Q1.

Photosynthesis is a two-stage process by which plants fix carbon dioxide.
Describe the light-dependent reactions of photosynthesis.

(5)

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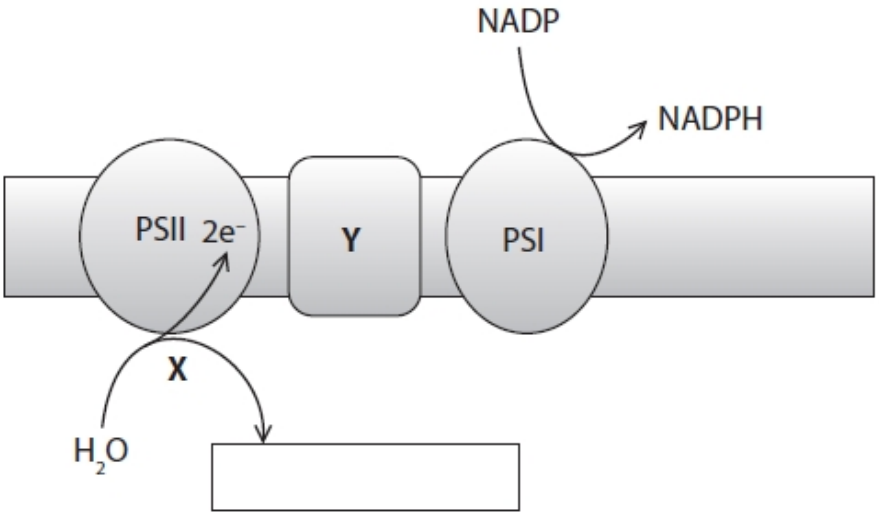
(Total for question = 5 marks)

Q2.

Photosynthesis is the process by which plants fix carbon.
The diagram shows some of the light dependent reactions of photosynthesis.



(i) Complete the box with the products of the reaction at PSII.

(1)

(ii) Which of the following is the type of reaction taking place at **X**?

(1)

- ☒ **A** condensation
- ☒ **B** hydrolysis
- ☒ **C** photolysis
- ☒ **D** reduction

(iii) Which of the following molecules are found in the PSI and PSII?

(1)

- ☒ **A** ATP
- ☒ **B** ATP synthase
- ☒ **C** chlorophyll
- ☒ **D** RUBISCO

(iv) In which part of the chloroplast does the reduction of NADP take place?

(1)

- ☒ **A** chloroplast outer membrane
- ☒ **B** chloroplast stroma
- ☒ **C** granum
- ☒ **D** thylakoid lumen

(v) Describe the role of the group of membrane proteins represented by **Y** in the diagram.

(2)

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Q3.

Photosynthesis is a two-stage process by which plants fix carbon dioxide.
The products of the light-dependent reactions are used in the light-independent reactions.

(i) In which part of the chloroplast do the light-independent reactions take place?

(1)

- ☒ **A** envelope
- ☒ **B** granum
- ☒ **C** stroma
- ☒ **D** thylakoid

(ii) What is the name of the enzyme used by plants to fix carbon dioxide?

(1)

- ☒ **A** GALPase (glyceraldehyde-3-phosphatase)
- ☒ **B** GPase (glycerate-3-phosphatase)
- ☒ **C** RUBISCO (ribulose bisphosphate carboxylase/oxygenase)
- ☒ **D** RuBPase (ribulose bisphosphatase)

(iii) Which of the following is the immediate product of the light-independent reactions of photosynthesis?

(1)

- ☒ **A** glucose
- ☒ **B** GP
- ☒ **C** RuBP
- ☒ **D** starch

(Total for question = 3 marks)

Q4.

An experiment was carried out to investigate the effect of temperature on the activity of the enzyme RUBISCO. This enzyme is involved in the light-independent reaction of photosynthesis.

The RUBISCO was isolated from cotton plants and its activity measured.

The results of this experiment are shown in the table below.

Temperature / °C	Activity of RUBISCO / arbitrary units
25	2.3
30	3.2
35	4.2
40	5.0
45	4.4
50	1.7

(a) Using the information in the table, explain the effects of temperatures above 40 °C on the activity of RUBISCO.

(5)

(b) Name the **two** substrates that would have been used in this experiment.

(1)

(c) Place a cross ☒ in the box to complete the following sentences.

(i) The pH was kept constant to make the experiment

(1)

☒ **A** accurate

☒ **B** precise

☒ **C** reliable

☒ **D** valid

(ii) The optimum temperature of RUBISCO can be determined by

(1)

☒ **A** measuring the activity at 1°C intervals between 35°C and 40°C

☒ **B** measuring the activity at 1°C intervals between 40°C and 45°C

☒ **C** measuring the activity at 1°C intervals between 35°C and 45°C

☒ **D** repeating the experiment at 35°C, 40°C and 45°C three more times

(Total for question = 8 marks)

Q5.

