Student's Name:.....

Signature.....

Random No.						Personal No.		

BIOLOGY
PAPER 1
(Theory)
2 Hours 30 minutes

END OF CYCLE EXAMINATIONS TERM I 2026

BIOLOGY

Paper 1

(Theory)

2 HOURS 30 Minutes

INSTRUCTTIONS TO CANDIDATES:

This paper consists of **two** *sections:* **A** *and* **B.** *It has* **four** *examination items.*

Section **A** *has* **Two Compulsory** *items.*

Section **B** *has* **two** *ITEMS: Answer* **one ITEM**.

Answers to section **A must** *be written in the spaces provided while answers to* **Section B** *must be written in the answer booklet(s) provided.*

Answer **THREE** *items in all.*

Any additional item(s) answered will **not** *be scored*

SECTION A

ITEM 1

In Iganga District, fish farmers reported that fish in one pond showed slow movement, poor feeding, and increased mortality. The pond was found to be contaminated with agricultural chemicals from nearby farms.

Laboratory tests showed that these chemicals interfered with membrane proteins, especially transport channels, and acted as enzyme inhibitors in respiration pathways. Fish cells showed reduced uptake of oxygen and nutrients, and enzymes involved in ATP production were less active.

Microscopic examination indicated that cell membranes had altered fluidity and impaired transport functions.

Table: Cellular Observations in Fish

Parameter	Normal fish	Affected fish
Membrane transport efficiency	High	Low
Enzyme activity (respiration)	High	Reduced
ATP production	High	Low
Oxygen uptake	Efficient	Poor

Task

(a) Explain how disruption of plasma membrane structure and enzyme inhibition affects transport processes, respiration, and survival in fish.

(b) Suggest how the pond conditions can be improved to restore fish health.

(a) Explanation of observed changes

- *Disruption of the plasma membrane alters its fluid mosaic structure, affecting membrane proteins such as transport channels and carriers. This reduces selective permeability, limiting uptake of oxygen, ions, and nutrients into cells.*
- *Altered membrane fluidity affects the proper functioning of embedded proteins. Transport proteins lose their shape or position, reducing efficiency of diffusion and active transport processes.*
- *Enzyme inhibition in respiration pathways reduces the activity of key enzymes involved in glycolysis, Krebs cycle, and electron transport chain. This slows down breakdown of substrates and reduces energy release.*
- *Reduced enzyme activity leads to decreased ATP production since fewer reactions occur in respiration. ATP is required for active transport and cellular processes, so low ATP limits nutrient uptake and cell function.*
- *Poor oxygen uptake further limits aerobic respiration because oxygen is the final electron acceptor. This reduces efficiency of ATP synthesis and may shift cells to less efficient anaerobic processes.*

(b) Strategies to restore fish health

- *Prevent chemical runoff from nearby farms to stop entry of toxic substances into the pond, protecting membrane structure and enzyme function in fish cells.*
- *Establish buffer zones around ponds using vegetation to trap and absorb agricultural chemicals, reducing contamination of water.*
- *Treat polluted pond water through filtration or dilution to remove harmful chemicals, restoring normal enzyme activity and membrane integrity.*
- *Monitor water quality regularly to detect changes in chemical levels early, allowing timely intervention before severe damage occurs.*
- *Promote safe and controlled use of pesticides to minimize release of harmful chemicals into the environment, reducing risk of contamination.*
- *Improve overall pond management practices such as proper drainage and controlled inputs, maintaining stable conditions that support normal cellular functions in fish.*

ITEM 2

In a hospital in Kampala, some patients treated with a certain drug developed fatigue, muscle weakness, and slow recovery. Further investigation showed that the drug acted as a non-competitive enzyme inhibitor, affecting enzymes involved in energy production.

Cell studies revealed that the drug also altered the structure of membrane proteins, reducing active transport of ions such as sodium and potassium. As a result, cells showed impaired membrane potential and reduced metabolic activity.

Table: Cellular Effects of Drug Exposure

Parameter	Normal cells	Drug-exposed cells
Enzyme activity	High	Low
ATP production	High	Reduced
Membrane transport	Efficient	Impaired
Ion balance	Stable	Disrupted

Task

(a) Explain how non-competitive enzyme inhibition and membrane protein disruption affect cellular metabolism and ion transport.

(b) Suggest ways through which drug-related cellular effects can be minimized while maintaining effective treatment.

