

1. (i) control;

CREDIT a description e.g.

- comparison
- to compare results with
- to show that (wavelengths of) light is producing the effect
- to show the result produced without light
- create baseline
- create set point
- validity

IGNORE 'fair test'

DO NOT CREDIT 'control variable' / 'controlled variable'

1

(ii)

Read as paragraph. Mark the first 2 responses only.

DO NOT CREDIT ref to **time** / same **number** of leaf discs / **same plant** (as these given in the question)

IGNORE 'fair test' without further explanation

- 1 discs, the same size / cut with same cutter, **so** same surface area;
ALLOW for same amount of pigment / chloroplast
- 2 discs taken from same part of the leaf / leaves used from the same part of the plant **so** same amount of, pigment / chloroplast;
- 3 tubes same distance from light source **so** light intensity is the same;
- 4 light bulb the same (wattage) each time **so** light intensity is the same;
- 5 same thickness of filter **so** light intensity is the same;
- 6 carry out in darkened room / only 1 light source in room / completely cover tube with filter, **so** only light of desired wavelength enters;
- 7 CO₂ in excess / AW, **so** CO₂ not limiting / enough CO₂ for photosynthesis / enough CO₂ for Calvin cycle / enough CO₂ for light independent stage;
- 8 same, volume / concentration / batch, of indicator **so** that colour changes are comparable;

- 9 heat, sink / shield, between light source and tube *to* reduce temperature changes;
- 10 carry out at, same / constant, temperature *as* temperature affects enzyme, activity / structure;
Enzyme ref must be qualified
- 11 carry out, repeats / replicates, *to*, calculate mean / identify anomalies;
IGNORE ref to improving reliability
IGNORE how anomalies dealt with
DO NOT CREDIT preventing anomalies
- 12 AVP (to include precaution and explanation);;
CREDIT any reasonable precaution with a suitable explanation (even if explanation already given)
e.g. • rinse test tubes with distilled water so starting pH is the same

2 max

- (iii) *Mark the first answer. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = 0 marks*

chlorophyll a;

ALLOW chlorophyll A / chlorophyll α
IGNORE p680 / p700 / PSI / PSII
DO NOT CREDIT chlorophyll a and b
DO NOT CREDIT chlorophyll alone

1

- (iv) 1 chlorophyll / pigments / leaf, reflect / does not absorb / absorbs little, green light / light of this wavelength;
Needs to refer to green rather than other colours
- 2 (green light) cannot be used in photosynthesis / no photosynthesis / little photosynthesis / no light dependent reaction (or described) / little light dependent reaction (or described)
correct ref to action spectrum in green region;
Needs to refer to green rather than other colours
- 3 little / no, photolysis / splitting of water;
CREDIT (some) photolysis with accessory pigments
- 4 little / no, CO₂, taken up / fixed (in light independent reaction);
- 5 some CO₂ produced during respiration;
- 6 (slight) increase in CO₂, increases acidity / decreases pH;
CREDIT increase in H⁺ decreasing pH for accessory pigments
- 7 AVP;
e.g. • accessory pigments absorb (some) green light

3 max

[7]

2. ***Question is asking for an increased rate of photosynthesis and maximum production***

IGNORE LIGHT

- 1 photosynthesis / named stage, is controlled by / needs / involves / uses, (named photosynthetic) enzymes;
Needs to be a clear generalised statement – cannot be implied from a description of the effects
IGNORE 'enzymes are affected by temperature'
- 2 temperature can be, increased by heater / reduced by ventilation (or fan) maintained by air conditioning (or other method);
*Needs to indicate **how** factor is controlled*
- 3 increase CO₂ concentration (in environment) by burning, fuel / gas / paraffin;
*Needs to indicate **how** factor is controlled*
CREDIT increase in CO₂ by other reasonable methods

- 4 *idea that* increased / more / higher, CO₂ (conc),
so CO₂ no longer a limiting factor / increases CO₂ fixation / (or described) increases
Calvin cycle (or described);

ALLOW ref to maximum rate for increase in rate

- 5 *idea that* easier to control,
water supply / irrigation (to prevent wilting) / humidity / minerals / fertiliser;

*Look for the idea that factors can be more easily regulated in
the greenhouse rather than outside*

CREDIT use of hydroponics

- 6 *idea that* easier to control use of, pesticides / pest control / biological control;

*Look for the idea that factors can be more easily regulated in
the greenhouse rather than outside*

- 7 AVP;