Chloroplasts and mitochondria are both found in plant cells.

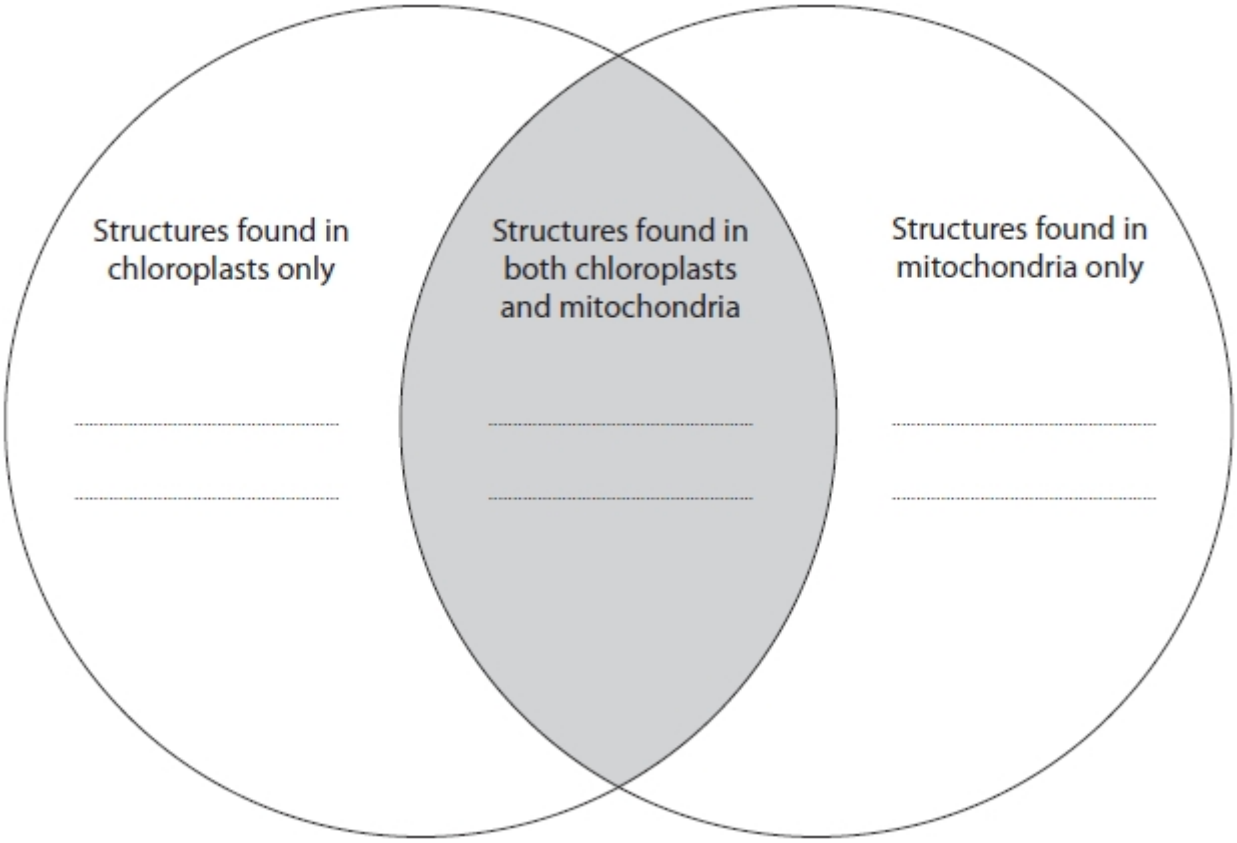
The structures found in chloroplasts and mitochondria can be studied using an electron microscope.

Some structures are found in both chloroplasts and mitochondria.
Other structures are found in either chloroplasts only or mitochondria only.

A Venn diagram can be drawn to represent this information. Structures found in both chloroplasts and mitochondria are written in the part of the diagram where the circles overlap.

Complete the Venn diagram below by writing the names of **two** structures in each part of the diagram.

(3)



(Total for question = 3 marks)

Q6.

Photosynthesis can be divided into two main stages, the light-dependent stage and the light-independent stage.

(a) Explain why the light-independent stage cannot take place without the light-dependent stage.

