SECTION A (40 MARKS)

Answer **ALL** questions

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. The sequence of nitrogenous base triplets on the coding strand of a DNA molecule is
GAG CTT AGC CAC
Which of the following options shows the correct corresponding sequence of bases on mRNA molecules?

A CUC GAA UCG GUG

B CTC GUU TGG UTG

C UTC GAU TCG UUG

D GUC GAU UCG GUG

ii. Diabetes insipidus is caused by

A low level of aldosterone.

B high level of aldosterone.

C low level of antidiuretic hormone.

D high level of antidiuretic hormone.

iii. "Mitochondria and Chloroplast are prokaryotic cells which formed a symbiotic relationships with other cells".

Which of the following supports the above statement?

I Both the organelles reproduce by binary fission

II Both the organelles reproduce by mitosis

III Both the organelles reproduce by meiosis

IV Both the organelles replicate their genome

A I and II

B I and IV

C II and III

D III and IV

iv. Assuming that a sampled population is at Hardy-Weinberg equilibrium, the population has 25 % of homozygous recessive genotypes (q^2). Using Hardy Weinberg equation ($p^2 + 2pq + q^2 = 1$), the frequency of a recessive allele (q) will be

A 25%.

B 50 %.

C 75 %.

D 100 %.

v. The table below shows the urinalysis results of three patients A, B and C.

Test	Normal	Patient A	Patient B	Patient C
Glucose	<130 mg/dl	110 mg/dl	200 mg/dl	90 mg/dl
Protein	<10 mg/dl	12 mg/dl	8 mg/dl	5 mg/dl
pH	4.5-8.0	7	6.8	6
WBC	Negative	Negative	Negative	Positive
Colour	Pale yellow	Pale yellow and clear	Pale yellow	Pale yellow

Which one of the following statements explains the results of the patients?

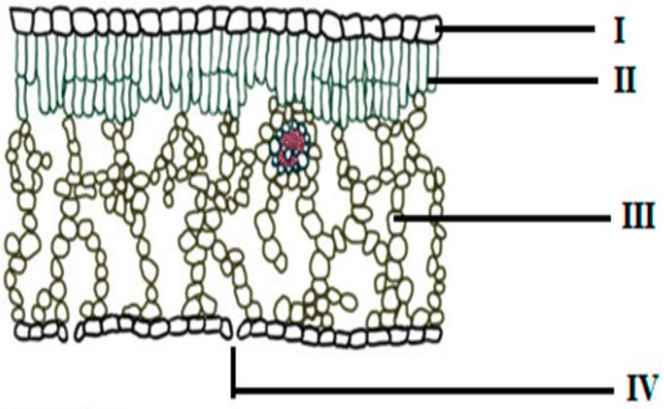
A Patient A has high sugar in the urine and patient B has a normal urine report.

B Patient C has a normal urine report and patient A has a urinary tract infection.

C Patient A has a normal urine report and patient C is suffering from a urinary tract infection.

D Patient B has high sugar in the urine and patient C is suffering from a urinary tract infection.

vi. The figure below shows the transverse section of a leaf. Identify the parts associated with the utilisation of carbon dioxide and water.



A I and IV

B I and II

C II and III

D III and IV

vii. During the contracted phase of skeletal muscle, the length of

A I band increases.

B sarcomere increases.

C H zone remains the same.

D A band remains the same.

viii. Pyruvic acid generated during glycolysis enters mitochondria, where it undergoes oxidative decarboxylation. This reaction involves

A removal of hydrogen and removal of carbon dioxide.

B removal of hydrogen and addition of carbon dioxide.

C addition of hydrogen and removal of carbon dioxide.

D addition of hydrogen and addition of carbon dioxide.

ix. The genetic code for straight hair in a person is encoded in mRNA. Based on the genetic code, the sequence of amino acids in straight hair is given below:

AUG AGU GGU CCA UUU CCU CGC UGU CCC

Met - Ser - Gly - Pro - Phe - Pro - Arg - Cys- Pro

The genetic code mutated on the fourth codon but there was no change in the hair quality. For this to occur, which one of the following codons should replace the fourth codon?

A GUU

B CAU

C CCC

D GGU

x. During prolonged fasting, the sequence of organic compounds used by the body to produce energy are

A carbohydrates, fats and proteins.

