2017 Photosynthesis and Respiration STQ MS

2017 / H2 / AJC PRELIM / P2 Q6

1 In anaerobic respiration in yeast, the pyruvate molecules are broken down to produce ethanol and carbon dioxide. The release of carbon dioxide can be used to investigate the rate of anaerobic respiration.

Fig. 6.1 shows and experiment which was set up to find the rate of anaerobic respiration.

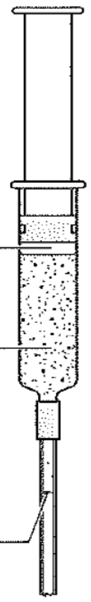


Fig. 6.1

The meniscus moves down the tube as carbon dioxide is released.

Table 6.1 shows the distance moved by the meniscus from the start point. This was recorded every 10 minutes.

Table 6.1

Time/ min	0	10	20	30	40	50	60	70	80	90
Distance travelled by meniscus from start point/ mm	0	1	2	5	9	14	21	45	73	98

(a) The rate of anaerobic respiration can be calculated by using the rate of movement of the meniscus.

Calculate the rate of anaerobic respiration between 70 and 80 minutes.

You will lose marks if you do not show your working.

Rate of Anaerobic Respiration = (73-45) mm / (80-70) min
= 28 mm / 10 min
= **2.8** mm min^{-1} [2

(b) This experiment was repeated three more times. Each time, the glucose (a monosaccharide) was replaced with a different disaccharide sugar:

Maltose – a disaccharide of glucose and glucose
Sucrose – a disaccharide of glucose and fructose
Lactose – a disaccharide of glucose and galactose.

Tables 6.2 (a), (b) and (c) show the results of these experiments.

Table 6.2 (a): Using maltose

Time/ min	0	10	20	30	40	50	60	70	80	90
Distance travelled by meniscus from start point/ mm	0	0	0	0	0	2	3	6	9	12

Table 6.2 (b): Using sucrose

Time/ min	0	10	20	30	40	50	60	70	80	90
Distance travelled by meniscus from start point/ mm	0	0	0	1	3	11	22	37	48	61

Table 6.2 (c): Using lactose

Time/ min	0	10	20	30	40	50	60	70	80	90
Distance travelled by meniscus from start point/ mm	0	0	0	0	0	0	0	0	0	0

With reference to the information provided in Tables 6.2 (a), (b) and (c) and your biological knowledge:

(i) Describe the difference in the results for maltose and sucrose, and suggest one explanation for this difference,

Glucose is the respiratory substrate for **glycolysis**;
Maltose: meniscus only starts moving at 50 min vs sucrose at 30 min/ movement of sucrose more than maltose + data;
Enzyme to break down sucrose is more readily available/at higher concentration than enzymes to break down maltose; [2

(ii) Suggest two explanations for the results for lactose.

Yeast does not have proteins channels that allows uptake of lacotse;
Yeast does not encode for lactase that breaks down lactose to glucose and galactose; [2
AVP;

(c) An electron micrograph of yeast, *Candida albicans*, is shown in Fig. 6.2.

Fig. 6.2

(i) On Fig. 6.2, label site of
i. Glycolysis
ii. Oxidative phosphorylation [2

(ii) State one visible structure of mitochondria from Fig. 6.2 and describe how it supports mitochondria's function.

Highly folded inner membrane + Increase surface area for embedment of more ETC/ ATP synthase to increase rate of ATP production

Membrane bound/ double membrane + Enclose matrix that contains enzymes for link reaction and Kreb's cycle/ compartmentalizes matrix for optimum conditions for enzymes to work; [1

(iii) Besides location, compare between oxidative phosphorylation and photophosphorylation. [4

Features	Oxidative phosphorylation	Photophosphorylation
Functions in the presence of..	oxygen	light
Source of energy	NADH and FADH2	light
No. of electron transport chain	1	2
Electron flow	linear – one-way	linear or cyclic
Final electron acceptor	oxygen	NADP (non-cyclic) PSI reaction center (cyclic)
Involvement of water	water produced	photolysis of water
Establishment of proton gradient	protons pumped outwards from matrix across inner mitochondrial membrane into intermembrane space	protons pumped inwards from stroma across thylakoid membrane into thylakoid space
Products	ATP, water	ATP, NADPH, oxygen

[Total: 13 marks]

2017 / H2 / CJC PRELIM / P2 Q6

2 Microalgae have been extensively studied for various purposes, such as the production of biomass as a source of valuable chemicals of health foods and for wastewater treatment. Recently, microalgal photosynthesis was considered to be an effective means to reduce the emission of carbon dioxide, a major greenhouse gas, in the atmosphere. Light is the most important factor affecting microalgal photosynthesis kinetics. In general, most microalgal mass culture systems are limited by light, because light is easily absorbed and scattered by the microalgal cells. Therefore, understanding and quantification of light dependence of microalgal activity is of great importance in designing an efficient photobioreactor, in predicting process performance, and in optimizing operating conditions.

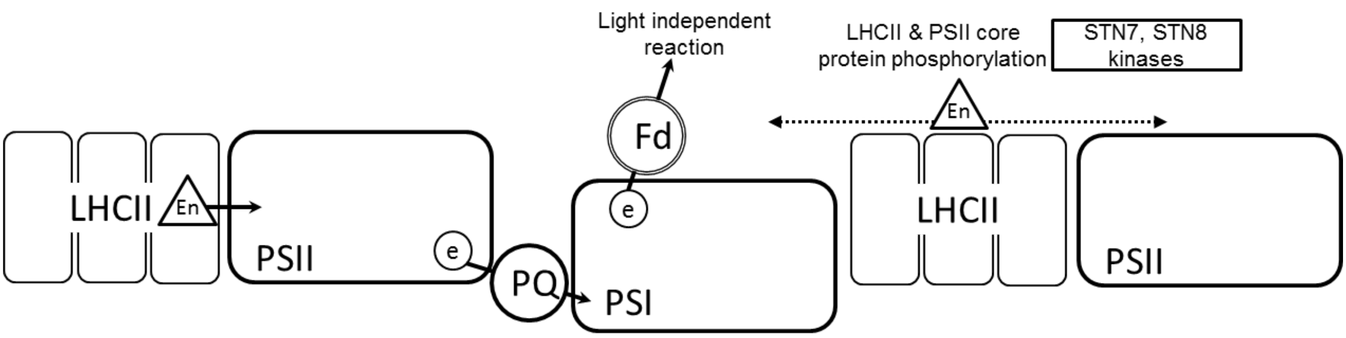
(a) Explain the trends seen when red, green and daylight (at 0.123gL-1) are compared.