(3)

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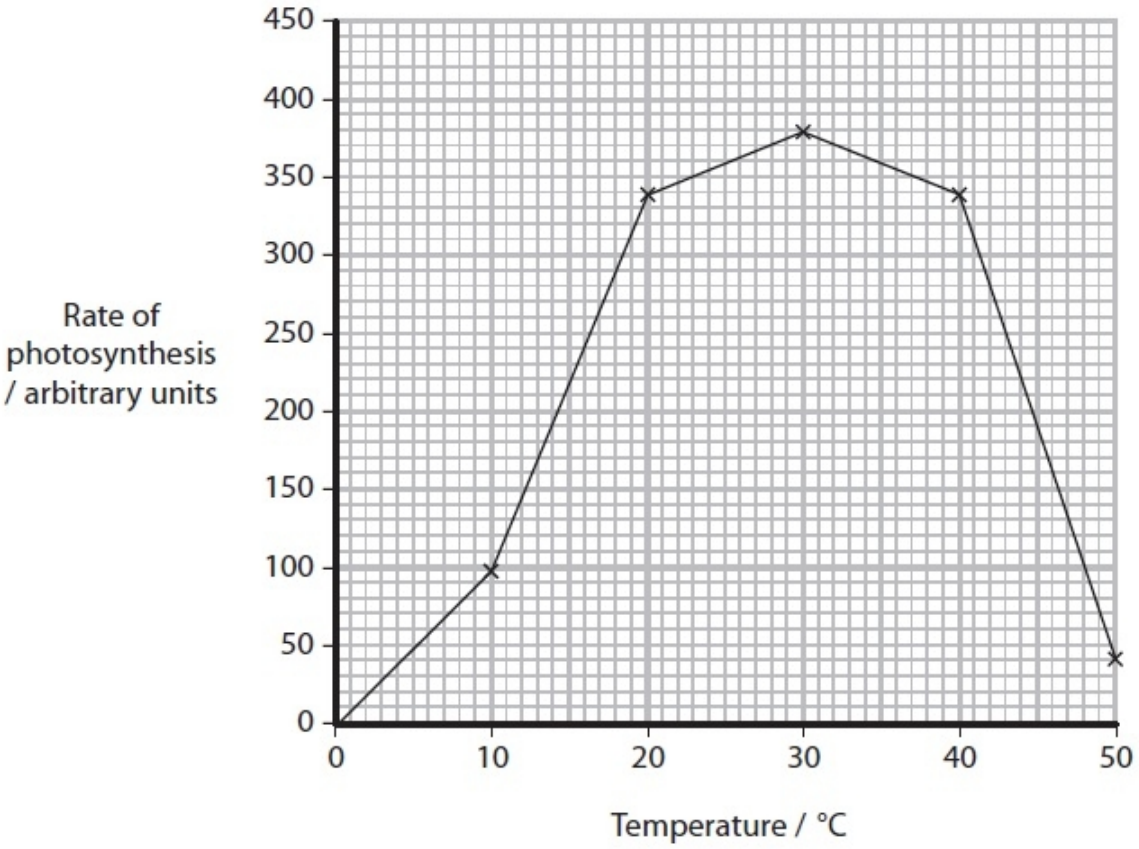
(b) An investigation was carried out by a student, to find the effect of temperature on the rate of photosynthesis in *Elodea canadensis* (Canadian pondweed).

The rate of photosynthesis was measured over a period of two hours at a fixed temperature. This was repeated at different temperatures.

All other abiotic factors were controlled.

The results of this investigation are shown in the graph below.



(i) Place a cross (☒) in the box next to the statement that describes what could be measured to find the rate of photosynthesis in this investigation.

(1)

- ☒ **A** increase in mass of Elodea
- ☒ **B** mass of nitrate absorbed
- ☒ **C** volume of carbon dioxide produced
- ☒ **D** volume of oxygen produced

(ii) The temperatures used in this investigation were 0ºC, 10ºC, 20ºC, 30ºC, 40ºC and 50ºC.

Suggest what the results of the investigation show about the minimum temperature required for photosynthesis in *Elodea*. Give a reason for your answer.

(2)

_____

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_____

(iii) Explain the meaning of the following statement.

"All other abiotic factors were controlled."

(2)

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(iv) The student, who carried out this investigation, wrote the following as part of her conclusion.

Enzymes control the rate of photosynthesis in Elodea.

Discuss how far the results of this investigation support her conclusion.

(4)