- e.g.*
- *gas / paraffin, heater supplies heat and CO₂*
 - *prevents described damage of plants by,
wind chill / frost / wind / hail / etc*
 - *description / effect, of photorespiration*

[4]

3. (a) (i) chlorophyll; *treat refs to a and b as neutral* 1
(ii) electron carrier / cytochrome / protein / electron acceptor / ferredoxin /
plastoquinone; 1

- (b) hydrogen ions are moved into the thylakoid space by action of electron
carriers;
higher concentration of / more, hydrogen ions / protons reduces the pH;
R *hydrogen, H*
A *hydrogen ions produced in lumen*
hydrogen ions, move / diffuse, down concentration gradient;
across / through, (thylakoid) membrane / from lumen to stroma;
through ATP synthetase / synthase / protein channel / stalked particles;
generates ATP;

AVP; e.g. ref. to by chemiosmosis
ref. to an electrochemical gradient / proton motive force max 4

[6]

4. (i) light absorbing/AW;
ref to excited electrons/AW;
used in light dependent stage;
ref. to location; e.g. chloroplasts, thylakoids,
photosystems, grana, lamellae
AVP; e.g. (long) hydrocarbon chains,
different pigments absorb different wavelengths. max 3

- (ii) high absorption of, wavelengths 450 – 480 nm/

blue region of spectrum;
 high absorption of, wavelengths 660 – 710 nm/
 red region of spectrum;
 low absorption of, wavelengths 500 – 620 nm/
 green region of spectrum;

for each marking point accept single figure in range.

If candidate gives range it

must fall within the range on the mark scheme.

only penalise lack of units once.

max 2

[5]

5. (primary) act as reaction centres/where electrons are excited;
 (accessory) other part of photosystem/antenna unit/surround reaction centre;
 (accessory) absorb different wavelengths of light (not absorbed by primary);
 (accessory pigments) transfer energy to primary pigments;
 names of primary (chl a, P680, P700) and accessory pigment
 (chl b, carotenoid);

max 2

[2]

6. **1 non-cyclic photophosphorylation;**
2 ref to photosystems 1 and 2 being involved; **A** *PS1 and 2/P700 and P680*
3 excited electrons emitted/AW;
4 ref to electron acceptor molecules;
5 (electrons pass along) chain of, electron carriers/ETC/cytochromes;
6 occurs in, thylakoid membranes/grana/lamellae;
7 sets up a, proton/H⁺/hydrogen ion/pH gradient; **A** *proton pump idea*
8 ref to ATP synth(et)ase; **A** *ATPase, stalked particle*
9 ref to, proton motive force/flow of protons;
10 chemiosmosis;
11 formation of ATP;
12 movement of electrons from PS2 to PS1;
13 ref to photolysis;
14 movement of electrons from water to PS2;
15 cyclic photophosphorylation;
16 PS1 only;
17 AVP; e.g. named electron acceptors, named electron carriers, ref. to water
 splitting enzyme, ref to position of photosystems.(PS1 intergranal
 membrane and PS2 grana)

max 8

QWC – clear well organised using specialist terms;

1

[9]

7. (i) light intensity; 1
(ii) some other factor becomes limiting;
carbon dioxide or temperature (linked to point 1); 2
[3]
8. 1 denaturing of enzyme;
2 change in shape of active site;
3 named photosynthetic enzyme;
4 less photolysis;
5 less ATP produced;
6 named step in Calvin cycle which is affected; **A** step described
7 increase in rate of respiration;
8 respiration occurring at faster rate than photosynthesis;
9 temperature compensation point;
10 increased rate of transpiration;
11 stomatal closure;
12 less carbon dioxide uptake;
13 AVP; e.g. ref to photorespiration 4 max
[4]
9. less reflection of light;
less transmission of light;
more light absorbed;
more, wavelengths absorbed; **A** colours of light
more, ATP / red NADP, formed;
increases temperature of leaf;
enzymes work more efficiently;
light intensity / temperature, being limiting; 3 max
[3]
10. *accept labelled sketch diagram for marking points below*
nitrogenous base / purine;
adenine;
pentose / 5 carbon, sugar;
ribose;
three, phosphate groups / Pi; **R** phosphate molecule
phosphorylated nucleotide;
A adenosine as an alternative to adenine **plus** ribose 4 max
[4]

