2]**

Fragment 1	**Fragment 2**	**Fragment 3**
200 bp	150 bp	100 bp

d) i. Promoting environmental awareness amongst people is regarded as one of the best ways to conserve natural resources. Support or refute with **TWO** justifications. **[2]**

ii. Would you prefer home remedy or pharmaceutical medicines to treat problems related to digestion? Justify with **ONE** reason. **[1]**

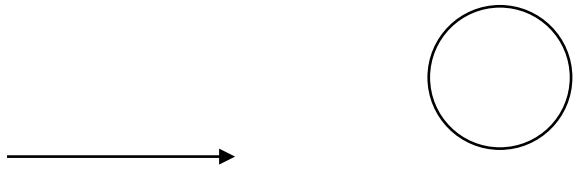
Question 7

a) i. How can genetic fingerprinting contribute to the establishment of a safe and equitable society? State **ONE** reason. **[1]**

ii. Evidence from embryology and genetics often point to similar conclusions regarding the evolutionary relationships among organisms. Give **TWO** reasons. **[2]**

b) Provide arguments either in support of or against Lamarck's claim regarding the inheritance of acquired characters. **[2]**

c) i. The pattern A represents glycolysis, while pattern B represents Krebs cycle. Justify. **[1]**



(A) (B)

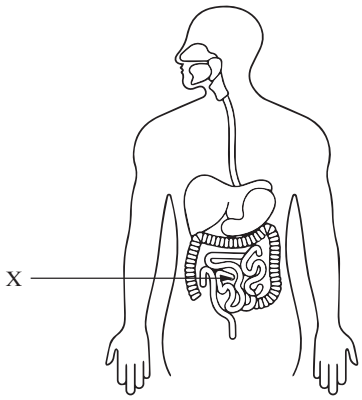
ii. Discuss any **TWO** applications of artificial intelligence in biological science. **[2]**

d) A patient has a deficiency in aldosterone production. Describe the expected impact on sodium levels in the urine as well as the overall urine volume. **[2]**

Question 8

a) Evaluate whether the provision of timbers for house construction in rural parts of Bhutan aligns with the practice of sustainable management of natural resources. Justify with **TWO** points. **[2]**

b) i. Describe **TWO** adaptive features of the part labelled X that assists in digesting different types of food. **[2]**



ii. Discuss the role of purines and pyrimidines in mantaining the stability of DNA with **TWO** points. **[2]**

c) i. What does the 5' and 3' indicate in the structure of DNA? **[1]**

ii. Formulate a hypotheis based on the amino acid sequences of organisms A, B, C, D and their common ancestor as given below. **[2]**

Organism	Amino acid sequence
A	Alanine–Leucine–Phenylalanine–Tyrosine–Histidine
B	Alanine–Histidine–Threonine –Glycine–Proline
C	Alanine –Histidine –Threonine –Glycine –Tryptophan
D	Alanine– Serine– Proline –Tyrosine– Glycine
Common ancestor	Alanine–Leucine– Proline –Tyrosine–Histidine

d) State recapitulation theory. **[1]**

Question 9

a) i. Bhutan's economic developmental policy is guided by the philosophy of Gross National Happiness. Explain briefly. **[1]**

ii. From the following data, design a research question and make an appropriate conclusion. **[2]**

Amount of CO_2 (g)	Number of O_2 bubbles
5	15
10	22
15	28
17	30

b) Anaerobic digestion is a common anaerobic process involved in treating sewage wastes. Evaluate the advantages of such treatment process by giving **TWO** justifications. **[2]**

c) i. The sizes of afferent and efferent arterioles differ from each other. How is this significant to the process of ultrafiltration? **[1]**

ii. Differentiate between endarch and exarch. **[2]**

Characteristics	**Endarch**	**Exarch**
Relative position of protoxylem		
Occurrence		

d) i. If a plant is subjected to prolonged period of darkness, how would this condition affect the NADPH availability in Calvin cycle? Give **ONE** reason. **[1]**

ii. How would the illegal extraction of stones and sand mining along Punatsangchu river basins impact the allelic frequency of the White-bellied heron? **[1]**
