MENTOR HIGH SCHOOL KITENDE

END OF YEAR EXAM 2025

S.5 BIOLOGY 1

PROPOSED GUIDE

Item 1

(a) [6 marks]

To understand the drop in ATP, we must first understand that thermophilic enzymes are adapted to work at very high temperatures. This means that at normal bakery temperatures the thermophilic pyruvate kinase will be ✓much less active. So , when the enzyme is less active the conversion of PEP to pyruvate becomes ✓much slower. When this conversion slows down, it directly reduces ✓substrate level phosphorylation at that glycolysis step. Since that step is one of the ATP generating steps in glycolysis, if this step becomes less efficient, then ✓less ATP will be generated per glucose. Because of this fall in ATP generation rate, metabolism must adjust the flow of carbon to maintain redox balance, therefore there is ✓less ethanol being produced (since less pyruvate enters fermentation) and ✓more CO_2 is being released (because pyruvate is being diverted into other pathways that release CO_2). All this together explains why ATP yield falls

(b) [5 marks]

When we see more CO_2 but less ethanol, this indicates that pyruvate is no longer being used mainly in alcoholic fermentation. Instead, the most logical interpretation is that pyruvate is being sent ✓into aerobic metabolism (TCA cycle). In the TCA cycle, pyruvate is converted by PDH into acetyl-CoA which then goes through oxidative reactions that ✓produce CO_2 but not ethanol. That matches the observed data because CO_2 rises while ethanol drops. So step by step: less pyruvate → ethanol, therefore the pyruvate must be ✓diverted to oxidative metabolism routes in mitochondria.

(c) [9 marks]

To prove this experimentally, the single most powerful test is to measure ✓oxygen uptake rate (O_2 consumption) of that yeast strain. If pyruvate is being used in

oxidative phosphorylation, then oxygen must be consumed as the terminal electron acceptor. Therefore, if oxygen uptake increases, this is ✓direct evidence of increased TCA and ETC activity. In addition, if ethanol output is dropping, but oxygen use is rising, then that would ✓confirm the shift away from fermentation. Oxygen uptake is better than just measuring one metabolite because O_2 consumption is ✓a direct functional signature of aerobic respiration, so if it increases, it proves conclusively that pyruvate is being sent down oxidative pathways instead of fermentation pathways.

Item 2 (a) [6 marks]

First, species Y has ✓very high phenolic concentration in its leaves. These phenolic compounds act like natural sunblock because they ✓absorb UV radiation and they ✓neutralise reactive oxygen species (ROS) that are generated under very strong sunlight. When phenolics remove UV and ROS, they ✓prevent photodamage to the light harvesting complexes including ✓PSII and PSI reaction centres. When the photosystems are protected from damage, then the electron transport chain can continue working properly even if the plant cannot keep large stomatal apertures. This is the reason why species Y can ✓keep stomata more closed to conserve water (because it has shallow roots) yet still ✓maintain a similar midday photosynthetic rate to species X under the very high light conditions in that glacial valley.

(b) [6 marks]

The simplest way to test whether phenolics actually protect the photosystems is to grow species Y under controlled conditions and then ✓chemically inhibit phenolic synthesis using a phenylalanine ammonia lyase (PAL) inhibitor. PAL is a key enzyme in phenolic biosynthesis, so blocking PAL blocks phenolic production. Then we keep all other environmental conditions constant and expose both the ✓normal (high phenolic) plants and the ✓PAL inhibited (low phenolic) plants to the same high light intensity. If phenolics actually protect the photosynthetic system, then ✓the phenolic-inhibited plants should show more photoinhibition and decline in performance compared to the normal plants.

(c) [8 marks]

The best variable to record is ✓Fv/Fm (maximum quantum yield of PSII) using chlorophyll fluorescence. Fv/Fm is a very direct, sensitive measure of the functional efficiency of PSII reaction centres. When PSII is damaged, ✓Fv/Fm drops. Therefore, if phenolics truly protect species Y, under high light intensity, the normal high-phenolic plants would ✓maintain higher Fv/Fm and the phenolic-inhibited plants would show ✓a larger drop in Fv/Fm. That result would show clearly that phenolics are protecting PSII from photodamage

Item 3

(a) [4 marks]

The fasting glucose falls from week 1 at 10.6 mmol/L to week 7 at 6.5 mmol/L. That is ✓a total fall of 4.1 mmol/L. However, when we look at the rate per week, the fall is quite steep in the early weeks but then ✓the rate of decrease slows down after week 4 because the weekly drop becomes smaller from that point onward.

(b) [4 marks]

During prolonged endurance exercise, skeletal muscle begins to ✓take up much more glucose. Exercise also ✓increases insulin sensitivity of muscles so there is ✓more GLUT4 transporter movement to the cell surface which makes glucose entry even faster. If liver glycogen stores are low, the liver ✓cannot release glucose fast enough to match uptake by muscle, so blood glucose concentration can rapidly fall and that is how ✓hypoglycemia develops in these patients.

(c) [4 marks]

One practical intervention is to consume ✓a small carbohydrate snack shortly before long duration cardio sessions. This provides an incoming glucose supply so the body does not have to rely entirely on liver glycogen. That means the liver ✓does not run out of glycogen too quickly and therefore ✓blood glucose concentration will not fall to hypoglycemic levels during prolonged exercise

Item 4

(a) [3 marks]

After repeated breath holds, the data shows that ✓respiration rate increases sharply because of CO_2 accumulation stimulating chemoreceptors, while ✓heart rate decreases because of the mammalian dive reflex.

(b) [4 marks]

During breath holding and face immersion, ✓trigeminal nerve receptors in the face become stimulated. These receptors send signals to the brainstem medulla. The medulla then ✓increases parasympathetic (vagal) nerve activity to the heart. This causes ✓suppression of SA node firing, resulting in ✓reduced heart rate, which is an oxygen conservation strategy.

(c) [5 marks]

An elite free diver would show ✓a much smaller post-apnoea ventilation increases because they have ✓greater CO_2 tolerance developed over years of training. They also exhibit ✓stronger and faster bradycardia due to chronic autonomic adaptation. Therefore, their cardiovascular and respiratory responses become more efficient, enabling ✓better oxygen economy during and after breath holding

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