CAMBRIDGE INTERNATIONAL AS & A LEVEL BIOLOGY · 9700

BIOLOGY



MARK SCHEME

13 PHOTOSYNTHESIS

SCORE	PERCENTAGE
/	%

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Paper 1 Multiple Choice Answers: Photosynthesis

Question	Paper	Q. No.	Answer
1606	9700_w15_qp_11	39	A
1607	9700_w15_qp_12	39	D
1608	9700_w15_qp_13	39	C
1609	9700_w15_qp_13	40	A
1610	9700_s15_qp_12	38	A

242. 9700_w15_ms_21 Q: 6

(a) (i) grass **;** [1]

(ii) rabbit(s) / grasshopper(s) **;** [1]

(iii) fox(es) **;** [1]

(b) denitrification **;**
nitrification **;**
nitrogen fixation **; A** Haber process [3]

[Total: 6]

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243. 9700_s16_ms_22 Q: 3

(a) (i) 1179 **;;**

one mark *if not to the whole person e.g. 1179.24 / 1179.2* **or**
if calculation correct but answer incorrect
e.g. 1.39 × 848.38 **or** 1.39 × (84 838 000/100 000) **or**
if no calculation to check but answer given as 1180 **[2]**

(ii) **1** provides information about / AW, proportion / percentage, (of population) affected / AW **;**
2 to, make (valid) comparisons / compare **;** *between countries / in one country over time*
3 provides information about severity of disease **;** AW

4 population size, taken into account / different for different countries / changes over time in a country **;**
do not need 'size' if 'use of 'population' is in correct context

5 *idea that* countries with larger populations will usually have more cases / higher number of cases may just mean larger population of country**;**

6 AVP **;** gives guidance about whether the disease is, spreading / becoming an epidemic / dying out (in one country) *in context of over time*
idea that number of cases per 100 000 are, standardised / normalised, values
7 use of data to support **;** *only two of Chad, Eritrea or Ethiopia where comparisons between countries stated* **I** *ref. to* other countries

(2009) actual cases and standardised cases

comparison (2009) to support mp 5 population size and actual cases

stated values of similar number of cases per 100 000 and populations of different sizes

countries compared, number of cases per 100 000 for any stated year, with comment about severity

number of cases per 100 000 for one country over time, with comment about severity / spreading / dying out / control / AW **[max 3]**

Q1.

1 (a) top half of leaf/just below (upper) epidermis;
packed (densely);
long axis in line with incident light/AW;

2 max

(b) contain large numbers of chloroplasts/large amount of chlorophyll;
large vacuole; *(only give if linked to next point)*
chloroplasts (in cytoplasm) close to cell wall/cell membrane;
short diffusion pathway;
(cell) elongated/arranged to intercept (maximum) light;
thin (cell) wall;
ref. movement of chloroplasts;

3 max

(c) contains photosystems/PS1 and PS2/chlorophyll and accessory pigments/ reaction centres;
maintain carriers/receptors in position;
site of photophosphorylation/light reaction;
site of ETC;
ref. proton pumping/proton gradient;
large surface area;
produce ATP/ref. ATP synthase;
produce reduced NADP;

4 max

(d) ref. to Rubisco;
carbon dioxide combines with RuBP;
driven/powered by ATP;
and reduced NADP;
forms PGA;

2 max

Total: 11

Q2.

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Question			Marks
4	(a)	**A** epidermal cell ;	
		B guard cell ;	2
	(b)	allows carbon dioxide into leaf ;	
		as rest of leaf covered with waxy / waterproof cuticle ;	
		down concentration gradient / diffuses ; *for **either** O_2 **or** CO_2*	
		controls water (vapour) loss ;	
		ref. to faster diffusion through small pores / edge effect ;	
		oxygen out ;	4 max
	(c)	ref. to chloroplasts ;	
		sausage shaped / AW ;	
		joined only at ends ;	
		unevenly thickened walls / thick above and below / thin furthest from the pore ;	
		ref. vacuole ;	2 max
			Total: 8

Q3.

Question			Marks
5	(a)	stroma of chloroplast ;	1
	(b)	combines with (5C compound) RuBP ;	
		to form unstable 6C compound / forms 2 molecules of (3C) GP ;	
		ref. enzyme / rubisco ;	2 max
	(c)	reduced NADP and ATP ;	
		(ATP is) source of energy ;	
		(reduced NADP is for) reduction of GP(PGA) to triose phosphate (TP) ;	
		ref. use of ATP in regeneration of RuBP ;	
		ref. to source of phosphate / phosphorylation ;	3 max
	(d)	RuBP, accumulates / goes up ;	
		due to reduced combination with CO_2 / AW ; *in either RuBP or GP, not both*	
		GP, goes down / not as much being formed ;	
		due to conversion to TP ;	3 max
			Total: 9

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Q4.

