ICING SUGAR FOR AUTOTROPHIC NUTRITION CAKE

1. (a) Describe the roles of each of the following in photosynthesis.

(i) Photophosphorylation.

Uses light;✓ energy to form ATP;✓ molecules from ADP;✓ molecules and phosphate;✓ molecules.

(ii) Lamellae.

Connects grana;✓ (thylakoid piles) containing chlorophyll;✓ and associated pigments for receiving light;✓ energy.

(iii) Water. (12 marks)

Splits;✓ in presence of light providing H^+ (protons);✓ and electrons for reduction;✓ of carbon dioxide.

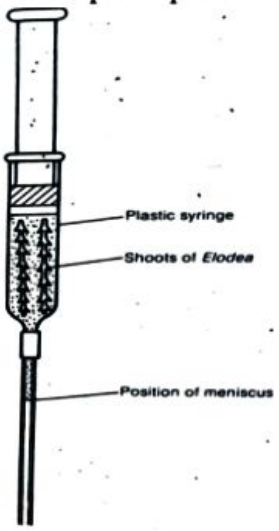
(b) The molecules NAD and NADP are similar in origin, structure and function yet occur in different processes. Explain what is meant by this statement. (04 marks)

Both are nucleotides;✓ comprising of phosphate, organic base and pentose sugar combined in a condensation;✓ reaction. They function to carry H+ (protons);✓ NAD occurs in cellular respiration;✓ whereas NADP occurs in photosynthesis;✓

(c) Two alleles controlling the presence or absence of chlorophyll were investigated by self-pollinating a plant known to be heterozygous collected and sown. One hundred seeds germinated but only 71 seedlings grew into plants. Comment on these results. (04 marks)

Genes of 29 seedlings;✓ were homozygous recessive (absence of chlorophyll);✓ did not photosynthesize, no food manufactured;✓ limited/no respiration, no energy;✓ for growth.

2. The diagram below shows an apparatus which can be used to measure the rate of photosynthesis in Elodea an aquatic plant.



Bubbles of gas collected in the syringe and force down the position of the meniscus.

(a) Assuming you have a boss and clamps, sodium hydrogen carbonate (bicarbonate) solution, distilled water, pipettes, beakers, a light source and PH papers, explain how you would use this this apparatus to investigate the effect of different concentrations hydrogen carbonate (bicarbonate) ions on rate of photosynthesis in Elodea. (05 marks)

Indicate four precautions you would take to obtain accurate results. (04 marks)

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(b) Explain how carbon dioxide combine with ribulose bisphosphate and ultimately enters storage starch during the dark phase of photosynthesis. (05 marks)

Carbon dioxide combines with Ribulose bisphosphate to form an unstable 6-carbon intermediate;✓ this breakdown into two molecules of 3-carbon glycerate 3-phosphate(GP);✓ GP is converted to triose phosphate (glyceraldehyde 3-phosphate, GALP);✓ using ATP and reduced NADP from light stage;✓ NADP is regenerated. Pair of GALP molecules are combined to form hexose sugar;✓ these are polymerized to form starch;✓ which is stored; some of GALP molecules are used to regenerate Ribulose bisphosphate.

Mention enzymes that catalyze the reactions

(d) Name two types of molecule, other than carbohydrate; which are used for storage in plants. (02 marks). *lipids;✓ and proteins;✓*

3. (a) Give a described account of the structure of a chloroplast. (06 marks)

Enclosed by an envelope of double membranes;✓ outer membrane is semi permeable;✓ inner membrane sorrounds the stroma;✓ stroma is semi-gel-like fluid, alkaline, rich in protein, chloroplast DNA and thylakoid membrane system;✓ thylakoids are interconnected, membranous sacs with chlorophyll;✓ these pile up to form grana;✓ (singular granum).

(b) Describe the physical and chemical mechanisms by which solar energy is converted into the chemical energy of ATP during the light stage of photosynthesis. (09 marks)

Light energy;✓ is trapped in pigment system II and boosts electrons to higher;✓ energy level. The electrons are received by electron acceptor;✓ are passed from electron acceptor along a series of electron carriers;✓ to pigment system I which is at a lower energy level;✓ light energy lost is converted to chemical energy;✓ by using it to convert ADP to ATP✓. Light energy absorbed by pigment system I, boosts electrons to even higher energy level;✓ and are received by another electron acceptor; electrons from photolysis;✓ (splitting of water using light energy) replaces electrons which had been removed from chlorophyll; loss of electrons from water causes it to split into protons and oxygen gas;✓ these protons combine with electrons from second electron acceptor and reduce NADP;✓ forming reduced NADP used in dark stage. Some electrons from second electron acceptor may pass back to chlorophyll molecule through electron transport system yielding ATP;✓ as they do so and this is called cyclic photophosphorylation;✓

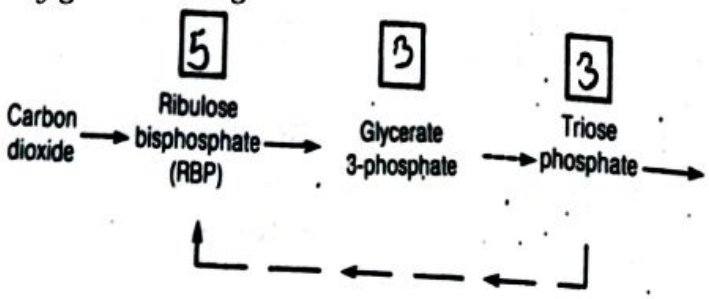
(c) Name the other products of the light stage and indicate their general importance in biological systems. (05 marks)

Reduced NADP;✓ proton carrier;✓ to the light independent stage.