ANS [L2] Novel

[5]

1. Comparing at 1500μEm^{-2}s^{-1} **red light yields the highest Photosynthetic rate 5.5 mgL-1h-1** due to the **presence of P680 and P700** absorbing best at those wavelengths.
2. Comparing at 1500μEm^{-2}s^{-1} **Green light yields 3.0 mgL-1h-1 the lowest absorption** as green light is **reflected**.
3. Comparing at 1500μEm^{-2}s^{-1} daylight yields a **moderate Photosynthetic rate 4.5 mgL-1h-1** due to the presence of P680 and P700 but **subject to the efficiency of light capturing**.
4. General trend within graph, at low light intensity, **all three showed that Light was a Limiting Factor**.
5. At **higher intensities** there is a plateau in all three graphs where **light is no longer a limiting factor**.

Fig. 6.2 shows a schematic showing the functional relationship between light harvesting complexes (LHC) and photosystems II & I. Regulatory complexes are also shown comprising of kinases and the regulation of excess energy between PS II and I.



Gollan et al 2015 Photosynthetic light reactions: integral to chloroplast retrograde signalling. Current Opinion in Plant Biology 27:180-191modified.

Fig. 6.2

(b) Explain what is the LHC and its role in photosynthesis.

ANS [L1] Novel

[2]

1. LHC is the Light Harvesting Complex comprising mainly of **Carotenoids and special chlorophyll**;
2. Role is to **consolidate / channel energy to the photosystems** in this way helps in the **promotion of electrons within Photosystems**;

(c) With reference to Fig. 6.2 explain the role of electrons in the photosynthesis as they move from Photosystem II to Photosystem I.

ANS [L1] Novel
[3]

1. electrons are of a **higher energy state** once promoted, are then **passed down the ETC** where **energy lost in the transfer is used to pump protons** into the **thylakoid space**;
2. **Chemiosmosis of H+ then drives the synthesis of ATP** using **ATP synthase**. ATP will then **be used in the Calvin cycle**.
3. Electrons passed from PSII through the ETC reach and **replenish PSI**.

(d) With reference to Fig. 6.2 suggest the implications of the role of LHC and PSII core protein phosphorylation from Photosystem II to Photosystem I.

ANS [L3] Novel
[3]

1. LHC and PSII core protein help with the **distribution of energy between PSII and PSI.**
2. At **high light intensity** there is a **redistribution of energy** so that **bleaching does not occur**.
3. At **low light intensities**, there is a **channeling of energy so that photosynthesis will continue**.

[Total: 13]

2017 / H2 / DHS PRELIM / P2 Q8

Question 8
(a) (i)
Dehydrogenase reduces NAD+ to NADH
when isocitrate is converted to α-ketoglutarate / succinyl-CoA; OR when malate is converted to oxaloacetate.
NADH carries the electron and proton to electron transport chain for ATP synthesis via oxidative phosphorylation.

OR

Dehydrogenase reduces FAD^{2+} to $FADH_2$
when succinate is converted to fumerate.
$FADH_2$ carries the electron and proton to electron transport chain for ATP synthesis via oxidative phosphorylation.

(a)(ii)
Depth B

Mean dehydrogenase activity was lower, ranging from 1.5-2.5AU, while that of depth A was higher, ranging from approximately 3.2-5.5AU.
At a greater depth, oxygen concentration is lower. Hence, rate of oxidative phosphorylation is lower.
Regeneration of NAD^+ / FAD^{2+} is slower hence there is lesser substrates for effective collision.

(b)
lactic acid fermentation
Pyruvate converted to lactate, NADH oxidised to NAD.

(c)(i)

Carbon dioxide concentration

(c)(ii)

Carbon dioxide concentration is higher near factories
More CO_2 for fixation with Ribulose Bisphosphate

2017 / H2 / JJC PRELIM / P2 Q6

4 Fig. 6.1 shows some stages in mammalian respiration.

glucose

$\downarrow$ **A**

hexose phosphate

$\downarrow$ **B**

triose phosphate

$\downarrow$ **C**

pyruvate

$\downarrow$ **D**

carbon dioxide and water

Fig. 6.1

(a) Name the processes taking place during Stage D and state precisely where they occur. [3]

1. **Link reaction – mitochondrial matrix;;**
2. **Krebs cycle – mitochondrial matrix;;**
3. **Oxidative phosphorylation – inner mitochondrial membrane;;**

(b) Intermediates produced at the end of Stages B and C are important in the conversion of carbohydrates to lipids such as triglycerides. Some of the triose phosphate can be converted into glycerol-3-phosphate, while pyruvate can undergo further reactions to form intermediates required for the synthesis of fatty acids.

(i) Describe the formation of triglycerides. [3]

1. **A triglyceride is formed by condensation reactions between 1 glycerol and 3 fatty acids;;**
2. **Each of glycerol's hydroxyl/–OH groups condenses with the carboxyl/ –COOH group of a fatty acid;;**
3. **In each condensation reaction, one water molecule is removed, resulting in the formation of an ester bond/linkage;;**

(ii) State two roles of triglycerides in living organisms. [2]

1. **Triglycerides serve as a good energy source;;**
2. **Triglycerides are a weight efficient means for organisms to store energy / serve as good energy storage molecules;;**
3. **Triglycerides serve as a good source of metabolic water;;**
4. **Triglycerides are good thermal insulators that reduce / prevent excessive heat loss from the body;;**
5. **Provide buoyancy to aquatic animals;;**
(any 2)

(c) The first reaction in Stage A is catalysed by the enzyme hexokinase. It has been observed that hexokinase is bound to the outer mitochondrial membrane in muscle cells which undergo high rates of glycolysis.