2	(a)	(i)	at low light intensities ; rate of photosynthesis is proportional to light intensity / light intensity is limiting ; after 1 units of light ; rate levels off / reaches plateau ; relevant fig plus units ;	[3 max]
		(ii)	(B) after 3 units light intensity not limiting ; CO_2 now limiting ; (C) curve continues to increase until 5 units of light ; light intensity limiting ; correct description of law of limiting factors ; detail. collisions of CO_2 and enzymes ; AVP ; e.g., further detail of enzymes	[4 max]
	(b)		optimum temperature ; method e.g. heaters / ventilation ; optimum CO_2 concentration ; burners / combustion / add dry ice / pump in CO_2 up to 1% ; high light intensity / longer duration of light / artificial lighting ; ref. irrigation ; ref. fertilisers ; ref. pest / disease control ; ref. artificial pollination ;	[2 max]
				[Total: 9]

Q5.

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7 (a) (i) *ref. wavelength*

1 chlorophyll **a** peaks at 430nm **and** chlorophyll **b** peaks at 450nm ;

2 chlorophyll **a** peaks at 660nm **and** chlorophyll **b** peaks at 635–640nm ;

3 ref. linking 400–500nm with blue light / ref. linking 600–700nm with red light ;

4 (both have) little absorption, between 500–600nm / in green light ;
A little absorption, chlorophyll **a** 450–600 **and** chlorophyll **b** 500–600 ;

ref. light absorption

5 (both) peaks in blue light are higher than peaks in red light ;

6 chlorophyll **b** higher than chlorophyll **a** in the blue end / chlorophyll **a** higher than chlorophyll **b** in the red end / AW ; **A** converse

7 comparative figures for light absorption to illustrate points 5 or 6 ; [3 max]

ignore units

(ii) 1 absorbed light used for photosynthesis ;

2 higher rate of photosynthesis in red and blue light ;

3 action peak(s) / high rate of photosynthesis, correspond to absorption peak(s) ;

4 blue / shorter wavelength, light has more energy / ora ;

5 not an exact match between absorption and action spectra (in middle region) ;

6 role of carotenoids / accessory pigments, (in middle region) ; [3 max]

(iii) they contain chlorophyll ;

green / blue green / yellow green, light reflected ; [2]

(b) **W** – label line to stroma ;
Y – label line to, granum / intergranal membranes ; [2]

(c) 1 light not limiting ;

2 much, ATP / reduced NADP, available ;

3 CO_2 is the limiting factor ;

4 because low concentration CO_2 (in atmosphere) ;

5 more CO_2 combines with RuBP ;

6 ref. rubisco ;

7 Calvin cycle / light independent stage ;

8 GP to TP ;

9 more hexose produced ;

10 ref. fate of hexose ; [5 max]

[Total:15]

Q6.

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8 (a) M – palisade ;

N – vascular bundle / phloem and xylem / vein ; [2]

(b) 1 ref. ABA absence ;

2 H^+ transported out of guard cells, actively / using ATP ;

3 low H^+ conc / negative charge, inside cell ;

4 K^+ channels open / K^+ diffuses into cell ;

5 water potential of cell falls ; **A** decrease in solute potential

6 water moves into cell by osmosis ;

7 volume of guard cells increase / turgor increases ;

guard cells:

8 have hoops of cellulose microfibrils which ensure increase in length rather than diameter ;

9 have ends that are joined together ;

10 have, thicker inner walls / thinner outer walls ;

11 curve apart / bend, (to open stoma) ; [6 max]

(c) (i) cyclic photophosphorylation ; [1]

(ii) photolysis ;

(water splits into) $2e^-$, $2H^+$ and $(½)O_2$;

enzyme is involved ; [2 max]

(iii) ATP ; [1]

(iv) hydrogen carrier ;

GP, reduced / hydrogen added ; **R** H_2

to, TP / 3 carbon sugar ;

uses ATP ; [2 max]

[Total: 14]

Q7.