B fats, carbohydrates and proteins.

C carbohydrates, proteins and fats.

D proteins, fats and carbohydrates.

xi. Withdrawing your hand on touching a hot surface is an example of reflex action. Which one of the following pathways is the correct sequence for a reflex action?

A Effector → motor neuron→ CNS → sensory neurons →receptors

B Receptors→ motor neurons→ CNS → sensory neurons → effector

C Effector→ sensory neurons→ CNS→ motor neurons → receptors

D Receptors→sensory neurons → CNS → motor neurons → effector

xii. While playing a long tennis match, Pema's muscles begin to switch to anaerobic respiration. Which of the following is true about the changes occurring in her muscles?

A ATP production increases

B NAD+ converts to NADPH

C Pyruvic acid is converted to acetyl CoA

D Pyruvic acid is converted to lactic acid

xiii. Study the equation given below:

$$6CO_2 + 12H_20 \xrightarrow[\textit{Chlorophyll}]{\textit{Sunlight}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

How does the equation relate to cellular respiration?

A Both utilize carbon dioxide and water to produce carbohydrates.

B Both metabolize carbohydrates to produce carbon dioxide and water.

C The above process utilizes energy to synthesise carbohydrates, while cellular respiration metabolizes carbohydrates.

D The above process utilizes energy to metabolize carbohydrates, while cellular respiration synthesise carbohydrates.

xiv. A student of grade XII studied the characteristics of circulatory system of different animals as shown in the table given below.

Organism	**Method of circulation/number of heart chamber**
I	Closed, 2 chambered heart
II	Closed, 4 chambered heart
III	Open, hemocoel
IV	Closed, 3 chambered heart
V	Diffusion

If the student creates an evolutionary sequence of the organisms I-V based on complexity, then the order would be

A V, III, I, II, IV.

B II, IV, I, III, V.

C V, III, I, IV, II.

D III, I, II, V, IV.

xv. A group of students carried out a research in three communities on species richness and evenness and the information was recorded as shown in the table given below.

Species	Community 1	Community 2	Community 3
A	18	70	35
B	21	5	5
C	17	4	12
D	19	11	40
E	25	10	8
Total	100	100	100

Which of the following statement is true about the above data?

A Community 3 has more species richness than communities 1 and 2.

B Community 2 has more species evenness than communities 1 and 3.

C Community 1 has more species evenness than communities 2 and 3.

D Community 1 has more species richness than communities 2 and 3.

xvi. Which one of the following shows the correct arrangement of anatomical features of a root?

A Epiblema, cortex, endodermis, protoxylem, pith, metaxylem and pericycle.

B Epiblema, cortex, endodermis, pericycle, protoxylem, metaxylem and pith.

C Cortex, pericycle, endodermis, epiblema, pith, metaxylem and protoxylem.

D Endodermis, epiblema, cortex, pericycle, endodermis, protoxylem, metaxylem and pith.

xvii. If you were to have your genome sequenced, which information would you be able to learn about yourself?

A identify the ancestry and genetic origin of diseases and susceptibility to drugs

B identify potential drugs that can rectify a disease, symptoms of the disease and its severity

C predict symptoms of a disease, vectors to be used in gene therapy and the causative organism of the disease

D determine the pedigree of a disease, produce recombinants and detect the presence of extracellular genes

xviii. Read the following excerpt:

"The White-bellied Heron, *Ardea insignis*, hereafter WBH, is classified as 'Critically Endangered' with an estimated global population of 50–249 mature individuals (Birdlife International 2018)".

The cause of the population decline in Bhutan is attributed to

I invasive species
II hydropower construction
III mining
IV fishing

A I, II and IV.
B I, II and III.
C I, III and IV.
D II, III and IV.

xix. Monocot plants like bamboo and sugar cane grow mostly in the southern parts of Bhutan. One of the reasons for the pattern of distribution of such plants to sub-tropical climates is

A chloroplast dimorphism.
B mesophyll tissues are differentiated.
C presence of stomata only on the lower epidermis.
D presence of a thick cuticle on the upper epidermis.

xx. The sequence of nitrogenous bases in a segment of DNA of species A, B and C is given below.