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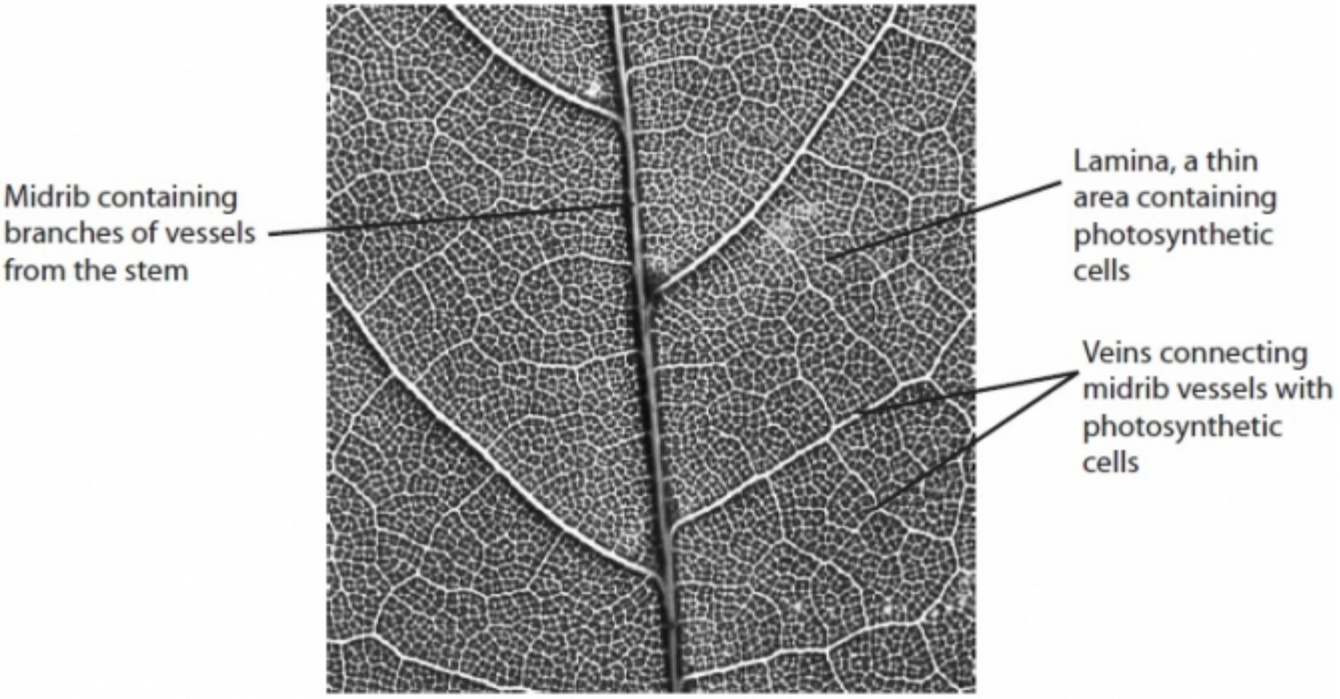
(Total for question = 12 marks)

Q7.
The photograph below shows part of a leaf, as seen using a hand lens.



Magnification ×20

(a) Suggest why each of the following is important for the production of carbohydrates in the photosynthetic cells.

(i) The thin lamina

(2)

_____

_____

_____

_____

_____

(ii) Vessels in the midrib

(2)

_____

_____

_____

_____

_____

(b) The photosynthetic cells contain many chloroplasts.

(i) Complete the table below by naming the part of the chloroplast where each of the reactions, **R**, **S** and **T**, takes place.

(3)

Reaction	Details	Part of the chloroplast
R	ADP + inorganic phosphate → ATP	
S	RuBP + CO_2 → 2 × GP	
T	2 × GP → 2 × GALP	

(ii) Place a cross ☒ in the box next to the name of reaction **R**.

(1)

☒ **A** carbon fixation

☒ **B** hydrolysis

☒ **C** phosphorylation

☒ **D** photolysis

(iii) Place a cross ☒ in the box next to the name of the enzyme involved in reaction **S**.

(1)

☒ **A** endonuclease

☒ **B** phosphorylase

☒ **C** RUBISCO

☒ **D** transcriptase

(iv) Suggest how GALP, formed by reaction **T**, can be used to synthesise the cellulose in plant cell walls.

(4)

_____

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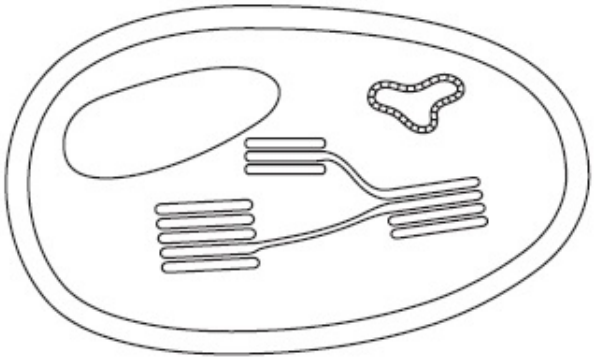
(Total for Question = 13 marks)

Q8.
Cells that photosynthesise contain many chloroplasts.

The diagram below shows a chloroplast.



(a) (i) Draw a line on the diagram to show where photophosphorylation takes place.

Label the line P.

(1)

(ii) Place a cross ☒ in the box next to the molecule produced by photophosphorylation.

(1)

☒ **A** ATP

☒ **B** NADP

☒ **C** oxygen

☒ **D** water

(b) (i) State where carbon fixation takes place in a chloroplast.

(1)

_____

(ii) The equation for carbon fixation is shown below.

molecule Y + CO_2 → 2 × molecule Z

Name the molecules Y and Z.