11. 1 NAD / FAD, involved in respiration;
 2 associated with, dehydrogenase enzymes / dehydrogenation;
 3 2 molecules of NAD (reduced) in glycolysis;
 4 link reaction producing 1 molecule of NAD (reduced);
 5 Krebs cycle produces 3 NAD (reduced) (per turn of cycle);
 6 detail of any one step in respiration where NAD (reduced) is produced;
 7 Krebs cycle produces 1 FAD (reduced) (per turn of cycle);
 8 carriers / transfers, hydrogen to, inner mitochondrial membrane / cristae /
 cytochromes / ETC;
 9 mitochondrial shuttle (bringing NAD reduced from glycolysis into matrix);
 10 NADP involved in photosynthesis;
 11 produced in non-cyclic (photo)phosphorylation;
 12 hydrogen comes from, water / photolysis;
 13 (used in) Calvin cycle / light independent stage;
 14 GP to TP step;
 15 AVP; e.g. NADP involved in transporting hydrogen from grana to stroma
 16 AVP; e.g. hydrogen split into electrons and protons at ETC

credit annotated diagrams

7 max

QWC – clear, well organised using specialist terms;

award QWC mark if three of the following are used

photophosphorylation	cristae	
glycolysis	photolysis	
Calvin cycle	link reaction	
Krebs cycle	dehydrogenase / dehydrogenation	1

[8]

12. **A** - stroma ; **A** ribosome
B - (outer/ inner) membrane / (chloroplast) envelope ; **R** cell membrane
C - thylakoid / lamella ; **A** lamellae
D - granum / granal stack ; **A** grana **A** thylakoid stack

[4]

13. (i) palisade (mesophyll) ;
spongy (mesophyll) ;
mesophyll / chlorenchyma – 1 mark 2
- (ii) 1.7, 3.1, 4.0, 4.7, 4.9, 5.0 ; 1
- (iii) selection of two temperatures 10 °C apart ;
respiration
ref to release of carbon dioxide (in dark is measure of respiration) ;
state two figures very close to value of 2, therefore supports ;
(all steps in) respiration enzyme catalysed ;
photosynthesis
data quotes must be from true rate of photosynthesis
only value between 5 °C and 15 °C is close ;
photosynthesis does not support as (other) values not near 2 ;
A data quote to illustrate this / ecf
not just enzyme-controlled process / AW ; 4 max
- (iv) light intensity limiting factor ;
low rate photosynthesis ;
rate respiration increases at higher temperatures ;
rate respiration, close to / exceeds, rate of photosynthesis ; A ora
net primary productivity is lower / sugars broken down more quickly
than formed ; 3 max
- [10]**
14. 1 Calvin cycle ;
max 4 from marking points 2 to 10
- 2 ribulose biphosphate carboxylase / rubisco ; *linked to marking point 3*
3 RuBP + carbon dioxide ;
4 (2 molecules of) GP ; A PGA
5 GP to TP ; A PGAL, GALP
6 uses ATP (from light reaction) ; *linked to marking point 5*
7 and red NADP / AW, (from light reaction) ; *linked to marking point 5*
8 some TP forms hexose sugars ;
9 (some) TP regenerates RuBP ; 5 max
10 AVP ; e.g. (unstable) 6C compound, detail of RuBP regeneration
- accept an annotated diagram of the cycle*
- [5]**
15. (a) *T. sillamontana*
thicker / fleshier / succulent ;
hairy ;
more compact / AW ;
ref to different leaf shape ;
AVP ; e.g. petiole rolled round stem 2 max
- (b) (i) *T. sillamontana* 14, *T. fluminensis* 19 ; 1