Species	DNA sequence
A	A-T-G-C-T-T-G-C-G-T-A-C-T-T-A-G-A-A-T-G
B	A-T-G-A-A-T-G-C-C-T-G-C-T-A-T-G-C-A-T-G
C	A-T-C-C-T-T-G-T-G-T-A-C-T-T-A-G-A-C-T-G

Which statement best explains the relationship between two organisms?

A Species A is more closely related to species B.
B Species B is more closely related to species C.
C Species C is more closely related to species A.
D Species A, B and C are not related to each other.

xxi. One of the practices for protecting habitat fragmentation is by

A building seed banks.

B creating wildlife corridors.

C developing national parks.

D protecting biodiversity hotspots.

xxii. Alpha diversity of two ecosystem 'A' and 'B' is 3 and 8 respectively. If the common species between the two ecosystems is 2, what will be the Gamma diversity?

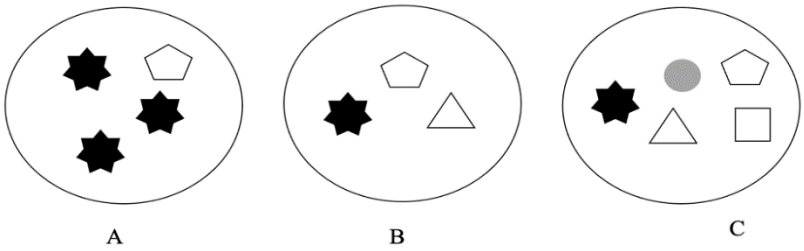
A 3

B 6

C 9

D 12

xxiii. The figure given below shows three populations A, B and C. Which statement given below is correct regarding the chances of survival of species in a population if there is a change in the environment?



A Population A will begin to evolve rapidly.

B The species in population B will be able to adapt to the change in the environment.

C Over time, species in population C will be more likely to survive in a changing environment.

D Over time, the species in population A will be more likely to survive the changing environment.

xxiv. As a conservationist, you are preparing a report on a Black-necked crane population living in Bhutan. In your report, which potential threats to the survival of the species will you predict considering environmental abiotic conditions and human activities?

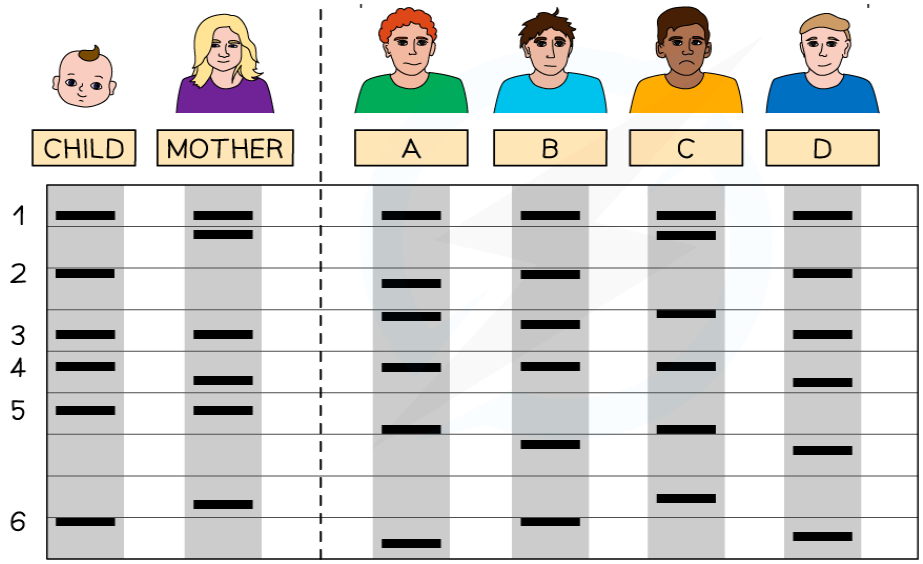
A The Black-necked crane is at risk from climate change, exotic species and possible habitat destruction.

B The Black-necked crane is at risk from climate change, habitat destruction and aggressive predators.

C The Black-necked crane is at risk from climate change, exotic species and overhunting in its habitat.

D The Black-necked crane is at risk from climate change, habitat destruction and sparse availability of food.

xxv. Identify the father of the child from the DNA profile given below.