Oxygen;✓ last electron acceptor;✓ in oxidative phosphorylation of aerobic respiration;✓

4. The diagram below summarizes the reactions which take place in the light independent stage of photosynthesis.

(a) Enter in the appropriate box on the diagram the number of carbon atoms in one molecule of each of the following.



(i) Ribulose bisphosphate
(ii) Glycerate 3-phosphate
(iii) triose phosphate. (01 mark)

AS indicated @;✓

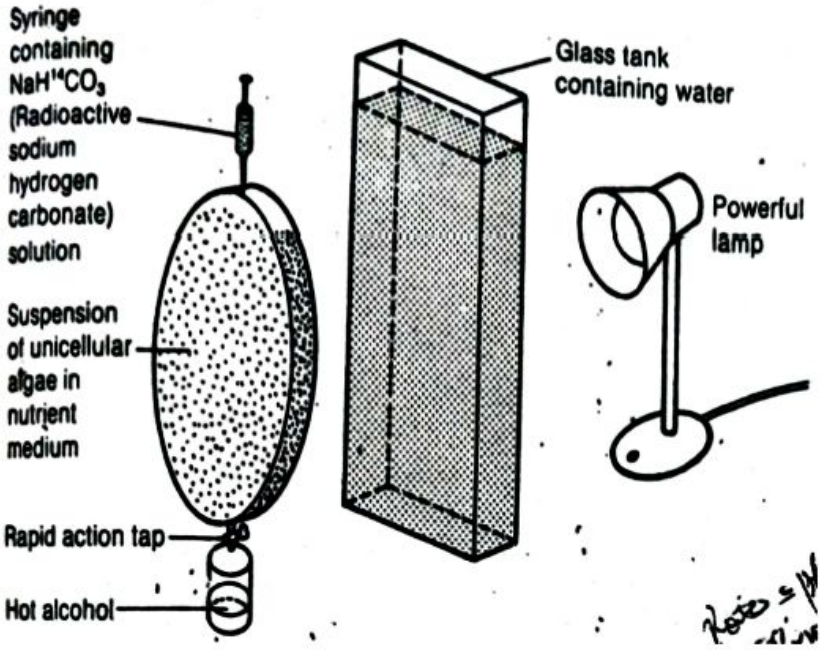
(b) Precisely where in the cell does carbon dioxide combine with ribulose bisphosphate? (01 mark)

In the stroma; ✓ *of chloroplast*.

(c) Name two substances, produced during light dependent stage of photosynthesis, necessary for converting glycerate 3-phosphate into triose phosphate. (02 marks)

ATP; ✓ *and reduced NADP;*✓

5. Apparatus used in an investigation to establish the sequence of biochemical changes in photosynthesis is illustrated below.



(a) suggest one reason for each of the following.

(i) The flattened shape of the glass vessel containing the algae.

Increases surface area; ✓ *exposed to light; for maximum absorption;*

(ii) The water tank.

Filters light;✓

(iii) the hot alcohol

Disinfectant; ✓

(i) the $NaH^{14}CO_3$ solution (04 marks)

Carbon dioxide supply;✓

6. (a) The equation for photosynthesis is often cited.

$6CO_2 + 6H_2O = C_6H_{12}O_6 + 6O_2$

Give four reasons for arguing that this equation is an over-simplification of the process. (08 marks)

- *Does not show how light energy is converted to chemical energy;*✓
- *Does not show intermediate products involved;*✓
- *Does not talk account for light stage and dark stage;*✓
- *Role of chlorophyll not specified;*✓

(b) giving a reason in each case for your answer, state the expected effect of 10°C rise in temperature on the rate of photosynthesis in

(i) very low light intensities.

Rate remains constant; very low light limits; ✓ *the process since it the source of energy;* ✓

(ii) High light intensities. (04 marks)

Rate increases; ✓ *temperature rise increases kinetic energy;* ✓ *of reacting molecules.*

(c) (i) Define the term "compensation point"

Point at which carbon dioxide produced during respiration equals to carbon dioxide used during photosynthesis; ✓

(ii) Plants show different compensation point. Suggest one reason for this. (04 marks)

Plants have different rate of photosynthesis; ✓ *and different rate of respiration;* ✓

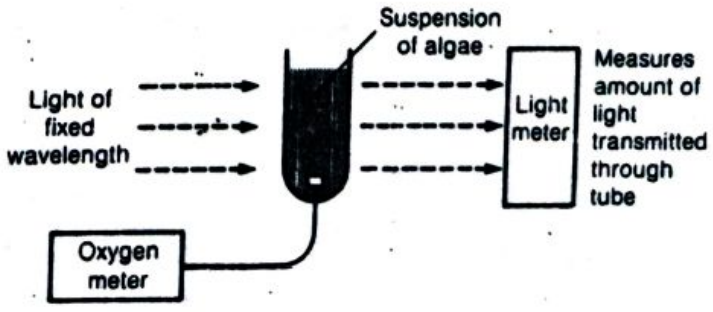
(d) The assimilation number (rate of photosynthesis mg^{-1} chlorophyll) was calculated for two varieties of elm; a so-called "green" and "yellow" variety. The results are given below.

variety	mg chlorophyll in 10g fresh mass of leaves	Assimilation number
Green	16.2	6.9
Yellow	1.2	82.0

Comment on the significance of these results. (03 marks)