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4 (a) (i) **J** – epidermis/epidermal cell ;
K – mesophyll (cell) ;
L – bundle sheath (cell) ; [3]

(ii) 1 mesophyll cells tightly packed/AW ;

2 so O_2 cannot reach bundle sheath cells ;

3 light independent stage/Calvin cycle **or** RuBP, in bundle sheath cells ;

4 ref. malate shunt ;

5 maintains high CO_2 concentration (in bundle sheath cells) ;

6 PEP carboxylase, has high optimum temperature/has higher affinity for CO_2/doesn't accept O_2 ;

7 (PEP carboxylase) not denatured ;

8 photorespiration is avoided ; [4 max]

(b) 1 reduces water loss/AW ;

2 wax does not melt ;

3 shiny surface reflects radiation ; [2 max]

(c) (i) greater <u>reduction</u> in sorghum than in soybean ;
use of comparative figures ; e.g. sorghum 5.5 to 1.2 **or** by 4.3
soybean 5.2 to 1.6 **or** by 3.6 [2]

(ii) *reject 'no' for all points*

1 less surface area ;

2 less absorption of light ;

3 less, photophosphorylation / light dependent reaction ;

4 less chemiosmosis ;

5 (due to) smaller thylakoid space **or** reduced proton gradient ;

6 less ATP (produced) ;

7 less reduced NADP (produced) ;

8 light-independent reaction / Calvin cycle, slows down ;

9 less carbon dioxide, fixed / combined with PEP ; **R** uptake [4 max]

[Total: 15]

Q8.

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8 (a) (i) 1. 26 °C optimum temperature for, rubisco / enzyme of Calvin cycle ;

2. (at just over 40 °C) enzymes / rubisco, denatured ;

3. so less carbon dioxide fixed ;

4. reduction in Calvin cycle / AW ;

5. increased rate of transpiration / AW ;

6. so stomata close ;

7. less carbon dioxide uptake ;

8. oxygen more likely to combine with rubisco ;

9. so increased photorespiration ; [5 max]

(ii) curve of C4 drawn with optimum to the right of existing curve ; *1 mark*

1. C4 / sorghum, enzymes, have higher optimum temperature (than C3) ;

2. has leaf structural features to avoid photorespiration ;

3. adapted to hot climate ; *2 max* [3 max]

(b) (i)

light intensity /lux	total CO_2 uptake / µmol	rate of photosynthesis /µmol s^{-1}
5	36	1.8
10	84	**4.2**
13	104	**5.2**
15	120	**6.0**

all 3 correct = 1 mark [1]

(ii) axes correct ;
units ;
correct plotting ;
suitable curve ; *between 5 and 15 lux*

accept ecf from table [3 max]

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(iii) when a process is affected by more than one factor / AW ;

the rate of photosynthesis is, restricted by / AW, the factor that is nearest its lowest value ; [2]

(iv) light intensity ; [1]

[Total: 15]

Q9.

8 **(a)** (guard cell) thicker inner / unevenly thickened, cell wall ; **ora**

ref. to differences in, size / shape ; [1 max]

(b) **(i)** (receptors) on plasma / cell surface, membrane (of guard cells) ; [1]

(ii) K^+ / potassium ; [1]

(iii) (guard cell has) higher water potential than epidermal cell ; **ora** [1]

(iv) decrease ; [1]

(c) **(i)** provides carbon dioxide ; [1]

(ii) 0.1 ;
% per minute ; *reject plural* [2]

(iii) 0 – 10 mins / initially, rate for **B** is faster than rate for **A** ;

10 – 20 mins / AW, rate decreases for **B** and not for **A** / rate decreases more for **B** ;

paired figs ; *A & B % at same time (minutes)* [2 max]

(iv) no, photosynthesis / light dependent reaction ;

oxygen used up in respiration ; [2]

(v) temperature ; [1]

(d) reduced NADP ;

ATP ; [2]

[Total: 15]

Q10.

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1 (a) **A** – palisade, mesophyll/cell/tissue/layer;

B – guard cell;

C – (sub-stomatal) air space;

[3]

(b) (i) 1. through the stoma(ta);

2. by diffusion/description;

3. from the, atmosphere/air; [max 2]

(ii) ribulose bisphosphate;
I RuBP [1]

(iii) reduces/donates hydrogen ; [2]
A H/hydrogen atoms/H^+ **AND** e^-
R H^+ / H_2

GP to TP ;
A PGA to PGAL

[Total: 8]

Q11.