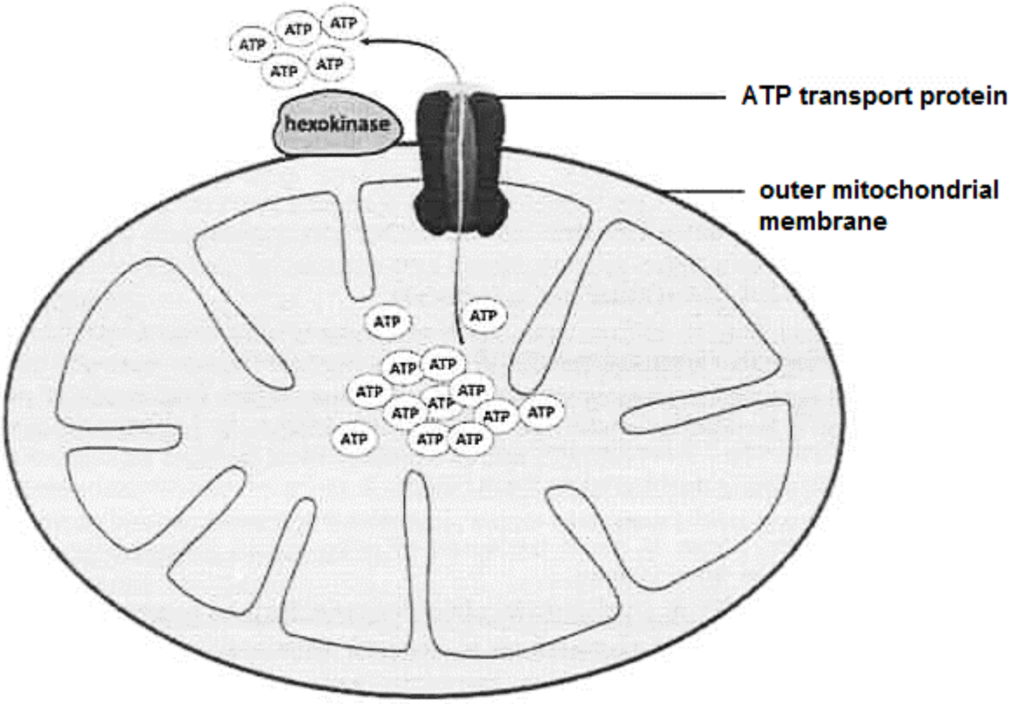


Fig. 6.2

With reference to the role of mitochondria and Fig. 6.2, suggest how the association of hexokinase with mitochondria can lead to high rates of glycolysis. [2]

1. **Mitochondria are the site of aerobic respiration to synthesise ATP;;**
2. **Due to the <u>close proximity</u> of hexokinase to the mitochondria, <u>ATP produced</u> by the mitochondria <u>can easily be used</u> by hexokinase <u>to phosphorylate glucose</u>;; increasing the rate of glycolysis.**

Fig. 6.3 shows an electron micrograph of a mitochondrion.

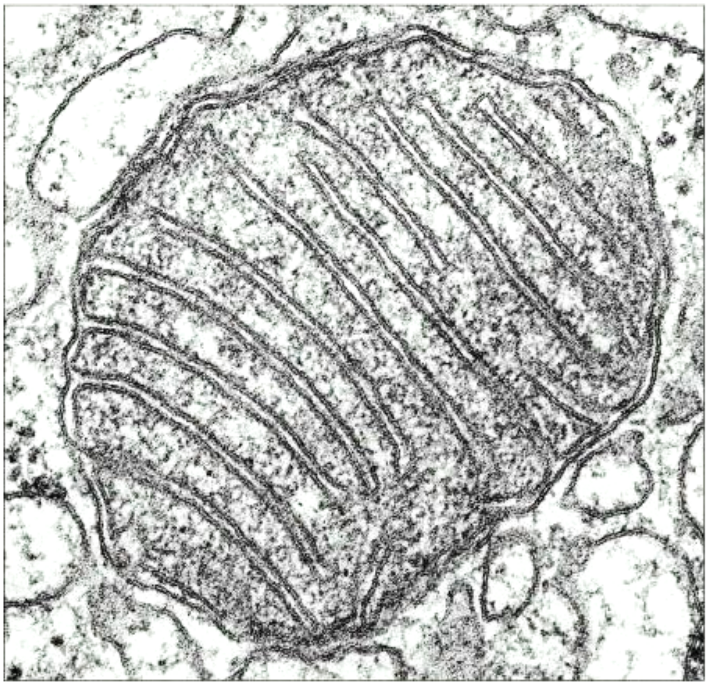


Fig. 6.3

(d) With reference to features visible in Fig. 6.3, outline how the structure of the mitochondrion is adapted for its function. [2]

1. **The inner mitochondrial membrane is highly folded, providing a large surface area where stalked particles, enzymes and electron carriers of the electron transport chain (ETC) *(any 1 e.g.)* needed for aerobic respiration can be located;;**
2. **The mitochondrion is enclosed by double membranes separated by (an extremely narrow fluid-filled space) intermembrane space, allowing for compartmentalisation within the mitochondrion / specialised metabolic pathways to take place in different areas;;**

[Total: 12]

2017 / H2 / NYJC PRELIM / P2 Q8

1
2
3
4
5

6 Heart muscle cells and epidermal cells were extracted from Chinese hamsters. The cells were lysed and the mitochondria and cytosol were isolated. The mitochondria and cytosol were then mixed and re-suspended in a culture of essential nutrients. This suspension system was used to study the process of cellular respiration.

At time 0, glucose was added to the system. At Time X, Digitonin, a detergent which disrupts membranes was introduced to the suspension system. A probe was used to measure the concentrations of ATP as well as the pH level in the mitochondria.

The experimental results are recorded in the graphs shown. **Fig. 8.1** shows the rate of ATP production for heart muscle cells and epidermal cells. **Fig. 8.2** shows the pH level of the mitochondria in both heart muscle and epidermal cells.