(2)

molecule Y _____

molecule Z _____

(iii) Name the enzyme involved in carbon fixation.

(1)

_____

*(iv) Suggest how molecule Z, the product of carbon fixation, can be used to synthesise starch.

(5)

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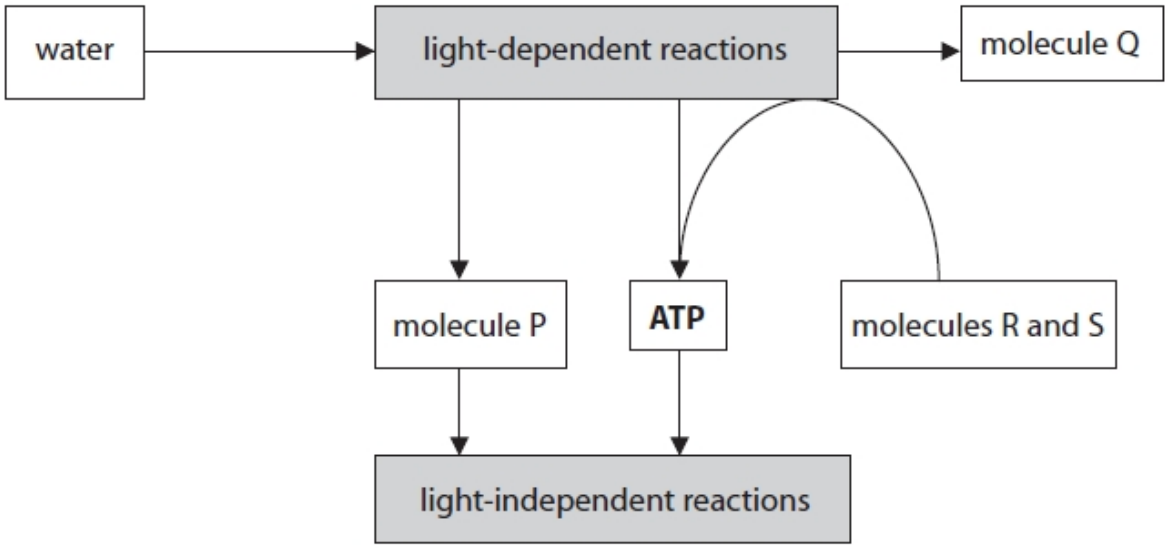
(Total for Question = 11 marks)

Q9.

(a) The diagram below shows some of the steps in the process of photosynthesis.



(i) Place a cross ☒ in the box next to the name of molecule **P** in the diagram.

(1)

- ☒ **A** carbon dioxide
- ☒ **B** oxidised NADP
- ☒ **C** reduced NADP
- ☒ **D** RUBISCO

(ii) Name the molecules **R** and **S** in the diagram.

molecule R _____

molecule S _____

(iii) Describe how molecule **Q** is produced.

(4)

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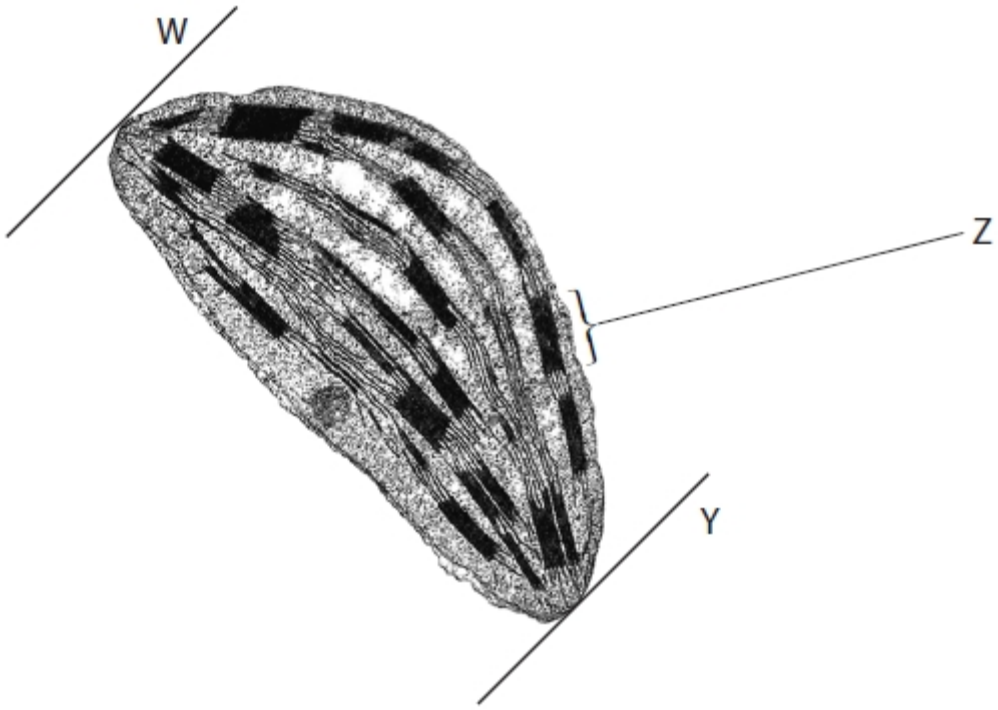
(b) The electronmicrograph below shows an image of a chloroplast.