1 (a) (i) *in high light intensity*
1. (as temperature increased) the volume of oxygen released / rate of photosynthesis, increased to a peak **and** then fell;

in low light intensity
2. (as temperature increased) the volume of oxygen released / rate of photosynthesis, remained constant **and** then fell;

3. supporting figures (two oxygen values at two different temperatures plus units); [3]

(ii) 1. light no longer limiting / temperature now limiting;

2. enzymes denatured / described;

3. so fewer enzyme-substrate complexes / AW;

4. so less photolysis (leads to less oxygen produced); [2 max]

(b) (i) photolysis; [1]

(ii) P680; **A** (photosystem) II [1]

(iii) respiration uses oxygen; [1]

[Total: 8]

Q12.

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Question 1

(a)
(i)
increase ;
rapid/sharp/steep ;
then decrease ;
does not drop to original value ; **2 max**

(ii)
decreases to 0 / all used up ; **1**

(b)
(i)
GP continues to be formed from RuBP;
(until) all RuBP used up ;
the GP falls as converted to hexose/glucose/TP ; **2 max**

(ii)
in dark RuBP not regenerated/converted to GP ; **R** used up
requires the products /ATP/reduced NADP from the light reaction / photophosphorylation ; **2**

(c)
ATP ;
reduced NADP ; **2**

Total : 9

Q13.

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Question 1

(a)
1 sun leaves reach compensation point / zero gas exchange at higher light intensity;
2 rate of photosynthesis increases more rapidly in sun leaves ;
3 CO_2 uptake is greater in shade leaves (ora) at low light intensity ;
4 higher rate of photosynthesis / CO_2 uptake in sun leaves (ora) at higher light intensity ;
5 more respiration in sun leaves (ora) at zero or low light intensity;
6 CO_2 uptake levels off in shade leaves (ora) ; **3 max**

accept CO_2 uptake for photosynthesis and vice versa
accept CO_2 production for respiration and vice versa

(b) light no longer limiting ;
some other factor limiting ;
example carbon dioxide concentration / temperature / ref:chlorophyll ; **3**

(c) at low light intensity little or no effect / light (dependent reaction) limiting rate ;
at high light intensity increasing temperature will increase the rate of photosynthesis ;
ref. (effect of temperature on the rate of) enzyme controlled reactions / light independent stage ;
detail – e.g. named enzyme (RuBISCO) / ref. Calvin Cycle ;

ignore reference to sun / shade leaves **3 max**

Total : 9

Q14.

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1	(a) 1	chlorophyll absorbs mainly red and blue light;	
	2	light absorbed by antenna complex;	
	3	energy transferred;	
	4	reaction centres/P700/P680;	
	5	light energy excites electron(s)/reference passing to higher energy level;	
	6	electron lost from chlorophyll	**3 max**
	(b) 1	water is split into H^+ and OH^-;	
	2	electron removed from OH^-;	
	3	to replace electron from photosystem/chlorophyll;	
	4	OH breaks down into O_2 and water;	
	5	H^+ used to form reduced NADP;	
	6	reference correct, balanced equation;	**3 max**
	(c) 1	reference flow of electrons along ETC;	
	2	reference to pumping H^+ across membrane;	
	3	reference to H^+/proton gradient across the thylakoid membrane;	
	4	flow of protons down gradient;	
	5	via ATPase/stalked particles;	
	6	formation of ATP from ADP and P_i;	
	7	cyclic, electron returns to original photosystem;	
	8	non-cyclic, electron from PSII to PSI;	**3 max**
	(d)	reference increased efficiency/short diffusion distance/close together;	**1**
			Total 10

Q15.

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9 (a) (i) ribulose ; [1]

(ii) ribulose bisphosphate carboxylase / rubisco ; [1]

(iii) stroma ; **R** stoma [1]

(iv) ATP / reduced NADP ; **R** reduced NAD [1]

(b) 1 light independent reaction / Calvin cycle, continues ;

2 RuBP (still) converted to GP ;

3 until used up ; *link to 2*

4 light dependent reaction stops ;

5 no, ATP / reduced NADP, produced ;

6 RuBP not regenerated ;

7 GP, coverted to TP / used to make hexose ; [4 max]

[Total: 8]

Q16.