A Father A

B Father B

C Father C

D Father D

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

Answer	Column A	Column B
	i. Brunner's gland	a. plasmid
	ii. Pericycle	b. connecting links
	iii. E. coli	c. bone resorption
	iv. Introns	d. DNA sequencing
	v. Euglena	e. myelin sheath
	vi. Genetic drift	f. adventitious roots
	vii. Osteoclast	g. non-adaptive change
	viii. Natural selection	h. duodenum
	ix. Schwann cells	i. nucleases
	x. Metagenomics	j. adaptive change
		k. bone building
		l. ileum

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

i.	Troponin and tropomyosin are_____ proteins that help muscles to relax.	
ii.	The mobile electron carrier present between complex I and II of ETC in a mitochondrion is _____.	
iii.	The variety of plants and animals that you observe in your school is an example of _____ diversity.	
iv.	Of the 3R's, _____ of materials saves energy.	
v.	The tendency of an organism to revert to its ancestral characteristics is known as _____.	

vi.	The sequence of nitrogenous bases in a transcript RNA is same as the _____ strand of DNA, except that the thymine is replaced by Uracil.	
vii.	The disappearance of species from the Earth due to human activities is known as _____ extinction.	
viii.	The outer shell of a walnut is formed by _____.	
ix.	The differences in electrical charges across a neurilemma when a nerve fibre is stimulated is called _____ potential.	
x.	During transcription the local unwinding and separation of two strand of DNA is carried out by _____.	

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

i.	Germline gene therapy is the most controversial approach in gene therapy. T / F	
ii.	Sympatric speciation involves geographical isolation. T / F	
iii.	The synthesis of sickle cell haemoglobin is due to premature termination of the haemoglobin protein. T / F	
iv.	Digestibility of bread increases by toasting because its starch is broken down into dextrin during the process. T / F	
v.	Cryopreservation is the in-situ conservation where embryos are cultured in a nutrient medium. T / F	
vi.	One of the critical factors that lead to speciation is reduced gene flow between two populations of the same species. T / F	
vii.	The practice of growing different crops alternately on the same farm in a pre-plan pattern is a sustainable approach to the conservation of natural resources. T / F	
viii.	The anaerobic respiration pathway in animal cells can be reversed, but the anaerobic respiration in yeast cannot be reversed. T / F	
ix.	Prokaryotic cell division is more complex than eukaryotic cell division because of compartmentalisation. T / F	
x.	An ecosystem with more individuals from taxonomically unrelated species is said to be the least diverse. T / F	

SECTION B (60 MARKS)

Attempt **ANY SIX** questions

Question 2

a) **[1]**

i. What do you understand by human-wildlife conflict?

ii. Individuals that suffer from mitochondrial disease are only able to endure intense exercise for a short period of time. Explain. **[2]**

b) Study the table given below and answer the question that follows. **[2]**

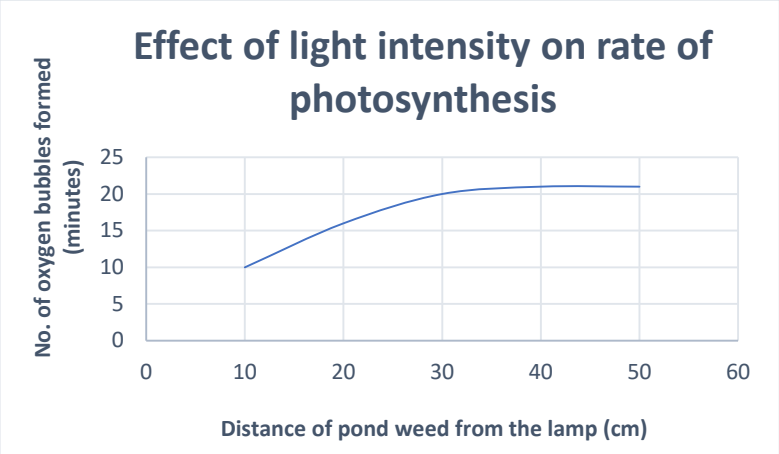
Organism	**Types of nephrons**
A	More cortical nephrons
B	More juxtamedullary nephrons

Of the two organisms A and B, give reasons as to where each organism would adapt in the situation given in the figures below.