(a) Explanation of observed changes

Non-competitive enzyme inhibition occurs when the drug binds to a site other than the active site, changing the enzyme's shape. This reduces enzyme activity regardless of substrate concentration, lowering the rate of reactions in energy production pathways such as respiration.

Reduced enzyme activity decreases ATP production because key steps in metabolic pathways are slowed. ATP is required for many cellular processes, so low ATP leads to fatigue and reduced cellular performance.

Disruption of membrane proteins affects transport systems such as ion channels and pumps (e.g., sodium-potassium pump). These proteins are essential for active transport and maintaining ion gradients across the membrane.

Impaired ion transport disrupts membrane potential because unequal distribution of ions (Na^+ and K^+) cannot be maintained. This affects processes such as nerve impulse transmission and muscle contraction, leading to weakness.

Reduced membrane transport also limits movement of nutrients and waste products, lowering metabolic efficiency and slowing recovery.

(b) Strategies to minimize drug-related effects

- *Adjust drug dosage appropriately to reduce the extent of enzyme inhibition while maintaining therapeutic effect, allowing normal metabolic activity to continue.*
- *Monitor patients regularly to detect early signs of impaired enzyme activity or ion imbalance, enabling timely intervention and dose adjustment.*
- *Use alternative drugs where necessary to avoid harmful non-competitive inhibition, ensuring effective treatment with minimal cellular disruption.*
- *Ensure proper prescription and controlled drug use to prevent misuse or overdose, reducing risk of excessive enzyme inhibition and membrane damage.*
- *Provide adequate nutritional support to supply substrates and cofactors needed for enzyme function, helping maintain metabolic activity despite drug effects.*
- *Educate patients on correct drug usage to improve compliance with prescribed doses and schedules, preventing complications from improper use.*

ITEM 3

In a secondary school laboratory in Luwero, students conducted an experiment using hydrogen peroxide and catalase enzyme. One group added a heavy metal contaminant, while another group changed the temperature conditions.

Results showed that the heavy metal caused irreversible enzyme inhibition, while extreme temperatures affected both enzyme activity and membrane structure of the cells used in the experiment.

Further observations indicated that cells exposed to harsh conditions had damaged plasma membranes, leading to leakage of cellular contents.

Table: Experimental Results

Condition	Enzyme activity	Membrane integrity	Reaction rate
Optimal conditions	High	Intact	Fast
Heavy metal added	Very low	Intact	Very slow
High temperature	Low	Damaged	Slow

Task

(a) Explain how enzyme inhibition and changes in plasma membrane structure affect reaction rates and cell stability.

(b) Propose how enzyme activity can be maintained under different conditions.

(a) Explanation of observed changes

- *Irreversible enzyme inhibition occurs when heavy metals bind permanently to the enzyme, often at the active site or other critical groups, altering its structure. This prevents substrate binding and permanently stops enzyme activity, resulting in a very slow reaction rate.*
- *Reduced enzyme activity lowers the rate of catalysis because fewer enzyme-substrate complexes are formed. This directly decreases the breakdown of hydrogen peroxide, slowing the overall reaction.*
- *High temperature disrupts enzyme structure by breaking bonds (e.g., hydrogen bonds), leading to denaturation. This alters the active site, reducing enzyme efficiency and slowing reaction rate.*
- *High temperature also affects the plasma membrane by increasing fluidity beyond optimal levels, causing structural damage. This leads to loss of selective permeability.*
- *Damaged plasma membranes allow leakage of cellular contents such as ions and metabolites. This disrupts internal conditions required for enzyme activity and reduces cell stability.*

(b) Strategies to maintain enzyme activity

- *Avoid contamination with heavy metals to prevent irreversible binding to enzymes, ensuring that active sites remain functional for normal catalytic activity.*
- *Maintain optimal temperature conditions to preserve enzyme structure and membrane stability, allowing enzymes to function efficiently and reactions to proceed at normal rates.*
- *Use clean and uncontaminated experimental materials to prevent introduction of substances that may inhibit enzymes or interfere with reactions.*
- *Control pH and experimental conditions to maintain the correct environment for enzyme activity, ensuring proper shape of the active site and efficient catalysis.*
- *Store enzymes properly (e.g., at low temperatures when not in use) to prevent denaturation and maintain their functional structure over time.*
- *Follow correct experimental procedures to ensure consistent conditions, reducing errors and maintaining reliability of enzyme activity and results.*