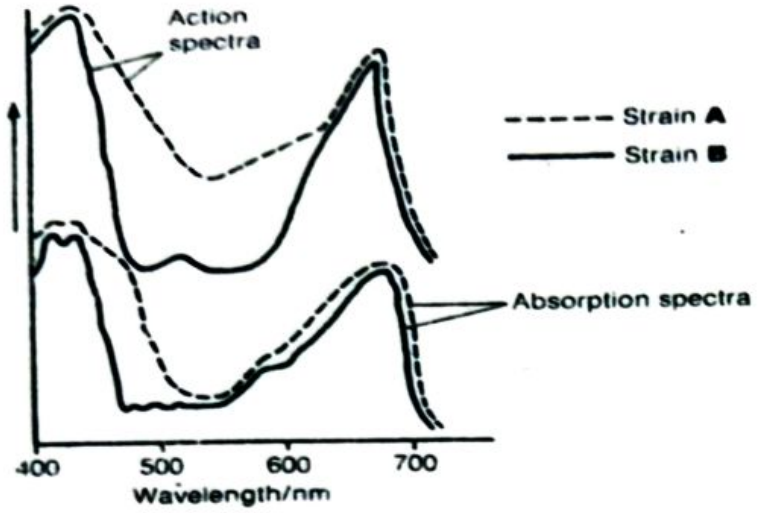
Yellow variety has higher assimilation number; ✓ *due to lower;* ✓ *mg chlorophyll in 10g fresh mass of leaves compared to the lower;* ✓ *assimilation number of green variety due to higher;* ✓ *mg chlorophyll in 10g fresh mass of leaves.*

7. Investigation were carried out using two strains of the same species of unicellular alga, one of which was a mutant that could not survives long periods of intense illumination.



Light of known wavelength was passed through a tube containing the alga and measurements were taken both of the oxygen produced and of the light transmitted. The experimental arrangement is represented in the following diagram.

The results obtained were used to plot the absorption and action spectra for each strain of alga. These are shown below.



(a) (i) what is meant by the term action spectrum?

Graph that shows effectiveness; ✓ of different wavelengths of light; ✓ in stimulating the process of photosynthesis;✓

(ii) What information from the experiment would have been used to plot the action spectra? (02 marks)

Wavelength;✓ and percentage absorption;✓

(b) (i) The amount of light transmitted through tubes without algae in them was 100%. Suggest how the figures plotted for the absorption spectra were derived from the results obtained with the light meter.

100% - value on light meter; ✓ to get amount of light absorbed; ✓ since absorption spectrum is graph showing relative amount of light absorbed by pigment at different wavelength of light.

(ii) Apart from temperature and PH (which have little effect), state two factors which should be standardized when using the apparatus shown above to measure the absorption spectra. (03 marks)

Light; ✓ carbon dioxide; ✓ water;✓

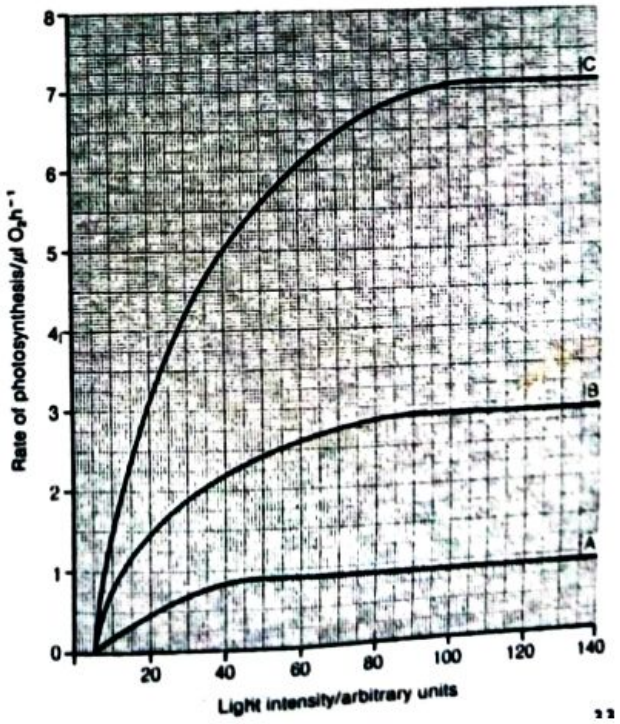
8. (a) The graphs shown below illustrate the results obtained in experiments performed to find out what effects increased carbon dioxide levels could have on the rate of photosynthesis in one type of annual crop plant. All experiments were carried out in controlled conditions at 16°C. The amount of artificial light given to the plants could be varied.

Rate of photosynthesis (as measured by evolution of oxygen) plotted against light intensity for three groups of plants supplied with different amounts of carbon dioxide.

Group A: with 0.01% by vol. carbon dioxide.
Group B: with 0.03% by vol. carbon dioxide.
Group C: with 0.15% by vol. carbon dioxide.

(i) At what light intensity do these plants given 0.03% CO_2 reach their maximum rate of photosynthesis under these conditions? (01 mark)

90 arbitrary units;✓



(ii) Suggest a reason for the form of graph A beyond 54 units of light. (01 mark)

Remains constant; ✓ *carbon dioxide used up now limiting;* ✓ *the process.*

(iii) Suggest a reason for the form of graph C beyond 54 units of light. (01 mark)

Increases gradually and later remains constant; ✓ *light intensity is no longer limiting the process;* ✓ *but carbon dioxide is doing so;*

(iv) Which graph best indicates the rate of photosynthesis one might expect to obtain from this species of plant in air at 16oC? (01 mark) *Graph B;*✓

(v) suggest why the graphs do not commence at the origin. (01 mark)

Very low light intensity; ✓ *at origin which can't run reaction.*

(vi) State two possible ways (other than amount of evolved oxygen) by which the rate of photosynthesis of the plants might have been measured. (02 marks)

- *Amount of carbon dioxide consumed;*✓
- *Amount of light energy absorbed;*✓
- *Amount of water absorbed;*✓