Fig. 8.1

—— Heart muscle cells

- - - - Epidermal cells

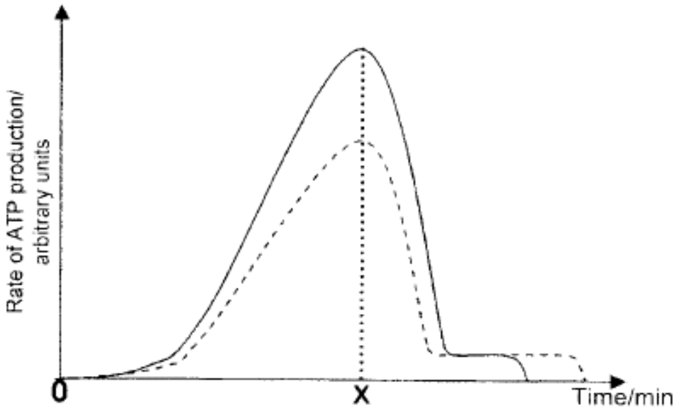
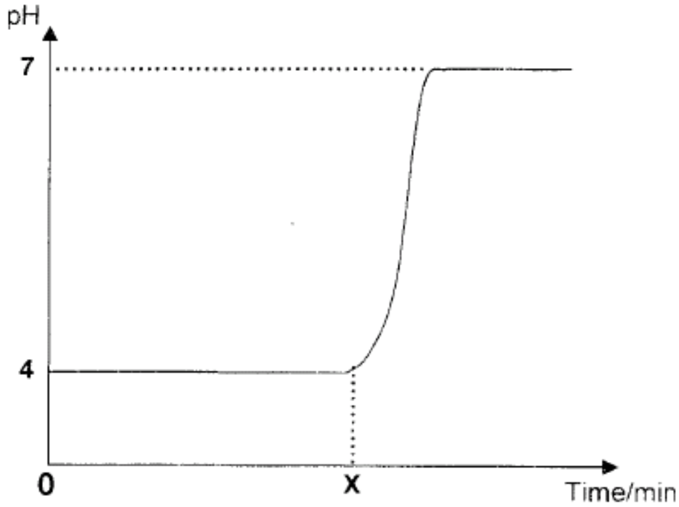


Fig. 8.2



(a) Account for the difference in the level of ATP production in both tissues after glucose was added.

Heart cells produce a <u>higher</u> level of ATP as it contains <u>more mitochondria</u> than epidermal cells;

[1]

(b) With reference to **Fig. 8.1**, explain the changes in ATP production over time for the heart muscle cell suspension.

2 marks max for the first 3 marking points

High energy electrons from reduced coenzymes are passed down a series of electron carriers on the ETC, each with an energy level lower than the one preceding it;

Energy from the flow of electrons is used to actively pump protons from matrix to intermembrane space, through conformational change of proteins in ETC;

Rate of ATP production increases with time before addition of X due to protons diffuse down the electrochemical proton gradient back into mitochondrial matrix through ATP synthase/ stalked particles, synthesizing ATP from ADP and Pi;

Ref to effect resulting from the membrane damage e.g. no ETC / ATP synthase / electrochemical gradient etc

Initial lag in ATP production because glycolysis is occurring to produce 2 ATP per glucose by substrate level phosphorylation;

OR

Rate of ATP production levels off because glycolysis can still occur and decreases to zero when glucose is used up;

[3]

(c) With reference to **Fig. 8.2**, state which region of the mitochondrion the pH probe was measuring. Explain your conclusion.

Intermembrane space;

Ref to pH4 + protons are actively pumped from matrix into intermembrane space;

[2]

(d) Suggest why cytosol was used to re-suspend the mitochondria.

Enzymes involved in glycolysis are present in the cytosol;

[1]

(e) From your biological knowledge, explain the adaptation of the double membrane for its role in the production of energy.

Membrane is impermeable to protons, creating electrochemical proton gradient across the inner mitochondrial membrane;

Highly folded inner membrane increase surface area for stalked particles containing ATP synthase and electron carriers to be embedded;

Compartmentalisation so that reactions can occur in different locations (ref. to provision of optimal conditions for enzymes such as that for Krebs' Cycle to work);

[2]
[Total: 9]

2017 / H2 / PJC PRELIM / P2 Q7

Question 7 [12 marks]

An experiment was conducted to investigate how various factors affect the rate of photosynthesis in cabbage. **Fig. 7.1** below shows the results of the experiments conducted.

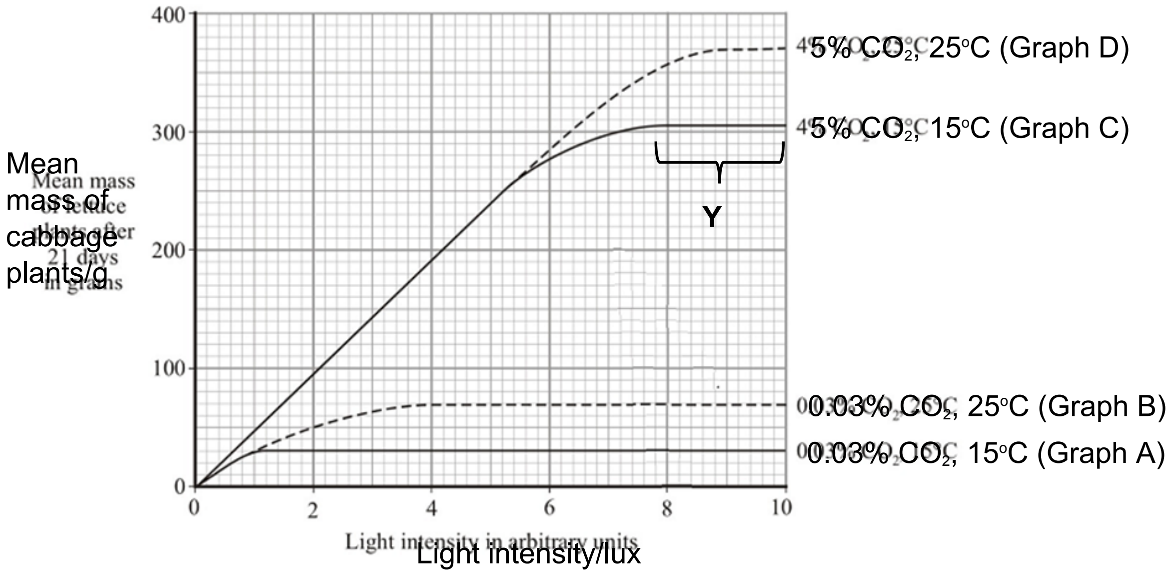


Fig. 7.1

(a) With reference to **Fig. 7.1**,

(i) state the best conditions for the growth of cabbage. [1]

5% carbon dioxide, 25ºC, and (any value between 8.8-10) lux;;

(ii) explain the region marked **Y**. [2]

a. **Light intensity is no longer the limiting factor / light saturation is achieved, ;**
b. **as mean mass of cabbage plants remains constant at 305g (accept range between 300-310g) beyond 8 lux (accept range between 7.6-8) lux;**
c. **Mean mass of cabbage plants will only increase if temperature is increased from 15ºC to 25ºC. ;**
d. **Rate of photosynthesis is limited by temperature;**

(iii) describe and explain the effect of increasing carbon dioxide concentration on the mean mass of cabbage at 25 ºC. [3]

a. **As the carbon dioxide concentration increases from 0.03% to 5%, the maximum mass increases from 70g to 370g of cabbage;;**

Max 1.5 for marking points b) to e)

b. **More CO_2 is used for more carbon fixation during light independent reaction;**
c. **Increase in carbon dioxide concentration will increase the frequency of effective collisions between enzyme, Rubisco and substrates, RuBP and CO_2;**
d. **Hence rate of enzyme-substrate complex formation increases;**
e. **Rate of formation of glyceraldehyde-3-phosphate increases;**

R: product, need to mention which product is responsible for the increase in mass

f. More glyceraldehyde-3-phosphate molecules are converted to form more glucose and cellulose which increases the mass of lettuce;

6 Pyruvate, a product of glycolysis, needs to move from the cytosol into the mitochondrion. After some processing, pyruvate will be converted to acetyl Co A which then enters the Kreb cycle.