(i) Place a cross ☒ in the box next to the name of the part labelled **Z**.

(1)

☐ **A** carbon dioxide

☐ **B** oxidised NADP

☐ **C** reduced NADP

☐ **D** RUBISCO

(ii) The equation below can be used to calculate the magnification of this chloroplast.

image length = actual length × magnification

The actual length of this chloroplast is 0.007 mm.
Measure the image length between lines **W** and **Y**. Use this equation to calculate the magnification of the image.

(3)

magnification = ...

(iii) Describe the structure of chloroplasts in relation to their roles in photosynthesis.

(3)

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(Total for question = 13 marks)

Q10.

Chloroplasts and mitochondria are both found in plant cells.

The chloroplast is involved in photosynthesis. Both the light-dependent and the light-independent reaction take place in the chloroplast.

Some of the products of these reactions are used by plants to synthesise lipids, such as triglycerides.

(i) Describe the structure of a triglyceride.

(3)

_____

_____

_____

_____

_____

(ii) Put a cross ☒ in the box next to the chemical reaction that is involved in the synthesis of a triglyceride.

(1)

☐ **A** condensation

☐ **B** hydrolysis

☐ **C** oxidation

☐ **D** reduction

(iii) Explain how the products of both the light-dependent and the light-independent reactions are used to synthesise triglycerides.

(4)

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(Total for question = 8 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to the following: • use of light (energy) to excite electrons in chlorophyll (1) • {photolysis / splitting of water} to produce oxygen, electrons and hydrogen ions (1) • electrons used { in the electron transport chain / to replace those lost by chlorophyll } (1) • generation of ATP / photophosphorylation (1) • reduction of NADP (1)	ALLOW electrons promoted to higher energy level ALLOW photosystem (PS) I or II for chlorophyll ALLOW correct equation ALLOW electrons used in redox reactions / electrons move along electron carrier proteins	5

Q2.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	$2H^+ + ½O_2$	Allow 'hydrogen ions', 'protons' and 'oxygen'	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	C (photolysis)		**(1)**

Question Number	Answer	Additional Guidance	Mark
(iii)	C (chlorophyll)		**(1)**

Question Number	Answer	Additional Guidance	Mark
(iv)	B (chloroplast stroma)		**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
(v)	A description that makes reference to two of the following: (1) • electron transport (1) • movement of hydrogen ions across thylakoid membrane (1) • ATP production / photophosphorylation		**(2)**

Q3.

Question Number	Answer	Mark
(i)	**The only correct answer is C – Stroma** A is not correct because light-independent reactions take place in the stroma B is not correct because light-independent reactions take place in the stroma D is not correct because light-independent reactions take place in the stroma	1

Question Number	Answer	Mark
(ii)	**The only correct answer is C – RUBISCO (ribulose bisphosphate carboxylase/oxygenase)** A is not correct because RUBISCO (ribulose bisphosphate carboxylase/oxygenase) is the enzyme that fixes carbon dioxide B is not correct because is not correct because RUBISCO (ribulose bisphosphate carboxylase/oxygenase) is the enzyme that fixes carbon dioxide D is not correct because is not correct because RUBISCO (ribulose bisphosphate carboxylase/oxygenase) is the enzyme that fixes carbon dioxide	1

Question Number	Answer	Mark
(iii)	**The only correct answer is B – GP** A is not correct because glucose is made from the products of the light-independent reactions C is not correct because RuBP is the molecule that CO_2 combines with to form molecules of GP D is not correct because starch is formed from glucose	1

Q4.

Question Number	Answer	Additional Guidance	Mark
(a)	1. idea that enzyme activity decreases ; 2. credit calculated reduction e.g. 0.6, 2.7 , 3.3 ; 3. idea that an increase in temperature results in increase in kinetic energy ; 4. causing changes in bonds (in the enzyme) / eq ; 5. idea that enzyme is denaturing (above 40 °C) ; 6. idea that carbon fixation is reduced ;	**5 ACCEPT** fewer enzyme-substrate complexes **NOT** starts to denature	(5)

Question Number	Answer	Additional Guidance	Mark
(b)	{RuBP / ribulose bisphosphate} AND {carbon dioxide / CO_2} ;	**ACCEPT** Rubp / ribulose biphosphate NOT CO / CO^2	(1)

Question Number	Answer	Mark
(c)(i)	**D** valid ;	(1)

Question Number	Answer	Mark
(c)(ii)	**C** measuring the activity at 1°C intervals between 35°C and 45°C ;	(1)

Q5.