(vii) suppose that, with group B plants, the temperature had been increased by 10oC at 30 light units and above. Draw on the graph, with a dotted line, any difference you might expect to the given curve. (02 marks)

Rapid increase; ✓ *after gradual increase;* ✓ *and later remains constant;* ✓ *thus higher than existing.*

(b) If the light intensity is reduced to a very low level the plants will be below the compensation point. Explain what is meant by this term. (02 marks)

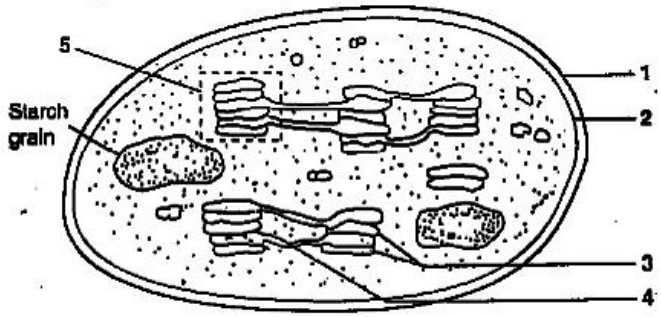
Point at which carbon dioxide produced from respiration equals to carbon dioxide used in photosynthesis; ✓ *If light intensity is reduced to a very low level, carbon dioxide from respiration would be much higher than that used in photosynthesis;*✓

9. Read the following account of photosynthesis and then write down the most appropriate word or words to complete the account.

There are four main pigments found in the chloroplast of higher plats. These pigments are situated in the *thylakoid;* ✓ of the chloplast. Chlorophyll a absorbs mainly *orange;* ✓ and blue-violet light. The pigments are organized into systems, the first of these to be involved is *pigment system II;*✓ .The absorption of light causes displacement of an electron from the chlorophyll a molecule. This

electron maybe passed back to the chlorophyll in a series of *electron carriers;* ✓which are at progressively lower energy levels. Coupled with this electron transfer is the synthesis of *ATP;* ✓this compound maybe used in two stages of light independent reactions of photosynthesis which occur in the *stroma;* ✓of chloroplast. The two stages are the conversion of *Glycerate 3-phosphate(GP);*✓to *Glyceraldehyde 3-phosphate(GALP)/triose phosphate;*✓and the resynthesize of the acceptor molecule *Ribulose bisphosphate(RuBP);* ✓Which combines with the carbon dioxide used in photosynthesis. During non-cyclic photophosphorylation other important reactions take place. The electron is combined with *hydrogen;* ✓ions resulting from the photolysis of *water;* ✓to form the reduced coenzyme called *reduced NADP;* ✓this coenzyme is used in the *Calvin;* ✓cycle. The electron emitted from chlorophyll molecule is replaced by electrons from the *–OH;* ions produced by the photolysis reaction. As a result, *oxygen;* ✓gas is given off. In most plants carbohydrates are the main product of photosynthesis, but other important nutrients, namely *fats;* ✓and *proteins,* ✓are often produced in considerable quantities. Many crops are grown in order to harvest these products. (17 marks)

10. The diagram below represents the structure of a chloroplast.



a) Name the parts labelled 1-5. (05 marks)

1 is outer membrane; ✓*2 is inner membrane;* ✓*3 is thylakoids;* ✓*4 is lamella;* ✓*5 is granum;* ✓

(b) Explain how the structure of a chloroplast is related to its function. (05 marks)

Outer membrane is semi permeable; ✓*regulate entry and exit of substances for maintain internal chloroplast environment.*

- *Extensive network of thylakoid membranes;* ✓*increase surface area for photosynthesis.*
- *Narrow intermembrane space enables H^+ ion concentration gradient;* ✓*to be rapidly established for chemiosmosis to occur.*
- *Inner membrane contains molecules for electron transport pathway;* ✓
- *DNA is present to act as genetic material for synthesis* ✓*of some protein.*

(c) Using only the following compounds, construct a single flow diagram to show the incorporation of carbon dioxide into carohydrates, amino acids and fatty acids. Carbon dioxide, triose phosphate(glyceraldehyde 3-phosphate, GALP), acetyl CoA, Ribulose biphosphate, fatty acids, amino acids, glycerate 3-phopahate (phosphoglyceric acid, GP). (05 marks)

