S.5 BIOLOGY THEORY PAPER
P530/1

SECTION A

ITEM 1

Mwesigwa works in a gold mining factory that produces toxic chemicals like cyanide that affect cellular respiration. Previously, he used to work tirelessly all day long before joining the factory. Currently, he feels fatigue, chest pain and slowed heart rate and totally inefficient. He went to the hospital for medical checkup, then later advised to start engaging in physical exercise. The table below shows parameters in Mwesigwa's body.

Parameter in Mwesigwa's body	***Oxygen consumption (µmol/min)***	***ATP production (µmol/min)***	***Lactate production (µmol/min)***
Before working in the factory	10	30	2
Currently while working in the factory	2	5	15
During exercise	25	60	10

Task

(a) Explain the observed changes in the parameters during the following conditions.

(i) While working in the factory.

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(ii) During exercise.

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(b) Suggest measures that Mwesigwa should perform so as to improve on his general body health.

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ITEM 2

Many fish farmers of Kasese district obtain fish feeds mainly algae from neighbouring in-land water bodies. However, through the ***Department of Zoology, Entomology and Fisheries at Makerere University***, studies on the population of single-celled algae in L. Katwe ecosystem have been conducted. Recently, they've observed a significant decline in the algae population. Initial investigations reveal that the algae cells appear unhealthy, with abnormal internal solute concentrations. The team suspects a problem with the cell membrane's function, and need your help to diagnose the problem. They have collected the following data and observations.

Data	***Observation***
Microscopic Observations	The cell membranes of the ailing algae appear structurally intact under a microscope, but some seem slightly more rigid than usual
Environmental Data	▪ The water temperature has increased by 5°C due to thermal pollution from Kasese Cobalt Company, a nearby industrial plant.

	▪ Salinity levels have decreased slightly due to increased freshwater runoff from recent heavy rains. ▪ Analysis reveals the presence of a new, non-polar pollutant in the water.
Experimental Data	The biologists measure the rate of glucose uptake by healthy algae cells versus ailing algae cells. Healthy cells show a normal uptake rate, while ailing cells show a significantly reduced rate. The biologists expose both healthy and ailing algae cells to a range of temperatures. They observe that the ailing cells are more sensitive to temperature changes; their membranes become more rigid at higher temperatures compared to healthy cells.

Tasks

(a) Describe the structure of the cell membrane and explain how it contributes to the membrane's selective permeability of materials in and out of the algal cells.

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(b) Discuss how each of the following factors could be affecting the permeability of the algae cell membranes.

(i) Increased temperature.

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(ii) Decreased salinity

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(iii) Non-polar pollutant

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(c) Which transport mechanisms are likely involved in glucose uptake, and how might the observed changes in membrane permeability affect these processes in the ailing algae?

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(d) Based on the data and your understanding of cell membrane function, explain what specific aspects of the cell membrane are likely compromised and suggest potential solutions or interventions to restore the health of the algae population.

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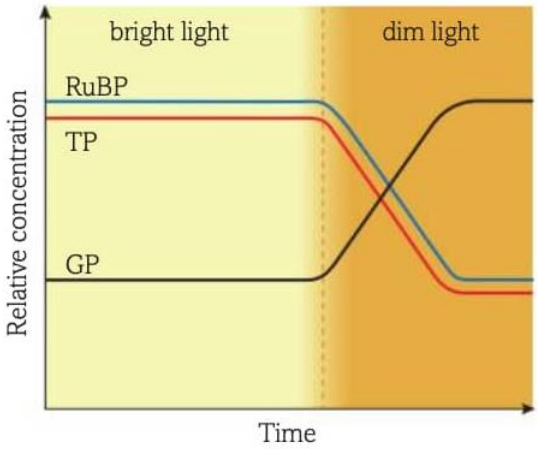
SECTION B

ITEM 3

A group of botanist at ***National Agricultural Research Laboratory (NARL) at Kawanda in Wakiso district*** are investigating the productivity of a new plant, but they are faced with the challenge of light and carbon dioxide concentration that usually regularly within few hours interval. They investigated and determined the changes in the main photosynthetic intermediates, *ribulose bisphosphate* (RuBP), *glycerate phosphate* (GP) and *triose phosphate* (TP) during the day and their findings were plotted as follows.



To eradicate famine and improve food security in different regions of the country, the team grew samples of the plant in ***Central*** and ***Northern*** Uganda. Central region is cool and has a relatively high carbon dioxide concentration due to the many established factories than north. They then compared the plant under study with the native plants in the areas and obtained the following data.