Compare Graph B and D only. Idea of increase/more and rate/per unit time should be included throughout

Fig. 6.1 is an electron micrograph of a mitochondrion.

R: description of light-dependent reactions which does not explain why mean mass of cabbage increases

(iv) The average carbon dioxide content of the natural environment is 0.035%. Using this fact, and the information given in **Fig. 7.1**, what conclusion can be made about how carbon dioxide affects rate of photosynthesis in the natural environment? [2]

a. .035% in the natural environment is close to 0.03% in the experiment,
b. shows that carbon dioxide concentration is a limiting factor on the rate of photosynthesis in the natural environment;;
c. At maximum light intensity at 25°C, Graph D showed higher rate of photosynthesis which resulted in 370g mass of cabbage whereas
d. Graph B showed lower rate of photosynthesis which resulted in only 70g of cabbage;;
OR
e. At maximum light intensity at 15°C, Graph A showed higher rate of photosynthesis which resulted in 30g mass of cabbage whereas
f. Graph C showed lower rate of photosynthesis which resulted in only 305g (accept range between 300-310) of cabbage;;

(b) While photosynthesis is the process by which carbon dioxide and water are used as starting materials for the synthesis of glucose using light energy, respiration involves releasing chemical energy in organic molecules such as glucose by oxidation and made available to living cells in the form of ATP. In particular, the yield of ATP under aerobic and anaerobic respiration are very different.

Explain the small yield of ATP from anaerobic respiration in both yeast and animals. [4]

a. During anaerobic respiration, there is no oxygen, thus there is no final electron acceptor for oxidative phosphorylation to take place;
b. This will result in electron flow via electron transport chain being blocked;
c. When this happens, there will be no protons pumped into intermembrane space from the matrix of mitochondria;
d. Proton gradient (and hence proton motive force) will be dissipated;
e. No chemiosmosis via ATP synthase → no ATP production via oxidative phosphorylation;
f. NAD+ and FAD will not be regenerated so link reaction and Krebs cycle cannot take place to generate more ATP, NADH and $FADH_2$;
g. Only glycolysis can take place to generate a net gain of 2 ATP molecules per glucose molecule;
h. Anaerobic respiration via lactate fermentation or alcoholic fermentation does not produce ATP but only regenerates NAD+ for glycolysis to continue;
i. only a net of 2 ATP molecules are synthesized via glycolysis via substrate level phosphorylation;
j. a large amount of energy is locked in lactate / alcohol;

2017 / H2 / RI PRELIM / P2 Q6

(a) Name the region within the mitochondrion where the Krebs cycle occurs and using the symbol **X**, indicate this region on Fig. 6.1. [1]

X: mitochondrial matrix

(b) Pyruvate requires the help of pyruvate translocase to enter the mitochondrion. The structure of pyruvate is shown in Fig. 6.2.

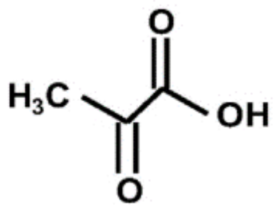


Fig. 6.2

Pyruvate translocase is located on the membrane labelled ‘A’ in Fig. 6.1.

Fig. 6.3 shows how pyruvate is transported across the membrane A.

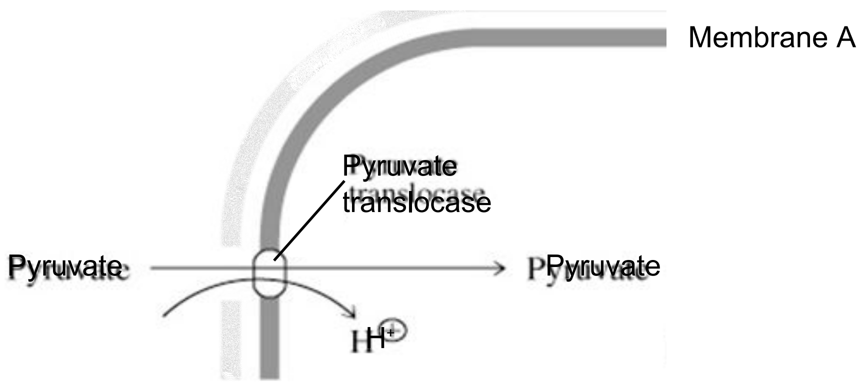


Fig. 6.3

(i) Explain why pyruvate requires the help of pyruvate translocase to cross membrane A. [2]

1. Pyruvate is charged*/polar* and therefore hydrophilic*
   OR
   pyruvate is too large to enter through transient pores;
2. hence requires a specific* transport protein / tpt protein provides a hydrophilic pore / channel;
3. to cross inner membrane of mitochondrion which has a hydrophobic core* ;

(ii) With reference to Fig. 6.3, describe the transport of pyruvate across membrane A. [1]

pyruvate transport is coupled with H^+ in the same direction and moved from intermembrane space into matrix;

(c) Other than pyruvate translocase, the electron transport chain and ATP synthase can also be found on membrane A.

(i) Explain how pyruvate translocase, the electron transport chain and ATP synthase are held in membrane A. [2]

1. Non-polar hydrocarbon chains of phospholipid bilayer can form hydrophobic interactions with non-polar R groups of amino acid residues found on exterior surface of proteins;
2. Charged phosphate head of phospholipid bilayer/aqueous solutions on either side of membrane can interact (e.g hydrogen bond, ionic bond) with charged /polar R groups of amino acid residues found on exterior surface of proteins.

(ii) Explain how mitochondria are adapted to contain many structures such as pyruvate translocase, the electron transport chain and ATP synthase. [1]

Inner membrane/cristae (membrane A) is highly folded to increase surface area for placement of the proteins;

(d) Fig. 6.4 shows a section of membrane A.