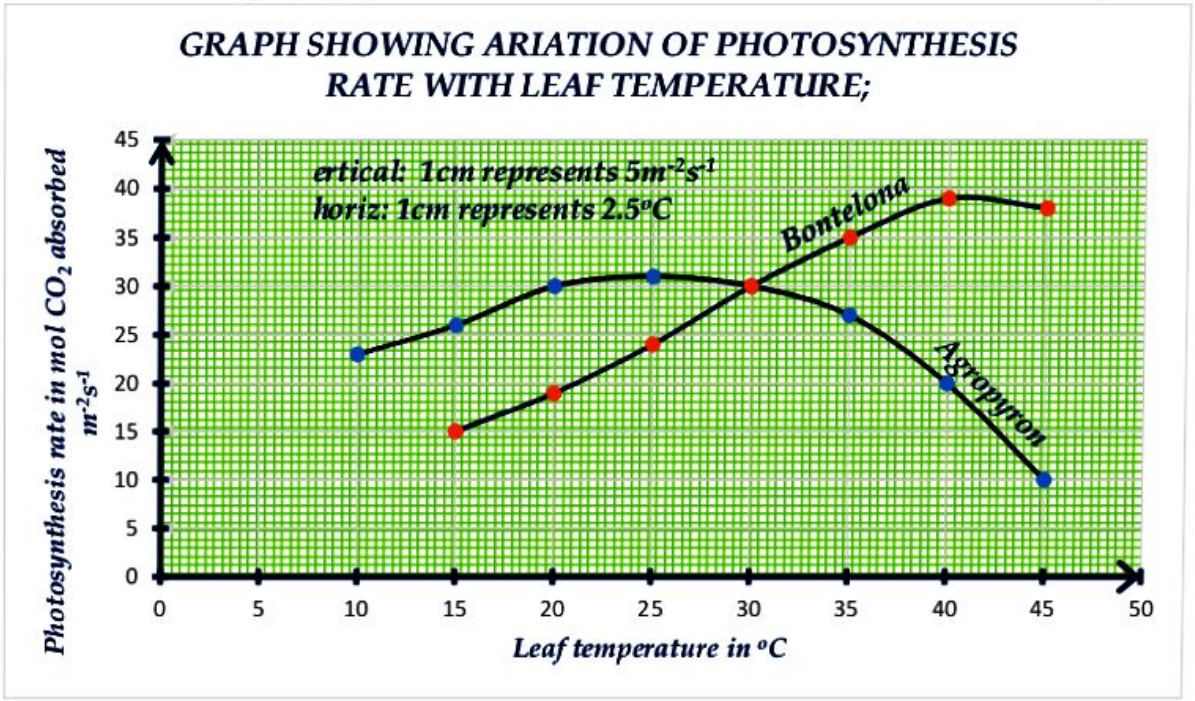
11. The statements in the table below refer to the light dependent and light independent (dark) reactions of photosynthesis. Copy and complete the table if the statement is correct for the process, place a tick in the appropriate box and if its incorrect, place a cross (X) in the inappropriate box.

Statement	Light dependent reaction	Light independent reaction
Oxygen produced	✓	X✓
Carbon dioxide fixed	X✓	✓
Occurs in stroma	X✓	✓
Uses NADPH and H^+	X✓	✓
Produces ATP	✓	X✓

12. The table below shows the effect of temperature on the rate of photosynthesis in two grasses, Agropyron and boutelona.

Leaf temperature/°C	*Photosynthesis rate/ mol CO_2 absorbed $m^{-2}s^{-1}$*	
	Agropyron	*Bontelona*
10	23	10
15	26	15
20	30	19
25	31	24
30	30	30
35	27	35
40	20	39
45	10	38

(a) Plot the data on a graph paper. (05 marks)



(b) From your graph, find the rate of photosynthesis at 22°C for each of the grasses. (02 marks)

Bontelona is +.20 mol CO_2 absorbed $m^{-2}s^{-1}$;✓

Agropyron is +.31 mol CO_2 absorbed $m^{-2}s^{-1}$;✓

(c) Suggest which of the two grasses is likely to grow faster in a tropical climate. Give a reason for your answer. (02 marks)

Bontelona; high rate of photosynthesis; in high temperature;✓

(d) (i) Suggest why the rate of photosynthesis declines at high temperatures. (01 mark)

High temperature denature photosynthetic enzymes;✓

(ii) State two other factors which can be limiting in the photosynthesis. (02 marks)

Light intensity; carbon dioxide concentration;✓

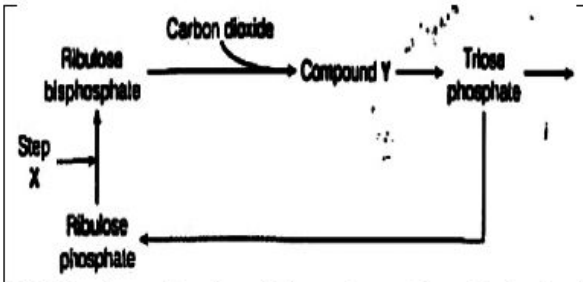
13. (a) briefly describe how ATP is produced as a result of light striking chlorophyll molecules. (02 marks)

Light energy;✓ *is trapped in pigment system II and boosts electrons to higher;*✓ *energy level. The electrons are received by electron acceptor;*✓ *are passed from electron acceptor along a series of electron carriers;*✓ *to pigment system I which is at a lower energy level;*✓ *light energy lost is converted to chemical energy;*✓ *by using it to convert ADP to ATP*✓.

(b) Although photosynthesis generates ATP, plants also generate ATP by respiration. Explain why this is necessary. (02 marks)

ATP produced during light stage;✓ *of photosynthesis is used in dark stage;*✓ *thus need to generate ATP by respiration.*

(c) The diagram shows the main steps in the light independent stage of photosynthesis.



(i) For what is ATP used in step X? (01 mark)

Activating;✓ *Ribulose phosphate making it more reactive;*✓

(ii) Name compound Y. (01 mark)

Glycerate 3-phosphate(GP);✓

14. (a) (i) where in the chloroplast does light independent stage of photosynthesis occur?

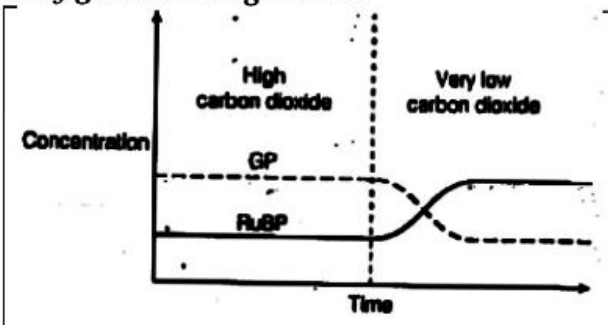
Stroma;✓

(ii) Describe briefly what happens in this stage of photosynthesis. (04 marks)

Carbon dioxide combines with Ribulose bisphosphate to form an unstable 6-carbon intermediate;✓ *this breakdown into two molecules of 3-carbon glycerate 3-phosphate(GP);*✓ *GP is converted to triose phosphate (glyceraldehyde 3-phosphate, GALP);*✓ *using ATP and reduced NADP from light stage;*✓ *NADP is regenerated. Pair of GALP molecules are combined to form hexose sugar;*✓ *these are polymerized to form starch;*✓ *which is stored; some of GALP molecules are used to regenerate Ribulose bisphosphate.*

Mention enzymes that catalyze the reactions

A sample of chlorella (a unicellular organism) was allowed to photosynthesize at high and very low carbon dioxide levels. The graph shows the concentrations of glycerate 3-phosphate (GP) and ribulose bisphosphate (RuBP) during the investigation.