Aspect determined	***Plant under study***	***Plants in central***	***Plants in north***
Compensation period (ppm)	9	10	50
Saturation point (ppm)	350	360	450
Optimum temperature (^{O}C)	32	30	10 - 25
Growth rate ($gm^{-2}d^{-1}$)	49	50 – 54	34-39

Task

(a) Explain how light intensity affected the photosynthetic processes in the plant that resulted in the changes in the relative concentrations of the photosynthetic intermediates.

(b) Explain physiological adaptations that enabled the plant to survive in central than in north.

(c) Which recommendations would you give to the research team so as to improve food security in northern Uganda?

ITEM 4

Kato, a regular football player at school and **Ibrah**, who lives a sedentary lifestyle visited his friend **Bonny** who was borne and stays in Kigezi highlands. Bonny's house is small, poorly ventilated and uses a gasoline - powered generator that runs day and night to provide heat, light and use of appliances, due to poor electrification of the area. On their first night at this place, Ibrah felt a lot of headache, dizziness and lost consciousness in the morning.

As they rushed Ibrah to the hospital, Kato being a resident of low altitude areas, felt a lot of fatigue, nausea and also developed shortness of breath, but Bonny managed to rush both of them to the hospital using a passersby motorcycle.

In the hospital, Ibrah was administered with 100% oxygen through a non-rebreathing mask until the concentration of carboxyhemoglobin lowered to 4%. Kato was allowed to rest and given plenty of fluids. These cases reduced as they continued to stay in this area. The following information was obtained from the hospital after analysis of Ibrah's situation and compared to the normal conditions.

Condition	***Normal***	***Ibrah's condition***	***Kato's condition***
Haemoglobin affinity (mmHg at a pH of 7.4 and $37^{O}C$)	26.7 -27.1	30	26.2
Carboxyhemoglobin (%)	3-4	30	4
Breathing rate (breaths per minute)	12-20	24	20
Number of red blood cells (%)	40	45	50

Bonny was happy to see his friends recovering. The following day as they were playing at home, Bonny was accidentally stung by a bee that caused him to sneeze, feel a lot of pain and swelling at the damaged area. When they called the medical worker, they were informed that Bonny's situation can be managed at home.

Task

(a) Identify and explain the changes that occurred in the body of each person leading to the stated symptoms.

(b) (i) Describe how the treatment given to Ibrah in the hospital helped him to recover from the dangerous situation.

(ii) Explain why the changes in these two boys diminished with time.

(c) Explain how Bonny's body responded to the bee sting and which first aid and advise can you given them?

ITEM 5

Irene runs a floriculture greenhouse and intends to sell flowers at valentine's day. She has discovered a new plant species, *Stella aurora*. The plant produces beautiful and scented flowers and thus expects it to earn her much money. She hypothesizes that *S. aurora* exhibits differential responses to red and blue light, and that these responses are mediated by auxin and gibberellin. Furthermore, she suspects that photoperiod influences flowering time in this species. Therefore, she exposed different light wavelengths and treatments the plant with growth hormones and investigated about its growth and development, and flowering. The experiment consisted of four treatment groups:

Group 1: White light (equal proportions of red and blue light), no hormone treatment.
Group 2: Predominantly red light, no hormone treatment.
Group 3: Predominantly blue light, no hormone treatment.
Group 4: White light, treated with a combination of auxin and gibberellin.

Plant height was measured weekly for 8 weeks. Additionally, the flowering time (days to first flower) was recorded for each plant. The data is summarized in the tables below.

Table 1: Average plant height (cm) over 8 Weeks

Week	***Group 1***	***Group 2***	***Group 3***	***Group 4***
1	2.5	2.3	2.6	3.0
2	5.0	4.5	5.5	6.5
3	7.5	6.8	8.3	10.0
4	10	9.0	11.0	13.5
5	12.5	11.3	13.8	17
6	15.0	13.5	16.5	20.5
7	17.5	15.8	19.3	24.0
8	20.0	18.0	22.0	27.5

Table 2: Average flowering time (Days)

Group	***Flowering time (days)***
Group 1	60
Group 2	70
Group 3	50
Group 4	40

Task

Using the above data:

(a) (i) Which light wavelength appears to promote the greatest stem elongation in *S. aurora* and state the roles it plays within the plant that caused the observed changes.
(ii) Draw conclusions on the effect of these lights on the photoperiodic response of plant.

(b) Explain the potential synergistic or antagonistic interactions of these hormones and how does this relate to the known functions of auxin and gibberellin.

(c) Explain the advice that you can give to Irene so as she registers much income.