Study Mania Scenario Examiner

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Time Allowed: 45 minutes

Biology

Constants / Useful Information

No subject-specific constants required for this paper.

Examination Rules

1. Attempt all questions.
2. Avoid unnecessary noise or distractions in the exam room.
3. Use a non-programmable calculator only where applicable.
4. Write clearly and present your work in an organized way.
5. Follow every instruction in each task carefully.
6. Manage time well and leave a short review window at the end.
7. Support your conclusions with evidence from the scenario.
8. Do not use unauthorized materials or external assistance.

Scenario Items

Item 1: Respiration

Metabolic Shift in High-Altitude Athletes

A group of elite long-distance runners from the Kapchorwa region of Uganda, situated at an altitude of approximately 2,500 m above sea level, are undergoing physiological testing. At this altitude, the partial pressure of oxygen (pO_2) is significantly lower than at sea level. During an intensive training session, their muscle cells must maintain a high rate of ATP production to sustain mechanical work. The biochemical analysis of their blood shows a marked increase in the concentration of lactate and a decrease in the pH of the blood entering the liver. One athlete, however, possesses a rare genetic variation that increases the efficiency of the enzyme Phosphofructokinase (PFK) even in the presence of high ATP levels. The school debate team presents three evidence sources on Respiration, and each source supports a different explanation for the same event.

Task A: As a student of Biology, explain the biochemical necessity for the observed increase in lactate concentration in the athletes' blood despite the presence of mitochondria in their muscle cells.

Task B: As a student of Biology, using the concept of allosteric regulation, evaluate how the genetic variation affecting Phosphofructokinase (PFK) would influence the rate of glycolysis during high-intensity exercise compared to a normal athlete.

Task C: As a student of Biology, the net energy yield of aerobic respiration is often cited as 36 to 38 ATP per molecule of glucose. Justify why the actual yield in these athletes might be lower, considering the energy cost of transporting NADH produced during glycolysis into the mitochondrial matrix.

Task D: Propose how the body utilizes the 'Oxygen Debt' incurred during this training session to restore the metabolic balance of the liver and muscle tissues post-exercise.