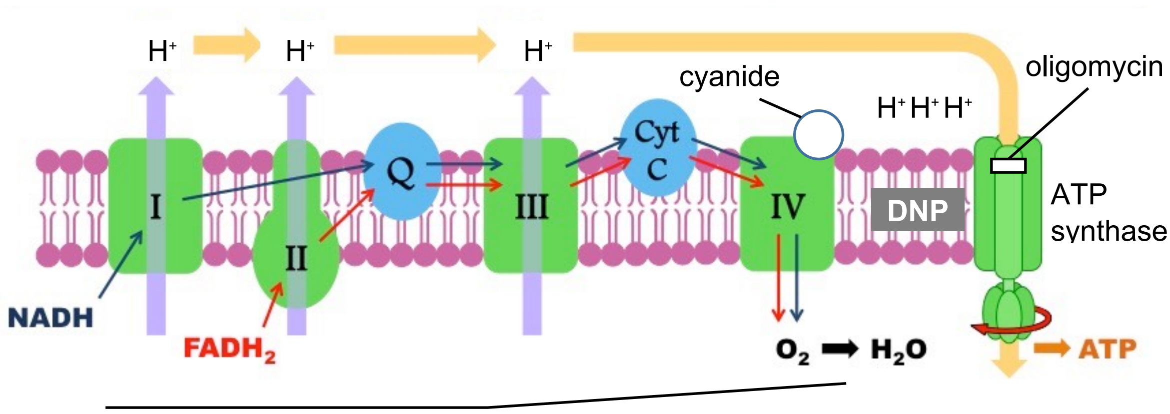


Fig. 6.4

Dinitrophenol (DNP), cyanide and oligomycin are chemicals that interfere with the normal functioning of the components shown in membrane A.

(i) DNP can shuttle H^+ across biological membranes.

With reference to Fig. 6.4, explain why fewer ATP molecules were produced when DNP was added to mitochondria. [1]

Lower proton gradient → no/fewer H^+ moves down concentration gradient through ATP synthase → fewer ATP molecules produced;

(ii) Cyanide inhibits complex IV shown in Fig. 6.4.

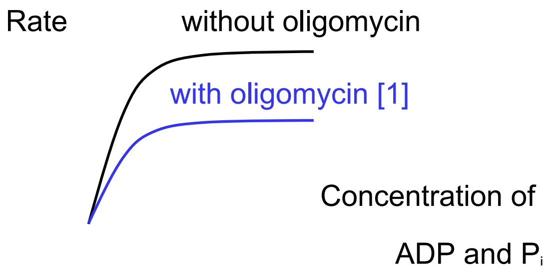
Explain why in the presence of cyanide, oxygen consumption decreases and lactate production increases.[4]

1. Complex IV will no longer be able to pass electrons to O_2, the final electron acceptor, resulting in less O_2 consumption;
2. Electron carriers remain reduced/prevention of reoxidation of electron carriers, thus preventing flow of electrons down ***electron transport chain**** (ETC);
3. NADH and $FADH_2$ will not be able to donate electrons to ETC, therefore no ***regeneration of NAD^+ and FAD****;

4. ***lactate dehydrogenase**** will reduce pyruvate to lactate thus increasing lactate production;
5. NADH is reoxidised to form ***NAD***$^{+*}$, so that glycolysis can continue to generate more ATP;

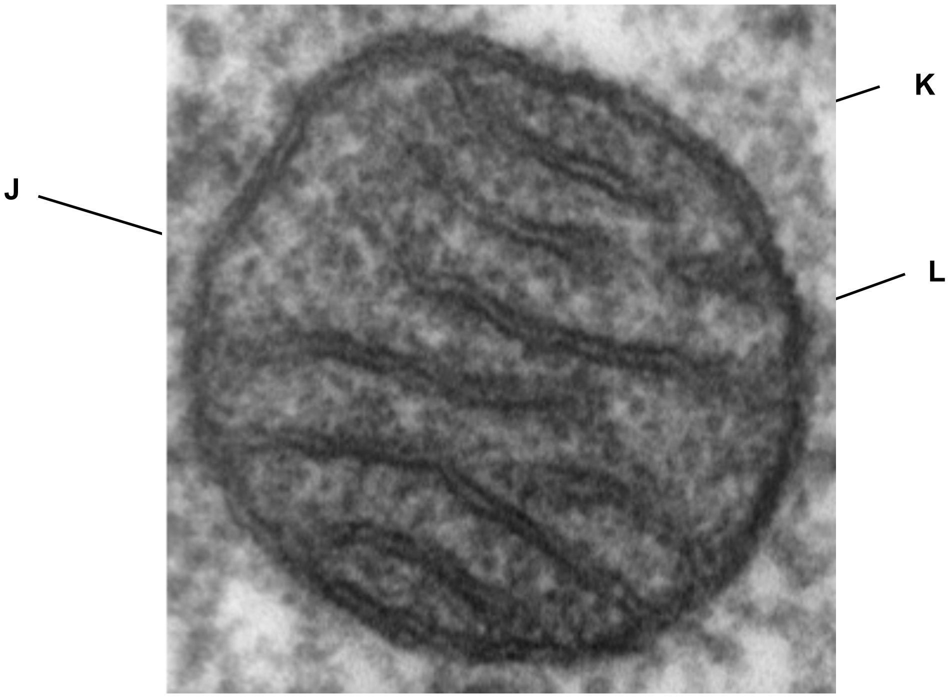
(iii) Oligomycin inhibits ATP synthase by blocking the proton channel, as seen in Fig. 6.4.

Indicate in the graph below, the effect of administering a fixed amount of oligomycin on the rate of ATP synthesis. [1]



[Total: 13]

2017 / H2 / RVHS PRELIM / P2 Q8

8	Fig. 8.1 is an electron micrograph of a mitochondrion.  **Fig. 8.1**				
	(a)	**(i)**	Identify structures **J** and **K**.		[1]
			J	(mitochondrial) Matrix;	
			K	inner (mitochondrial) membrane / crista;	
		(ii)	Describe how structure **J** is adapted to its function.		[1]
			Matrix contains enzymes for Krebs cycle / link reaction;;		
	(b)	**(i)**	State the role of high concentration of protons at **L**.		[1]
			It acts as a source of potential energy for the synthesis of ATP by ATP synthase;;		
		(ii)	Explain how the high concentration of protons is generated at **L**.		[3]
			1. electrons from NADH / $FADH_2$; 2. passes along a chain of electron carriers (releasing energy in a series of small steps); 3. free energy released; 4. is used to pump protons; 5. from matrix into intermembrane space; 6. inner mitochondrial membrane is impermeable to ions;		

		In an investigation to determine the effect of chemical **M** on respiration, mitochondria were incubated in four ways: 1. with glucose 2. with pyruvate 3. with glucose and chemical **M** 4. with pyruvate and chemical **M** The results are summarised in Table 8.1.		