(b) Account for the different concentrations of RuBP during the whole course of the investigation. (03 marks)

RuBP concentration is low and remains constant in high carbon dioxide concentration because rate at which its used to reduce carbon dioxide is equal to rate at which its regenerated; its amount increases in very low carbon dioxide concentration because the rate at which its regenerated from PGAL is less than the rate at which its reduced.

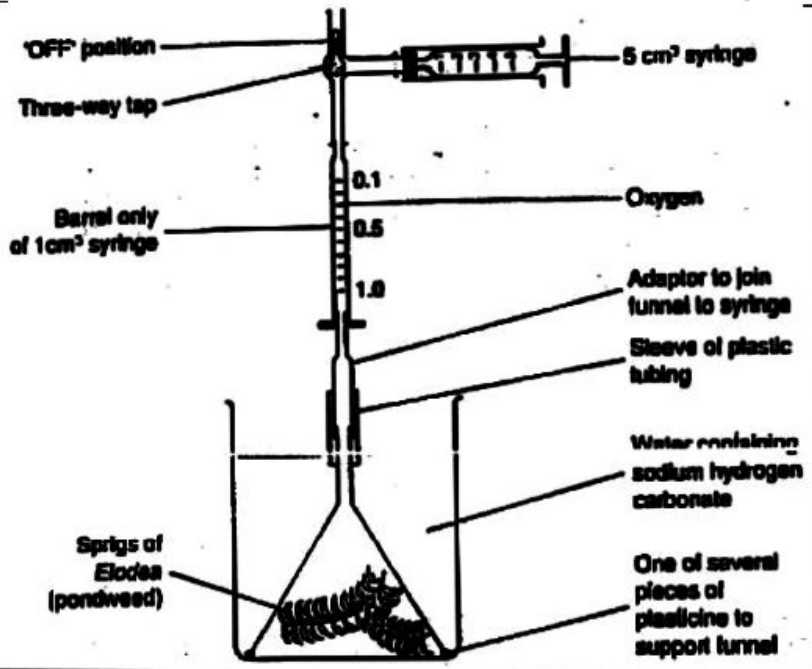
(c) Explain why the concentration of GP falls when the level of carbon dioxide is reduced. (01 mark)

GP is the first stable compound of CO2 fixation; ✓ *when level of CO2 is reduced, little GP is formed. GP is being reduced to PGAL to form more RuBP.*

(d) Give two conditions which should be kept constant throughout the investigation. (01 mark)

Light intensity; ✓ *Temperature;* ✓

15. The diagram below shows the apparatus used to investigate the rate of photosynthesis in elodea



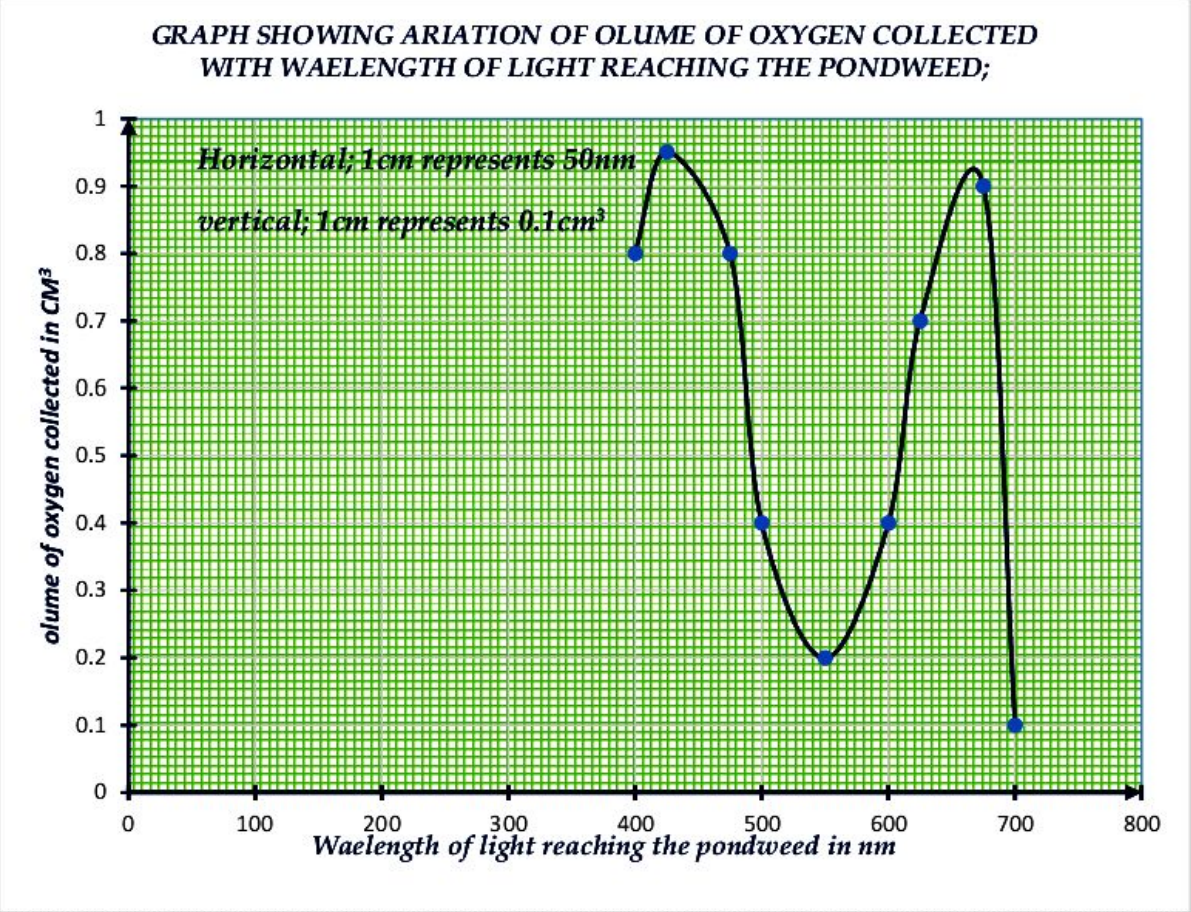
(Canadian pondweed) when exposed to different wavelength of light. Light was provided using a projector with a color filter placed in front of the light beam. The light source was fixed at 50cm from the beaker containing the pondweed. The volume of oxygen collected was recorded after 5minutes' illustration using each of the colored filters.