- (ii) same magnification / AW ;
several leaves ;
leaves from similar parts of plants ;
same (environmental / light / water / soil / fertiliser) conditions ;
AVP ; e.g. same age 2 max
- (c) 1 *T. sillamontana* drier / *T. fluminensis* wetter / AW ;
T. sillamontana
2 xerophytic / xeromorphic ;
3 fewer stomata / ora ;
4 hairs ;
5 trap water vapour / water potential gradient lower ; **R** trap, water /
moisture
6 (so) transpiration / evaporation, slower ;
7 white hairs qualified ;
8 fleshy, stem / leaves, store water ;
9 AVP ; ref surface area to volume ratio, ref to rolling qualified
T. fluminensis
10 leaves further apart ;
11 so do not, trap air / shade each other ;
12 leaves, darker / have more chlorophyll ;
13 so improved photosynthesis ;
14 smooth / shiny, leaves allow water to drip off ; 5 max
- (d) *T. fluminensis* has, max / optimum, rate at, 7 a.u. / 42 (- 50) % ;
T. sillamontana rate increases with increasing light intensity ;
T. sillamontana data quote (x + y) ;
comparative statement re data ;
comparative statement re conditions ;
AVP ; e.g. *T. fluminensis* may be damaged by high light intensity 3 max
16. (a) 1 rate of respiration can equal rate of photosynthesis / CO_2 used = CO_2
produced / O_2 used = O_2 produced;
2 ref to compensation point;
3 mitochondria use oxygen;
4 chloroplasts produce oxygen;
5 mitochondria are always active / respiration continues
independently of light;
6 chloroplasts are inactive in dark / photosynthesis does not take
place without light;
7 oxygen released by, chloroplasts / photosynthesis, can be utilised by
mitochondria / respiration;
8 at high light intensities, chloroplasts produce more oxygen than the
mitochondria consume;
9 AVP; e.g. valid refs to CO_2 exchange max 4
- (b) phosphate ions are used to produce ATP;
in oxidative phosphorylation / Krebs cycle / chemiosmosis / electron
transport / ATP synth(et)ase;

[13]

ATP leaves mitochondria; max 2

- (c) carrier protein / transport protein / transmembrane protein involved;
 A ref to a specific channel
 concentration of triose phosphate is higher in the chloroplast (than in the cytoplasm);
 because it is a product of, photosynthesis / light independent reaction / Calvin cycle;
 triose phosphate moves, down concentration gradient / from high to low concentration;
 ATP not involved / no energy used; max 2

- (d) *ignore references to chloroplasts or mitochondria being cells, having cytoplasm and reference to free ribosomes*
 free / naked, DNA; A DNA not surrounded by, membrane / envelope have an inner folded membrane / AW;
 ribosomes, smaller than those in cytosol / similar in size to prokaryotic ribosomes; A ref to 70S and 80S
 circular DNA; A loop
 AVP; e.g. absence of introns
 R absence of a nucleus from the chloroplast or mitochondrion
 R ref to membranous organelles as chloroplasts and mitochondria are these organelles max 2

[10]

17. chlorophyll a; A chlorophyll for one mark as an alternative to chl. a and b
 chlorophyll b;
 xanthophylls;
 carotenoids / carotene;

[2]

18. 1 occurs in stroma;
 2 a series of enzyme-controlled reactions;
 3 carbon dioxide fixed by RuBP;
 4 carboxylation;
 5 enzyme is Rubisco;
 6 (unstable) 6C intermediate;
 7 forms (2 molecules) of GP;
 8 forms TP;
 9 using ATP (linked to point 8);
 10 reduction step;
 11 using reduced NADP;
 12 ref to either ATP or NADP red coming from light dependent reaction;
 13 (most of) TP regenerates RuBP;
 14 rearrangement of carbons to form pentose sugars;
 15 ATP required, for phosphorylation / ribulose phosphate to ribulose biphosphate;
 16 AVP; e.g. TP can be used to form, lipids / amino acids / hexose sugars / suitable named example max 7
- QWC – legible text with accurate spelling, punctuation and grammar;** 1

[8]

19. (a) ref limiting factor;
 not carbon dioxide;
 named factor e.g. light / temperature / limited number of chloroplasts; **R** water
 photosynthesis at maximum rate;
 explanation of effect of named factor e.g. ref to enzyme action; max 2
- (b) ref respiration;
 production of carbon dioxide; **R** release
 (at low concentrations, CO₂ was) diffusing / moving down a concentration gradient;
 respiration faster than photosynthesis / AW;
 AVP; e.g. below compensation point max 2
- (c) control of variables / light is a variable; **R** ‘fair test’ unqualified 1
- (d) *accept ora here*
 maintenance of water supply;
 xylem / vascular bundles, intact;
 water required for, photosynthesis / turgor; **A** water prevents wilting
 stomata might close if the leaf detached;
 leaves site of photosynthesis;
 AVP; e.g. ABA, water stress, sugar transport max 2

- (e)
- 1 one similarity between barley and sugar cane;
 - 2 one difference between barley and sugar cane;
 - 3 temperature ref between or within species;
 - 4 CO₂ concentration ref between or within species; A ppm for concentration
 - 5 data quote comparison with units;
 - 6 ref to habitat; e.g. tropics, named country, biomes (biological zones), climate
 - 7 ref to biochemistry; e.g. C4 / C3, different enzymes
 - 8 ref to enzymes;
 - 9 AVP; e.g. ref compensation point

max 5

[12]