M1. (a) (i) RuBP – 5; GP – 3; TP – 3; Glucose – 6;
(all correct = 2 marks; 3 or 2 correct = 1 mark)
2

(ii) stroma;
1

(iii) light-dependent reaction / (photo)phosphorylation;
(accept photolysis)
1

(iv) 5 out of 6 / 83% / equivalent;
1

(b) enzymes involved / not a photochemical reaction;
slow rate of enzyme/chemical reaction at low temperature /
less kinetic energy / fewer collisions;
2

[7]

M2. (a) adding CO_2 decreases pH / makes more acid
OR removing CO_2 increases pH / makes more alkaline;
(credit anywhere but do not credit this mark if stated that oxygen is an alkaline gas)

rate of photosynthesis > rate of respiration in **A**;
respiration only in **B**;
rate of photosynthesis = rate of respiration in **C**;
4

(b) (i) shows that indicator alone does not change colour in light;
1

(ii) so that all tubes receive same amount of heat
1

[6]

M3. (a) electrons;
from chlorophyll / photolysis;
2

(b) (i) RuBP combines with carbon dioxide to produce 2 x GP;
1

(ii) less used to combine with carbon dioxide /
less used to form glycerate 3-phosphate;
1

(c) (i) used in photosynthesis allows detection of products;

1

(ii) ATP and reduced NADP not formed;
GP is not being used to form RuBP / is being formed from RuBP;

2

(iii) used in respiration / formation of starch / cellulose;

1

[8]

M4. (a) (i) chlorophyll molecule/electron gains energy/becomes (excited)/ is raised to higher energy level;
chlorophyll molecule loses (excited) electron/becomes positively charged;

2

(ii) energy lost by electrons (is used to – 'drive' reaction between ADP and Pi.);

1

(b) reduction/described;
of GP to triose phosphate;

2

[5]

M5. (a) the more light absorbed, the greater the rate of photosynthesis;
light provides the <u>energy</u> for light dependent reactions / photolysis / light independent reactions / production of reduced NADP / exciting electrons in chlorophyll;
(do not give credit if energy is used in photosynthesis)

2

(b) count the number of bubbles / measure the volume of gas / measure the change in pH / carbon dioxide / hydrogen carbonate ions;
(credit oxygen produced)

1

(c) 530 – 630 nm;

(any values within this range)

limited absorption of light / (green) plants reflect green light /
limited photosynthesis at these wavelengths of light;

(allow references to no light absorbed or no photosynthesis)

2

(d) (i) chlorophyll excited / reduced NADP formed;
electrons from chlorophyll / reduced NADP changes the dye colour;

2

(ii) ADP and phosphate needed to produce ATP / ATP is a product of the light dependent reactions;
ADP levels are a limiting factor;

(must explain the idea of limiting factors – do not credit answers like more ADP causes more photosynthesis)

2

[9]

M6. (a) Grana/thylakoids/ lamellae;

1

(b) **A** = oxygen/O_2

B = ADP and phosphate/P_i /phosphoric acid/correct formula;

C = reduced NADP; ALLOW NADPH/$NADPH_2$ /NADPH + H^+

3

(c) (i) Absorbs light/energy;
Loses electrons/becomes positively charged/is oxidised;
Accepts electrons from water/from OH^- ;
Causes more water to dissociate/pulls equilibrium to the right;

max 3

(ii) Electrons raised to higher energy level/electrons excited;
Use of electron carriers/cytochromes/acceptors;
For production of ACT

[REJECT 'energy production']

3

(d) (i) GP formed from RuBP + CO_2;

GP → TP/sugar-phosphate/sugar/to RuBP;
GP formed at same rate as it is used;

3

(ii) No CO_2 to combine with/not enough CO_2 to combine with;

RuBP not changed into GP/TP;
RuBP reformed from GP/TP;

max 2

[15]

M7. (a)

	Photosynthesis	Anaerobic respiration	Aerobic respiration
ATP produced	✓	✓	✓
Occurs in organelles	✓		✓
Electron transport chain involved	✓		✓

1 mark per column

Mark ticks only. Ignore anything else if different symbols such as crosses are used as well.