The following results were obtained.

Color of filter	Wavelength of light reaching the pondweed/nm	Volume of oxygen collected/cm^3
violet	400	0.80
Indigo	425	0.95
Blue	475	0.80

Blue-green	500	0.40
Green	550	0.20
Yellow	600	0.40
Orange	625	0.70
Red	675	0.90
Far red	700	0.10

(a) Plot the data on a graph paper. (05 marks)



(b) Sate the name of the process which occurs during photosynthesis to produce the oxygen w which was collected. (01 mark)

Photolysis;✓

(c) (i) Calculate the relative amount of photosynthesis occurring in green light as a percentage of the maximum rate obtained in this investigation. Show your working. (02 marks)

Relative amount of photosynthesis in green light = (volume of oxygen collected in green light) /(maximum volume of oxygen collected);✓

(0.2x100)/0.95; ✓ *=21.1%;*✓

(ii) State a reason why, even though leaves reflect green light, some photosynthesis is still able to occur when green light falls on a leaf. (01 mark)

Green light absorbed by other pigments(carotenoids); ✓ *for photosynthesis.*

(iii) Explain how the volume of oxygen collected over the same time period would alter if the light source with the green filter in place was placed 25cm away from the beaker. (02 marks)

Volume of oxygen collected would increase; ✓ *short distance of light gives much energy;* ✓

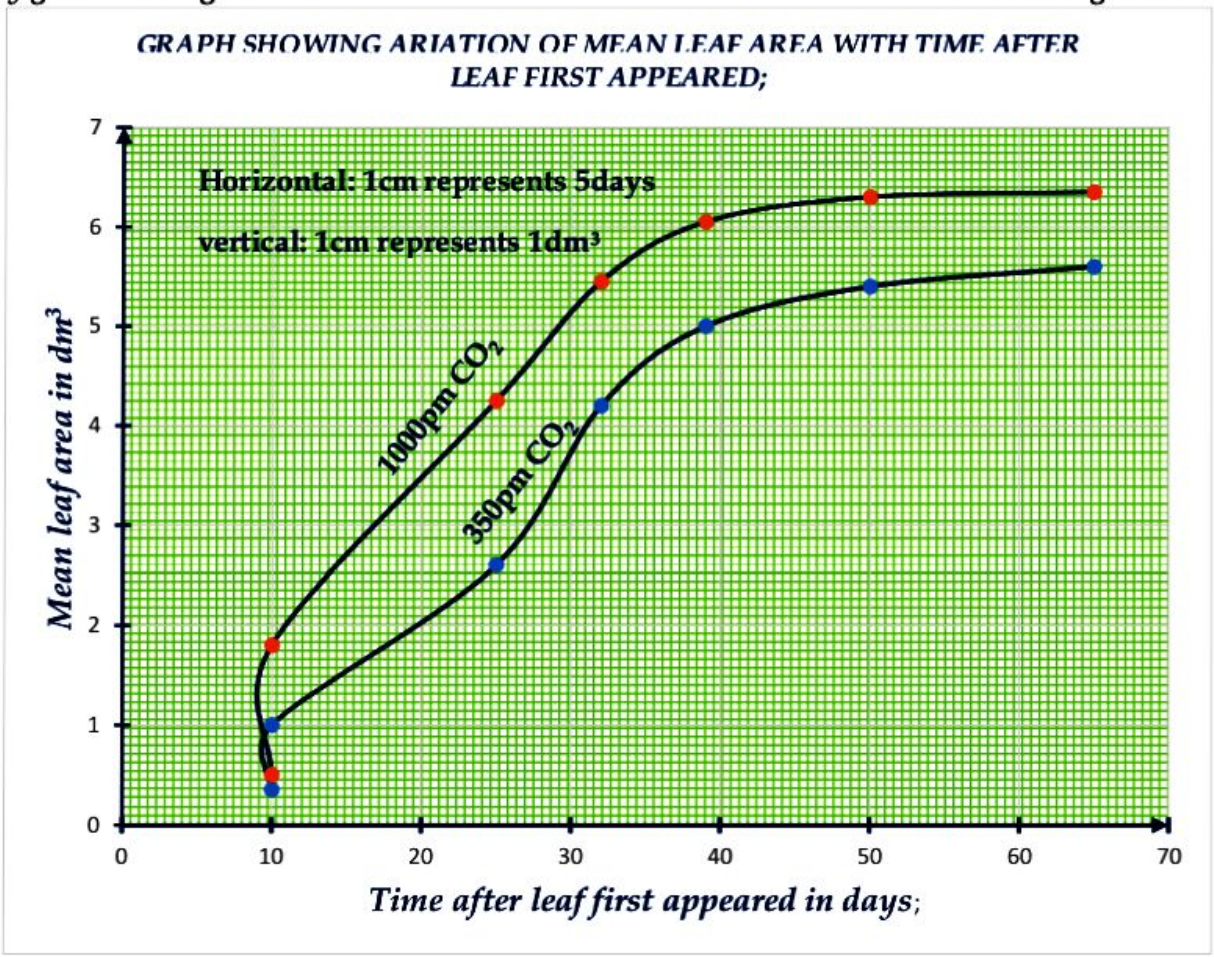
(d) Name the two other compounds (other than oxygen) which are formed during the light dependent stage of photosynthesis, and state their use in the Calvin cycle (light independent stage). (04 marks)