Terrestrial environment

Aquatic environment

c) Wangpo conducted an experiment to study the effect of light intensity on the rate of photosynthesis. After the observation, he plotted a graph to analyse the data.

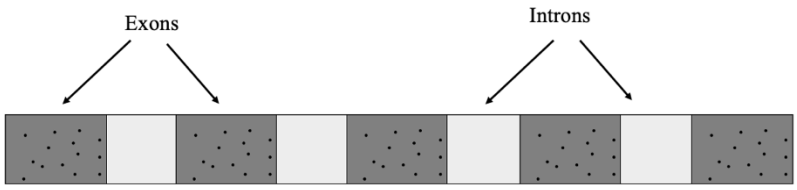


i. Looking at the graph, did Wangpo conduct the experiment correctly? Give a reason to support your answer. **[1]**

ii. If you were to plot the graph, how would you do it differently? Draw the graph in the space provided. **[1]**

d) **[2]**

i. Figure given below represents the heterogeneous nuclear RNA (hnRNA) transcribed from a DNA molecule of a Eukaryotic cell. Illustrate with labelling the changes that occur in hnRNA during posttranscriptional modification.



ii. A patient undergoes surgery to remove the gall bladder. If you were a physician, what dietary recommendation would you give to the patient and why? **[1]**

Question 3

a) How are eukaryotic cells more efficient than prokaryotic cells? Give **TWO** reasons. **[2]**

b)

i. Mention any **ONE** role of vasa recta in the concentration of human urine. **[1]**

ii. The adaptive features of plants are directly related to the environment in which they grow. Explain any **TWO** adaptive features. **[1]**

c) "Carnivores, such as lions, are indirectly dependent on photosynthesis to survive". Considering the organisms and processes involved in carrying out photosynthesis, provide reasons to explain the above statement. **[2]**

d)

i. CRISPR is a gene editing technology which has a wide range of applications like gene editing, medicine and increase food security. While there are a lot of positive sides to anticipate, it also has negative implications on society. Justify with **TWO** reasons. **[2]**

ii. The table below shows the characteristics of amphibians and reptiles. Study the table and create the characteristics of the missing link between the two groups of organisms. **[2]**

Amphibians	**Reptiles**
• Lives in water and land • Vertebrates • Skin is smooth and slimy • Breathe through their skin, as well as their lungs in some cases • External or internal fertilization • Cold-blooded	• Lives on land • Have backbones • Body completely covered with scales • Cold-blooded • Produce shelled eggs or bear live young • Fertilize eggs internally • Have at least one lung

Question 4

a) Complete the flow chart given below on the biochemical events occurring during muscle contraction. **[2]**

i) Depolarisation of sarcrolemma

↓

ii) _____

↓

iii) Conformational changes in actin filaments

↓

iv)_____

↓

v) _____

↓

vi) Sliding of actin filaments over myosin filaments

↓

vii) Contraction of muscle

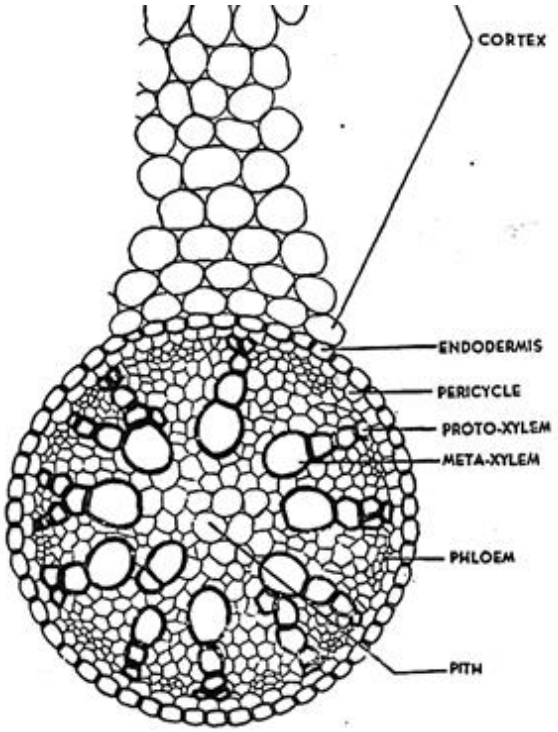
↓

viii)_____

b) An original population of heterozygous individuals for a particular character has an extreme phenotype which has a selective advantage when there is a change in the environment. **[2]**