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8	(a)	(i)	*at low light intensity* 1. rate of photosynthesis increases as light intensity increases ; 2. light <u>intensity</u> is limiting factor ; *at higher light intensity* 3. graph, levels off / forms a plateau / rate becomes constant ; 4. CO_2 / some other factor, becomes limiting ;	[3 max]
		(ii)	1. above light intensity of 1 rate is always higher for expt. 2 ; 2. plateau reached at lower light intensity for expt. 1 ; 3. maximum / plateau, rate is double for expt. 2 ; 4. expt 2 has much more CO_2 (conc) (compared to expt 1) ; 5. CO_2, no longer limiting after 4.2 in expt.2 / is limiting in expt. 1 up to 2.8 ;	[3 max]
	(b)	1	enzymes, denatured / active site changes shape ;	
		2	rubisco / enzyme in cyclic photophosphorylation ;	
		3	Calvin cycle affected / description ;	
		4	less photolysis ;	
		5	less ATP produced ;	
		6	increased rate of respiration ;	
		7	respiration rate faster than photosynthesis rate / ref. compensation point ;	
		8	increased rate of transpiration ;	
		9	stomatal closure ;	
		10	less CO_2 uptake ;	[5 max]
				[Total:11]

Q17.

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8	(a)	1	stomata ;	
		2	air spaces (between cells) ;	
		3	thin cell walls ;	
		4	moist internal walls ;	
		5	thin leaf ;	
		6	cylindrical palisade cells ;	
		7	large surface area of, palisade / mesophyll, cells ;	[4 max]
	(b)		0.0025 / 2.5 x 10^{-3}; **A** 0.003 only if 0.0025 in answer	[1]
	©	1	photosynthesis takes place ;	
		2	oxygen is produced ;	
		3	collects, inside disc / on surface of disc ;	
		4	disc, less dense / more buoyant ;	[3 max]
	(d)		rate of photosynthesis increases as light intensity increases ;	
			paired data quotes from columns 2 and 4 ;	[2]
	(e)	1	light intensity no longer limiting ;	
		2	carbon dioxide, concentration / rate of diffusion, now limiting ;	
		3	temperature, too high / denatures enzymes ;	[2 max]
				[Total: 12]

Q18.

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8 **(a)** 1 absorb light ; **A** harvest light / trap light **R** collect light

2 pass <u>energy</u> to, primary pigment / chlorophyll / reaction centre ; [2 max]

(b) *cyclic photophosphorylation*

1 electron emitted returns to, PSI / same photosystem or same chlorophyll molecule ;

non-cyclic photophosphorylation

2 electron emitted from PSII absorbed by PSI ;

3 reduced NADP produced ;

4 photolysis occurs ; **A** splitting of water

5 (photolysis) only involves PSII ;

6 oxygen produced *3 max*

accept ora for cyclic for marking points 3, 4 and 6

mark to max 3 if cyclic and non-cyclic are described the wrong way round [4 max]

(c) **(i)** some other factor becomes limiting / temperature no longer limiting ;

CO_2 / light intensity ; [2]

(ii) line falls towards 70°C ; [1]

(iii) *rate of photosynthesis falls*
enzyme / rubisco, denatured / AW ;

substrates not able to fit active site / AW ; [2]

(d)

adaptation	how the adaptation helps photosynthesis
thin cell wall	greater light penetration / short diffusion distance (for gases) ;
cylindrical shape	air spaces ;
large vacuole	chloroplasts near outside of cell for better light absorption / maintains turgor ;
chloroplasts can be moved within the cell	absorb maximum light / avoid excessive light intensities ;

[4]

[Total: 15]

Q19.

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8 (a) 1 high rate of photosynthesis at 430–435 nm **and** 655 nm wavelengths ;

2 idea of (high) absorption of light at these wavelengths ;

3 highest rate, at 430–435 nm ;

4 shorter wavelengths have more energy ;

5 low(er rate) in, middle range / 500–600, of wavelengths ;

6 low light absorption here ;

7 absorbed light used for photosynthesis ;

8 in light-dependent stage ; [4 max]

(b) (i) ATP ;

reduced NADP ; [2]

(ii) 1 ATP provides energy ;

2 reduced NADP, is reducing agent / provides hydrogen ;

3 for converting GP to TP ;

4 (ATP used to) regenerate RuBP ; [3 max]

(c) process / photosynthesis, affected by more than one factor ;

rate is limited by the factor nearest its minimum value / AW ; [2]

(d) 1 enters leaf through (open) stomata ;

2 by diffusion ;

3 substomatal air space ;

4 many air spaces in spongy mesophyll ;

5 spaces between palisade cells ;

6 dissolves in moisture on cell (walls) ;

7 enters through cell walls ; [4 max]

[Total: 15]

Q20.