Question Number	Answer	Additional guidance	Mark
	1. chloroplast only : grana, thylakoid (membrane / lumen), stroma, (inter granal) lamellae, starch {grains / granules};	**NB TWO structures needed for each mark**	
	2. both chloroplasts and mitochondria : (double) membrane, ribosomes,;	2 Ignore cytoplasm Accept (loop) DNA	
	3. mitochondria only : matrix, stalked particles, {cristae / folded inner membrane} ;	3 Ignore mesosomes	**(3)**

Q6.

Question Number	Answer	Additional guidance	Mark
(a)	1. idea that products of light-dependent stage are {needed for / used in / eq} {light-independent stage / Calvin cycle} ; 2. reference to (products of light-dependent stage) are {reduced NADP / eq} and ATP ; 3. reference to use of {reduced NADP / eq} for {reduction / eq} of {carbon dioxide / GP / eq} ; 4. reference to use of ATP as source of energy ;	**3. Accept** source of hydrogen ions for GALP **Ignore** ref to ATP	**(3)**

Question Number	Answer	Mark
(b)(i)	D volume of oxygen produced ;	**(1)**

Question Number	Answer	Additional guidance	Mark
(b)(ii)	1. (minimum temperature) is {between 0 °C and 10 °C / above 0 °C but less than 10 / 10 °C} ; 2. idea of no photosynthesis at 0°C but photosynthesis is taking place at 10 °C ; 3. reference to no {data / readings / measurements / evidence / eq} between 0 °C and 10 °C ; 4. idea that at 0 °C water is frozen ;	**3. Accept** if correct temp range has been given already	**(2)**

Question Number	Answer	Additional guidance	Mark
(b)(iii)	1. reference to abiotic factors {are non-living / non-biological / do not involve organisms / eq} ; 2. idea that **other factors** need to be kept constant ;	**2. Ignore** controlled	**(2)**

Question Number	Answer	Additional guidance	Mark
(b)(iv)	**Supporting conclusion:** 1. idea that shape of graph is typical of an enzyme-temperature graph ; 2. rate increases (up to 30 °C) because more {enzyme-substrate complexes / collisions between enzymes and substrates} / eq ; 3. rate decreases (after 30°C) due to enzyme denaturation / eq ; **Not supporting conclusion:** 4. idea that other factors could be affecting photosynthesis ; 5. idea of {gas / oxygen / carbon dioxide} solubility changing with temperature ; 6. idea of {correlation / not causation} ;	**1.** idea that rate of photosynthesis is affected by temperature in a similar way to enzymes	**(4)**

Q7.

Question Number	Answer	Additional Guidance	Mark
(a)(i)	1. idea of {fast / maximum} {gas exchange / uptake of carbon dioxide / eq}; 2. idea of penetration of light ; 3. idea that carbon dioxide is used in the {light-independent stage / Calvin cycle / formation of GP}; **OR** idea that light is used in {light-dependent stage / photolysis / photophosphorylation / eq } ;	**Accept** CO_2 but **ignore** incorrect formula	(2)

Question Number	Answer	Additional Guidance	Mark
(a)(ii)	1. transport (in xylem) of water (to the leaves) / eq ; 2. transport (in phloem) of {sucrose / sugar / carbohydrates } (away from the leaves) / eq; 3. (water) for {light-dependent reaction / photolysis / source of hydrogen (ions)}; **OR** idea of (transporting sugar) to make more room for more carbohydrate synthesis ;	**Accept** H_2O but **ignore** incorrect formula **Accept** phosphates but **ignore** mineral ions **Not** glucose or any other name sugars **Accept** reducing power, NADPH **Accept** (phosphates) for ATP synthesis	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	Reaction / Details / Structure {thylakoid (membrane) / grana / granum} ; stroma ; stroma ;	**Not** thylakoid space **Ignore** electron transport chain **Not** stoma / stomata **Not** stoma / stomata	(3)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	C ;		(1)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	C ;		(1)

Question Number	Answer	Additional Guidance	Mark
(b)(iv)	1. reference to conversion (of GALP) to glucose / eq; 2. (which is) β glucose ; 3. reference to formation of glycosidic bonds ; 4. between C_1 and C_4 / these bonds are 1-4 (glycosidic bonds) ; 5. by condensation ; 6. reference to {straight / unbranched} (chains of glucose) ; 7. reference to cellulose as a {polysaccharide / polymer of glucose / eq} ;	**NB** this is a question about the **formation** of cellulose, not its structure **NB** a reference to these bonds being formed must be made	**(4)**

Q8.