Draw a graph to represent the above statement and explain your answer.

c) Figure below is the T S of a young monocot plant. Study the diagram and answer the questions that follow.



i. Mention **TWO** features which indicate that the given section is of monocot plants. **[1]**

ii. How is a monocot plant different from a dicot plant based on the section given above? **[1]**

d)

i. "Community forestry, through the involvement of people at the community level, has been a successful approach towards the sustainable management of resources but not everyone offers the same views and supports the initiative". Express your views on the statement giving suitable reasons. **[2]**

ii. Anthropogenic activities contribute to the evolution of new species. Explain with **TWO** examples. **[2]**

Question 5

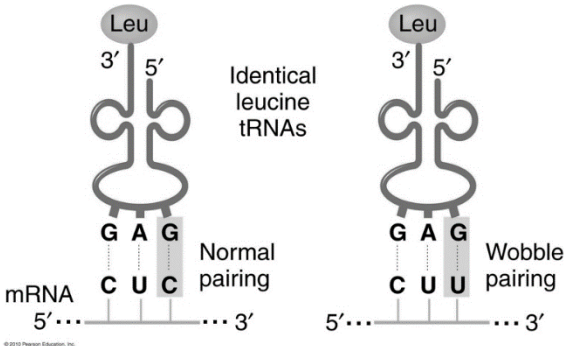
a) Describe the relationship between muscle, muscle fibre, myofibril, sarcomere and myofilaments while lifting an object. **[2]**

b)

i. Indigestion, constipation and heartburn are some of the common disorders related to digestion. One of the ways of treating digestive disorders are by using plant products. Design a solution to heal such disorders applying the concept of botano-chemicals. **[1]**

ii. Bhutan's social, cultural and spiritual practices share an intricate relationship with the environment. How do these practices contribute to the conservation of biodiversity? **[2]**

c) Study the figure given below to answer the questions that follow. **[2]**



i. Explain the phenomenon given in the figure.

ii. What is the advantage of such a phenomenon in an organism?

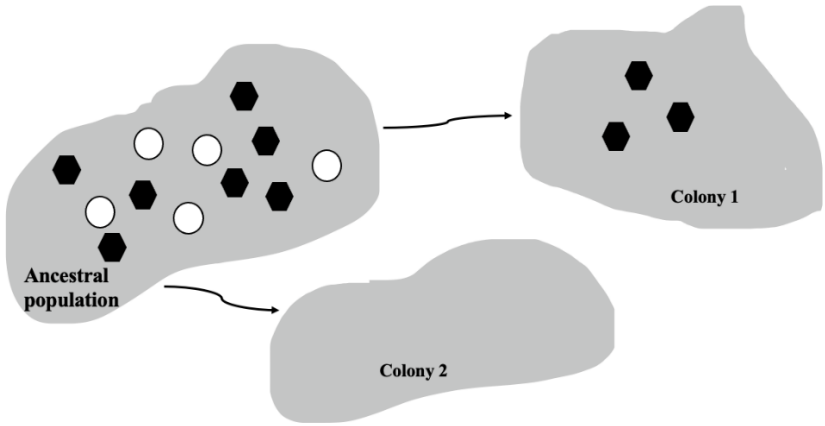
d) **[1]**

i. Explain homologous organs with an example.

ii. Aerobic respiration occurs in five major steps. What is the advantage of releasing energy in a stepwise manner? **[2]**

Question 6

a) The figure below shows the population of an organism having variants of black and white colour. Study the figure to answer the questions that follow.



i. Explain the phenomenon occurring in the given figure. **[1]**

ii. If a few of both white and black variants of the organism migrate and colonise colony 2, would the gene pool of the new population be the same as colony 1? Explain. **[1]**

b)

i. Genetic fingerprinting has a wide range of applications. Give **FOUR** points on how the application of this technology in medicine, research and criminology can contribute to a just and harmonious society. **[2]**

ii. If you were to study the diversity of plants in your locality, what methods and precautions would you employ? Why? **[2]**

c) In an experiment, Sangay took a sample of 3 different food components in 3 test tubes as given in the table below: **[2]**

What change would you observe if you added the following enzyme to each test tube? Complete the table below.