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7 (a) (i) 1. (blue) light is absorbed and used for photosynthesis ;

2. CO_2 , used / concentration decreased ;

3. leads to, rise in pH / decrease in acidity ; [max 2]

(ii) 1. respiration **but no** photosynthesis ;

2. CO_2, produced / released ;

3. leads to, decrease in pH / increase in acidity ; [max 2]

(b) (i) absorb light (energy) ;

pass (light) <u>energy</u> onto, primary pigment / chlorophyll a / reaction centre ; [2]

(ii) $H_2O \longrightarrow 2H^+ + 2e^- + \frac{1}{2} O_2$;

A $2H_2O \longrightarrow 4H^+ + 4e^- + O_2$ [1]

(iii) grana / thylakoid, <u>membrane</u> ; [1]

[Total: 8]

Q21.

7 (a) **A** – photosystem II / P680 / PS II ;

B – photosystem I / P700 / PS I ; [2]
if photosystem given for both but wrong way round give one mark

(b) (i) 1. carbon dioxide fixation ;

2. production of GP ;

3. ref. to rubisco ; [max 2]

(ii) 1. reduction (of GP) / donates hydrogen ;

2. GP to TP ; [2]

(iii) 1. supplies, energy / phosphate ;

2. (to convert) GP to TP ;

3. (to) regenerate of RuBP ; [max 2]

[Total: 8]

Q22.

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1 (a) (i) stroma ; [1]

(ii) lower CO_2 concentration ;

less, carbon fixation / CO_2 combining with RuBP / RuBP converted to GP ;

RuBP reformed from TP ; [max 2]

(iii) 0.01 ;;

A 0.012 **or** $1.8 \div 150$ **or** $\frac{2.0 - 0.2}{150}$ **or** $\frac{2.0 - 0.2}{350 - 200}$ for 1 mark [2]

(b) less TP ;

(so less) conversion to, (other) carbohydrates / lipids / amino acids / proteins ;
A named examples, e.g. glucose / hexose / cellulose / starch

AVP ; e.g. 1 – (amino acids) used to make proteins for, growth / cell division
e.g. 2 – (carbohydrate / lipid) for respiration for, growth / cell division [max 2]

[Total: 7]

Q23.

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1 **(a)** transport proteins – **Y** ;

pigments – **X** ; [2]

(b) *DNA*
codes for, proteins / polypeptides / enzymes ;

one example of protein or enzyme ;
e.g. rubisco / electron acceptor / ATP synthase / transport

ref. transcription / mRNA ; [max 2]

(c)

factor	stage	✓or ×
carbon dioxide concentration	Calvin cycle	✓
	photolysis	×
light intensity	Calvin cycle	×
	photolysis	✓
temperature	Calvin cycle	✓
	photolysis	×

;;;

all 6 correct = 3 marks
4 or 5 correct = 2 marks
2 or 3 correct = 1 mark [3]

[Total:7]

Q24.

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8 (a) (i) **A** – RuBP / ribulose bisphosphate ;

B – fatty acid ;

C – nitrates ; **A** suitable nitrogenous substance e.g. ammonium ions
I nitrogen / ammonia [3]

(ii) non-cyclic photophosphorylation ; [1]

(iii) condensation / polymerisation ; **A** anabolic

glycosidic ; [2]

(iv) 1 enters via stoma(ta) ;

2 by diffusion / down a concentration gradient ;

3 passes through air spaces ;

4 dissolves in film of water (on cell surface) ;

5 (diffuses) through cell, wall / surface membrane (of palisade cells) ; [max 3]

(b) 1 excited electrons leave, chlorophyll a / photosystem ;

2 pass along ETC ;

3 protons present from photolysis ;

4 protons (pumped) into intermembrane space ;

5 rubisco is in stroma ;

6 *idea that* protons leaving stroma raises pH ; [max 3]

[Total: 12]

Q25.

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8 (a) **X** pointing to chloroplast ;

Y pointing to cell wall ;

Z pointing to any membrane ; [3]

(b) (i) rate on *y*-axis **and** light intensity on *x*-axis ;

all points plotted accurately ;

line of best fit ; [3]

(ii) 1 at low light intensity light is the limiting factor ;

2 at high light intensity other factors become limiting ;

3 such as, temperature / carbon dioxide concentration ; [3]

(c) (i) chlorophyll b **and** carotenoids ; [1]

(ii) 1 absorb light (energy) ;

2 at wavelengths not readily absorbed by, chlorophyll a / primary pigment ;

3 pass energy to, chlorophyll a / primary pigment ;

4 in reaction centre ; [max 3]

(iii) reflected ; [1]

(iv) action spectrum ; [1]

[Total: 15]

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