Question Number	Answer	Additional Guidance	Mark
(a)(i)	Line to diagram feature {grana / thylakoids / thylakoid membrane / inter-granal membrane } ;	**Ignore** any labelling of the line	(1)

Question Number	Answer	Additional Guidance	Mark
(a)(ii)	A ; ATP		(1)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	stroma ;	**Accept** phonetic spelling eg strona, stromma **Not** stoma / stomata	(1)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	Y. RuBP / ribulose bisphosphate ; Z. GP / glycerate (3) phosphate ;	**Y. Accept** ribulose biphosphate **Not** ribose **Z. Accept** (3) phosphoglyceric acid / (3) PG / PGA / 2-Hydroxy-3-phosphonooxypropanoic acid **Not** glyceraldehydes (3) phosphate / GALP	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	RUBISCO / ribulose bisphosphate carboxylase (oxygenase) ;	**Accept** ribulose biphosphate carboxylase RUBISCO written in upper or lower case or a mixture **Not** ribose	(1)

Question Number	Answer	Additional Guidance	Mark
*(b)(iv)	QWC – Spelling of technical terms must be correct and the answer must be organised in a logical sequence 1. idea of conversion (of *GP / Z*) to *GALP* / eq ; 2. using *ATP* and reduced *NADP* / eq ; 3. idea of conversion (of *GALP*) to {*glucose* / hexose} eq ; 4. (which is) a *glucose* ; 5. reference to formation of *glycosidic bonds* ; 6. these bonds are 1-4 and 1-6 (*glycosidic bonds*) / eq ; 7. by *condensation* ; 8. ref to *amylose* and *amylopectin* ; 9. credit details of *amylose* e.g. straight chain, 1-4 bonds ; 10. credit details of *amylopectin* eg branched, 1-4 and 1-6 bonds ;	**QWC emphasis is spelling** **NB** this is a question about the **conversion** of GP and the **formation** of starch, not its structure 1. **NB** idea of conversion needed 3. **NB** idea of conversion needed **5. NB** a reference to these bonds being formed must be made	**(5)**

Q9.

Question Number	Answer	Mark
(a)(i)	**C** reduced NADP	(1)

Question Number	Answer	Additional Guidance	Mark
(a)(ii)	1. ADP / adenosine diphosphate ; 2. PO_4^{3-} / phosphate ;	ACCEPT either way round 2. ACCEPT Pi / inorganic P	(2)

Question Number	Answer	Additional Guidance	Mark
(a)(iii)	1. molecule Q is {oxygen / O_2}; 2. made from water / H_2O; 3. idea of {photolysis / light splitting the water molecule / eq} ; 4. into {O / (atom of) oxygen} (and H^+ and electrons) ; 5. idea that two water molecules are needed to form one molecule of oxygen ; 6. in chloroplast ;	1. reject O , 1/2 O_2 4. ACCEPT $H_2O \rightarrow 1/2\ O_2 + 2H^+$	(4)

Question Number	Answer	Mark
(b)(i)	**A** granum	(1)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	1. (image length) 76 / 76.5 / 77 (mm) / eq ; 2. image length / 0.007 ; 3. (76) 10857.14286 / eq ; (76.5) 10928.57143 / eq ; (77) 11000 / eq ;	2. CE applies 3. CE applies	(3)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	1. idea of compartmentalisation (from cytoplasm); 2. thylakoid (membranes) are site of {light-dependent reaction / photophosphorylation / chemiosmosis} ; 3. credit named molecules {within / on / eq} membrane ; 4. idea that (thylakoid) membranes provide a space for accumulation of H^+ ; 5. stroma is site of {light-independent reaction / Calvin cycle / carbon fixation} ; 6. reference to {RuBP / RUBISCO / eq} ;	1. ACCEPT description of separation 3. e.g. chlorophyll / carotenoids / photosystems / electron carrier proteins / ATP synthetase / NADP reductase	(3)

Q10.

Question Number	Answer	Additional guidance	Mark
(i)	1. one glycerol and three fatty acids ; 2. reference to ester bonds (between fatty acids and glycerol); 3. idea that (triglycerides /fatty acids / hydrocarbon chains) may be saturated or unsaturated ;	3 Accept description of presence and absence of double carbon carbon bonds	(3)

Question Number	Answer	Mark
(ii)	**The only correct answer is A - condensation** ***B*** *is not correct because hydrolysis breaks bonds* ***C*** *is not correct because this is not an oxidation reaction* ***D*** *is not correct because this is not a reduction reaction*	(1)

Question Number	Answer	Additional guidance	Mark
(iii)	1. use of reduced NADP produced by light-dependent reaction; 2. use of ATP produced by light-dependent reaction; 3.(light-independent reaction produces) {GALP / trioses} used in synthesis of {FAs / glycerol / triglyceride} ; 4. {GALP / trioses} converted to amino acids used to synthesise {proteins / enzymes} / eq ; 5. idea of enzymes used in synthesis of triglycerides ;	3 Accept GALP to glucose to glycerol	(4)