Enzymes	**Test tube A (egg-white)**	**Test tube B (potato)**	**Test tube C (butter)**
Salivary amylase	No change	_____	No change
Pepsin	_____	No change	_____
Intestinal lipase	No change	No change	_____

d)

i. Define passage cells. **[1]**

ii. Why is the transmission of impulse faster in myelinated neurons than in non-myelinated neurons? **[1]**

Question 7

a) Explain with an example how mutations lead to the evolution of organisms. **[2]**

b)

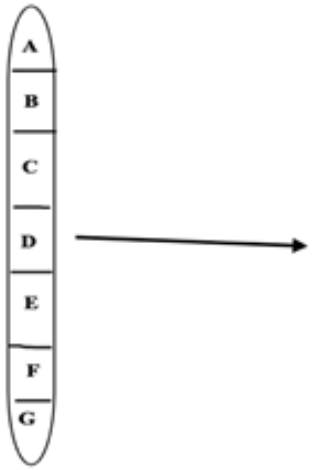
i. Biosphere reserves are more important than national parks and sanctuaries. Why? **[2]**

ii. From genetics and fossil records, which one is more reliable in support of organic evolution? Justify. **[1]**

c)

i. Mention any **TWO** bioethical issues associated with the use of gene therapy. **[1]**

ii. The figure given below is a chromosome in a cell which undergoes mutation by rotating a block (B, C and D) of genes by 180 degrees. Show the final figure in the space given below and explain the type of mutation. **[1]**



d)

i. Explain the role of oxyntic cells in digestion. **[1]**

ii. Red Panda, Tiger, White Bellied Herons and Black-necked crane are protected species. How would the decrease in the population of these protected species affect biodiversity? **[2]**

Question 8

a) The use of microorganisms to treat wastewater has more advantages than chemical treatment. Explain **TWO** advantages of using microorganisms in treating wastewater. **[2]**

b)

i. If calcium ions in the fluid surrounding a neuron are removed, how would this affect the transmission of information between two neurons? **[1]**

ii. Read the following excerpt to answer the questions that follow.

Tshering says, "I wonder why alcohol makes you urinate frequently?" Sonam said that he learned about this in his Biology class. He explained that alcohol inhibits a hormone which helps retain water.

1) Explain how this hormone works. **[1]**

2) Long-term, excessive use of alcohol can affect the liver and kidneys. How do these two organs interact and work together? **[1]**

c) You are provided with the following specimens, sunflower stem and maize stem. State **TWO** key features each to classify the specimens either as dicot or monocot. **[2]**

d) **[1]**

i. What is the advantage of having multiple pigment molecules in the photosystem?

ii. The inability to provide food security contributes to the increase in activities such as overharvesting, poaching and hunting. If not controlled through proper measures, these could cause irreparable damage to the natural ecosystem. Devise a plan to reduce the impact of anthropogenic activity on an ecosystem to ensure food security. **[2]**

Question 9

a) **[1]**

i. At a personal level, what can be done to reduce our consumption of natural resources? List any **TWO** measures.

ii. Hydropower is one of the major developmental goals for Bhutan. Do you think this is a sustainable approach to the economic development of our country? Justify your statement with **TWO** appropriate reasons. **[2]**

b)

i. What would be the tonicity of glomerular filtrate as it passes through the descending and ascending limb of loop of Henle? **[1]**

ii. How are parenchyma cells in aquatic plants modified to adapt to their environment? **[1]**

c)

i. How can the use of technology contribute to the conservation of biodiversity in Bhutan? Explain any **TWO** points. **[1]**

ii. The human insulin gene (INS) is a small gene of 1,425 base pairs located on chromosome 11. During the transcription process if one of the base pairs gets deleted, would there be any change in the functionality of insulin hormone translated from mRNA? Why? **[2]**

d)

i. What is the difference in the flow of genetic information between eukaryotic cells and retrovirus? **[1]**

ii. Dorji studied the evolutionary relationship amongst species A, B, C, D, E and F. He noted the following relationship among them. **[1]**

I Species D is an extinct recent common ancestor of species B and C.

II B, C and D all evolved from E.

III Species F is distantly related to E, with extinct species A being the most recent phylogenetic link between the two species.

Construct a phylogenetic tree using the information given above.