Table 8.1

	CO_2 evolution	O_2 consumption	ATP production by oxidative phosphorylatio n
Glucose	x	x	x
Pyruvate	✓	✓	✓
Glucose + chemical **M**	x	x	x
Pyruvate + chemical **M**	✓	✓	x

(c)	**(i)**	Explain why carbon dioxide is produced when mitochondria are incubated with pyruvate but not when incubated with glucose.	[3]	
		1. no glycolytic enzymes in mitochondria; **2. glycolysis does not occur in the mitochondria / glycolysis can only occur in the cytosol;** **3. glucose cannot be oxidised to form pyruvate;** **4. pyruvate can enter mitochondria but glucose cannot;** **5. CO_2 produced by decarboxylation in link reaction;** **6. and Krebs cycle;**		
	(ii)	Suggest why when mitochondria are incubated with pyruvate and chemical **M**, oxygen consumption occurs but not ATP production.	[2]	
		1. Chemical M only block ATP synthase so no phosphorylation of ADP/no flow of H^+ down concentration gradient (through ATP synthase);; **2. Chemical M does not affect ETC to transfer electrons to oxygen;;**		

2017 / H2 / SAJC PRELIM / P2 Q5

A student set up an experiment to investigate the effect of carbon dioxide on photosynthesis. First, he de-starched a small potted plant by putting it in the dark for two days. Then, he chose two leaves and inserted them into conical flasks, **A** and **B**, fitted with rubber stoppers. Lithium hydroxide was placed in Flask **B** to absorb all carbon dioxide present. The plant was then left under a table lamp for 15 minutes. Fig 5.1 shows the experimental setup.

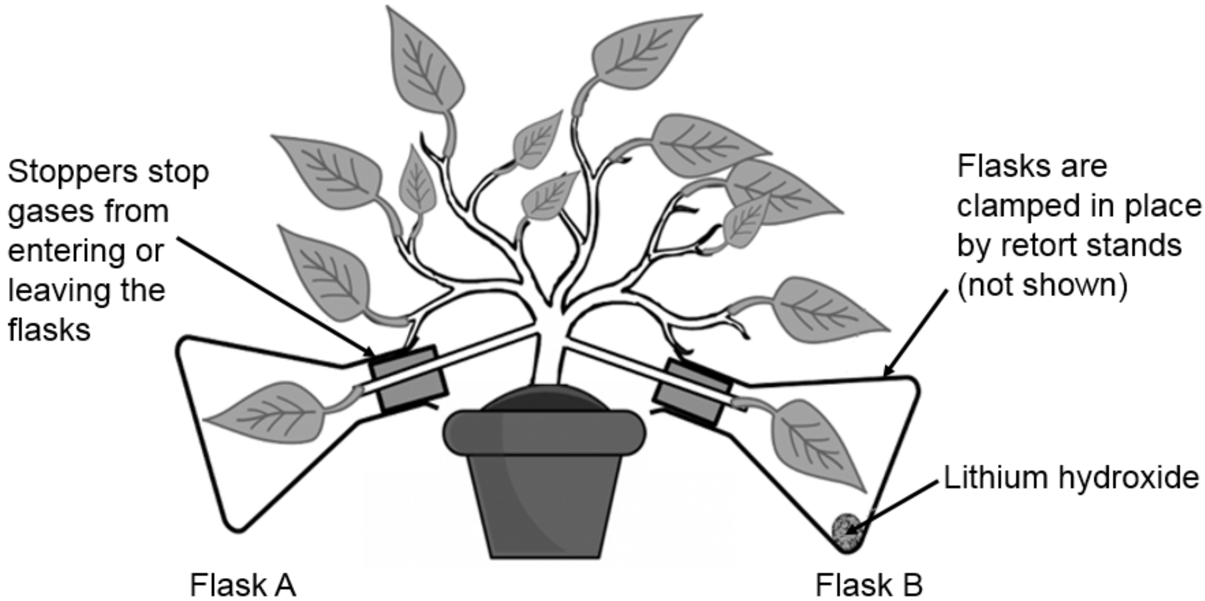


Fig 5.1

He removed a sample of each leaf every 5 minutes (by punching out a leaf disc of approximately 0.2 cm in diameter, using a single-hole puncher) and return the leaves to their respective flasks immediately. Each leaf disc was then tested for the presence of ribulose bisphosphate (RuBP) and starch. Table 5.2 shows the results he obtained.

Table 5.2

Flask	Concentration of RuBP / μmolm^{-2}				Concentration of starch / μmolm^{-2}			
	0 min	5 min	10 min	15 min	0 min	5 min	10 min	15 min
A	0.0	2.2	3.0	3.1	0.0	2.1	3.4	6.5
B	0.0	2.7	4.2	6.8	0.0	0.3	0.5	0.5

(a) State two other variables which must be kept constant to maximize the validity of the results obtained for this experiment.

……………………………………………………………………………………………………[1]

1 Size of the leaves chosen (in flask A and flask B)
2 Distance from light source/light intensity
3 Temperature
4 Size of flask (affecting the volume of gas)

[Reject: leaves must be from the same plant as diagram already show only one pot of plants; pH of soil as fluctuations in pH will affect both leaves equally and hence, not affect the results]

(b) With reference to Table 5.2, describe the relationship between the presence of carbon dioxide and concentration of starch.

……………………………………………...…………………………………………..…[2]

1. In the presence of carbon dioxide (i.e. Flask A), starch concentration increased from 0.0 to 6.5 μmolm^{-2} from 0 - 15 min.
2. while in the absence of carbon dioxide (i.e. Flask B), starch concentration increased much **less**, from 0.0 to 0.5μmolm^{-2} from 0 - 15 min.