ATP; ✓ *and reduced NADP;* ✓ *they are used to convert glycerate 3-phosphate(GP);* ✓ *to glyceraldehyde 3-phosphate(GALP);* ✓

16. Two groups of tomato plants were grown in atmospheres containing 350pm and 1000pm carbon dioxide respectively (pm = volume parts per million). Other conditions were kept at a constant optimum level. The area of the 7th leaf of each plant was measured from 10days after it first appeared. The table gives the mean leaf area for each group of plants.

Time after leaf 1st appeared/days	Mean leaf area/dm^3	
	350 pm CO_2	1000pm CO_2
10	0.35	0.50
10	1.00	1.80
25	2.60	4.25
32	4.20	5.45
39	5.00	6.05
50	5.40	6.30
65	5.60	6.35

(a) Plot this data on a suitable graph. (05 marks)



(b) From the graph, determine the rate of growth in area of the 7th leaf during the 22nd day after it first appeared, in atmosphere of;

(i) 350pm CO2

Rate of growth = (mean leaf area/time after leaf first appeared);✓

22/22 = 1dm³/day;✓

(ii) 1000pm CO2. Show your working (02 marks)

38/22 = 1.7dm³/day;✓

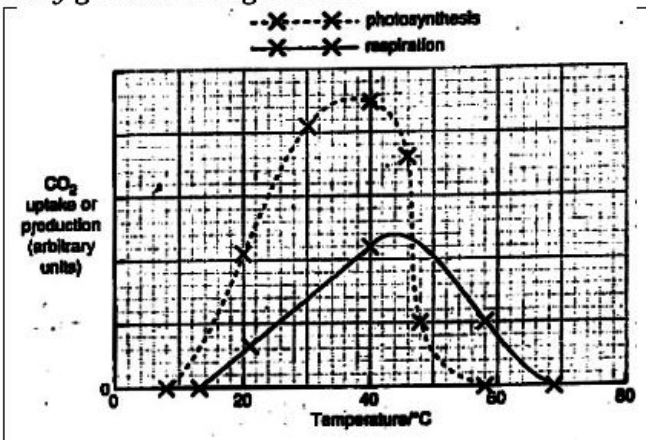
(c) Describe one difference shown in the graph, other than growth rate, between the leaves grown under different treatments. (01 mark)

Rate of photosynthesis;✓

(d) Use your biological knowledge to account for the results of the experiment. (02 marks)

Mean leaf area at 1000pm CO2 is higher than 800pm CO2;✓ *due to higher rate of photosynthesis;*✓

17. The graph shows the effect of temperature on rate of respiration and photosynthesis in a well-illuminated leaves (light and other variables kept constant)



(i) At what temperature was the net gas exchange zero? (01 mark)

At 48°C;

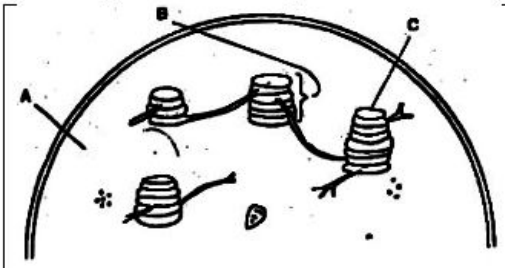
(ii) suggest a possible reason why the rate of respiration in the leaf is less affected by temperature above 40°c than is the rate of photosynthesis. (01 mark)

Respiratory enzymes have a higher tolerance to high temperature than photosynthetic enzymes;✓

(iii) What would be the effect of rise in temperature on rate of photosynthesis if the intensity of light falling on the leaf was very low? Explain your answer. (03 marks)

Rise in temperature would cause no change on rate of photosynthesis;✓ *because very low light intensity would provide little energy;* ✓ *limiting the process;*✓

18. The diagram below represents the structural part of chloroplast.



(a) Name the structures A, B and C. (03 marks)

A is stroma;✓ *B is grana;*✓ *C is thylakoid;*✓

(b) Using accurate, ruled guide-lines and the letters given below, show on the diagram the area where:

(i) ATP is produced (X) *on C/B;*✓

(ii) NADP is reduced (Y) *in A;*✓

(iii) ATP is broken down into ADP and inorganic phosphate (Z). *in A;*✓ (03 marks)

(c) State the type of molecule in the chloroplast contains:

(i) Magnesium *chlorophyll;*✓

(ii) Iron *cytochrome;*✓ (02 marks)

(d) (i) What name is given to the substance which combines with CO2 in the Calvin cycle? (01 mark) *Ribulose bisphosphate;*✓

(ii) What name is given to the first stable product produced in the Calvin cycle (light independent stage of photosynthesis) (01 mark) *Glycerate 3-phosphate(GP);*✓

END

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