OR

1. The presence of carbon dioxide leads to a higher concentration of starch
2. E.g. at 15min, starch concentration in the presence of carbon dioxide (i.e. Flask A) is at 6.5 μmolm^{-2} while in the absence of carbon dioxide (i.e. Flask B), starch concentration is at 0.5μmolm^{-2}

(c) Explain the absence of RuBP in both leaves at the start of the experiment.

……………………………………………...…………………………………………..…[2]

1. In the dark (during de-starching), the leaves carried out carbon fixation to convert **RuBP to PGA**.
2. However, in the dark, no ATP and NADPH were produced,
3. hence, chloroplasts are unable to convert **PGA to PGAL** and to regenerate **RuBP from PGAL**.

(d) The increase in RuBP concentration for the leaf in Flask A reached a plateau from 10 min to 15 min of exposure to light but continued to increase in the leaf in Flask B up to 15 min. Explain why.

……………………………………………...…………………………………………..…[3]

1. (In Flask A, concentration of RuBP reaches a plateau because) the RuBP that is being used up (in carbon fixation) equals the RuBP that is regenerated (from PGAL in the Calvin cycle).

2. (In Flask B, exposure to light causes) the production of ATP and NADPH in the light-dependent reactions, which will convert existing PGA to PGAL (don't double penalize from part (c)), and **regenerate RuBP from PGAL**.

3. However, in the absence of carbon dioxide, carbon fixation does not occur, and RuBP **accumulates** in the leaf.

The student watered the potted plant too excessively, causing the soil to become waterlogged. Fortunately, the roots of this plant could carry out anaerobic respiration under low oxygen conditions in the soil.

(e) Outline the process of anaerobic respiration in the roots under waterlogged conditions.
....[4]

1 Glucose is converted to pyruvate via glycolysis in the cytosol.
2 Pyruvate is then decarboxylated to acetaldehyde/**ethanal** with the release of CO_2.
3 This reaction is catalysed by pyruvate decarboxylase.
4 NADH then reduces acetaldehyde/ethanal to ethanol,
5 catalysed by alcohol dehydrogenase.
6 NAD+ is **regenerated** for use in glycolysis to generate some **ATP** continuously.

[Q5: 12 marks]

2017 / H2 / TJC PRELIM / P2 Q7

9 Glucose and fructose are two common fruit sugars used in winemaking. Another sugar used in the fermentation industry is sucrose. The effects of the three sugars on fermentation by yeast were investigated and the results are shown in Fig. 7.1 and Fig. 7.2.

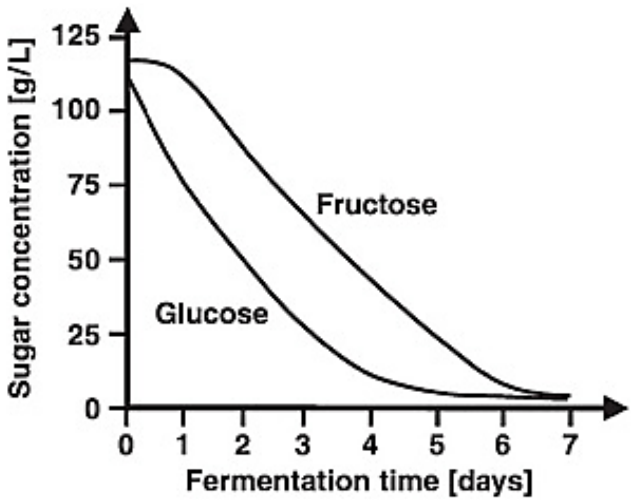


Fig. 7.1

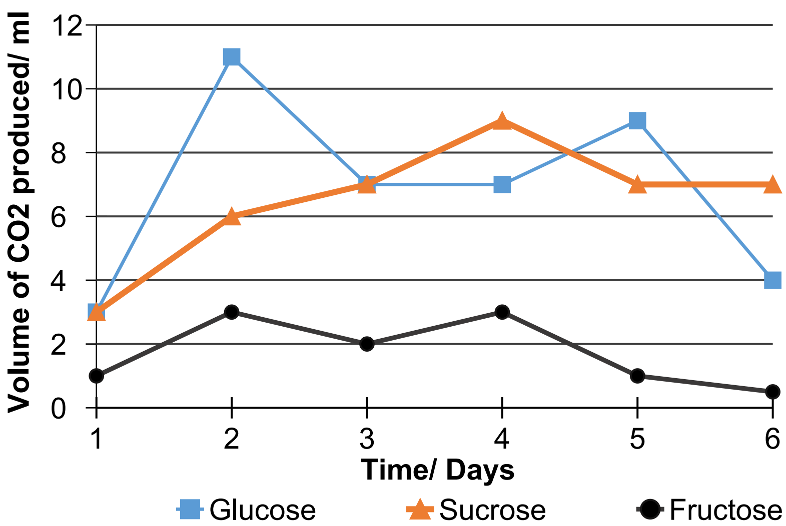


Fig. 7.2

(a Describe how ethanol is formed by yeast. [2]

1. **Pyruvate is first decarboxylated to ethanal. The enzyme is pyruvate decarboxylase.**

2. **Ethanal is then reduced by NADH to form ethanol. NAD+ is regenerated. The enzyme involved is alcohol dehydrogenase.**

With reference to Fig. 7.1 and Fig. 7.2, explain the order in which the sugars were utilized by yeast for fermentation. [4]

1. **Glucose, then sucrose, followed by fructose.**
2. **Concentration of glucose decreased at a faster rate than concentration of fructose – at day 2, concentration of glucose dropped from 110 g/L to 50 g/L, as compared to concentration of fructose which dropped from 115 g/L to 90 g/L**
3. **CO_2 produced was also higher at 11 mL for glucose than for fructose (3 mL) and sucrose (6 mL)**
4. **These show that more glucose was used for fermentation, resulting in a higher level of CO_2 produced during the conversion of pyruvate to ethanal**

Fig. 7.3 shows a respirometer.

Fig. 7.3

Briefly explain how you can determine the rate of respiration using the set-up shown in

Fig. 7.3. [2]

1. **Potassium hydroxide absorbs CO_2 produced**
2. **O_2 will be absorbed by the seeds**
3. **Thus, the level of the coloured oil will move up towards tube B**

Suggest how the compensation point of a plant will be affected when it undergoes anaerobic respiration.

1. **Compensation point is the amount of light intensity when rate of respiration corresponds with rate of respiration.**
2. **During anaerobic respiration, less CO_2 is produced as compared to aerobic respiration.**
3. **Compensation point will likely decrease**

[Total: 11]