If crosses are used instead of ticks allow cross as equivalent to a tick.

Reject tick with a line through

3

(b) $ADP + P_i \longrightarrow ATP$;

Both sides correct, but allow other recognised symbols or words for phosphate ion. Reject P unless in a circle.

Accept = as equivalent to arrow

Accept reversible arrow

Ignore any reference to kJ/water

1

(c) 1. Energy released in small/suitable amounts;

2. Soluble;

3. Involves a single/simple reaction;

1. In context of release, not storage. Ignore producing energy/manageable amounts.

2. Reject "broken down easily/readily". Reject "quickly/easily resynthesised".

2 max

(d) 1. ATP is unstable;

2. ATP cannot be stored / is an immediate source of energy;

3. Named process uses ATP ;

4. ATP only releases a small amount of energy at a time;

3. Accept processes such as active transport, muscle contraction, glycolysis.

Reject answers such as keeping warm, movement, respiration, metabolism, growth.

2 max

[8]

M8. (a) (i) Temperature and light;

1

(ii) Increase in temperature causes increase in rate of photosynthesis/uptake of carbon dioxide;

Increase in light/more/medium/high light (intensity) causes increase in rate of photosynthesis/uptake of carbon dioxide;

2

(b) 2.75 – 2.81 (mg g^{-1} hr^{-1})

Accept answers in range 2.75 – 2.81

1

(c) 1. Growth will decrease (at higher temperature);

2. Rate of respiration will increase at higher temperature;

3. Photosynthesis decreases as limited by light/as there is less light;

Ignore references to effect of temperature on rate of photosynthesis

3

[7]

M9. (a) (i) Some carbon dioxide will be produced in respiration;
Used in photosynthesis;

1 max

(ii) Rate of increase of photosynthesis decreases/curve flattens;
Something other than carbon dioxide concentration/temperature/
Light becomes limiting;

Q *answers which describe the rate of photosynthesis decreasing should not be awarded credit*

2

(b) Link establishes between carbon dioxide concentration, photosynthesis and yield of grain;
Link established between carbon dioxide and global warming;
As curve starting to flatten (at current carbon dioxide) concentrations
Increase in yield may not be very large;
Other factors/named factor linked to higher carbon dioxide concentration/temperature might have adverse effect;
Harvest will be earlier as identified stages become shorter;
Although not significant as already at higher temperatures;

4 max

[7]

M10. (a) (i) pigment reflects/does not absorb green or yellow or orange;
pigment absorbs blue or violet;
pigment absorbs red;

(accept correct wavelengths instead of colours)
(any 2 for 1 mark)

1

(ii) light (energy) absorbed by chlorophyll;
raises energy level of electrons / electrons are excited/emitted;
ATP formed;

3

(b) more wavelengths / colours absorbed;
more (efficient) photosynthesis can occur at these depths / low light intensities
or
more (efficient) photosynthesis can occur when some wavelengths are not present;

2

[6]

M11. (a) Glycolysis;
Glucose and pyruvate/pyruvic acid;

2

(b) Light-independent reaction;
Ribulose bisphosphate/RuBP and carbon dioxide;

2

(c) Light-independent reaction;
Triose phosphate and glucose/hexose;

Q *Do not accept sugar or carbohydrate as alternative for glucose*

2

[6]

M12. (a) 1 5C/RuBP combines with CO_2;

2 to form 3C compound / TP / GP;

3 using ATP;

4 and reduced NADP / eq;

5 2 molecules of 3C compound/ TP / GP form hexose;

6 all RuBP is regenerated;

7 10 molecules of 3C/TP/GP form 6 molecules of 5C/RuBP;

6 max

(b) 1 electron transport chain accepts excited electrons;

2 from chlorophyll / photosystem;

3 electrons lose energy along chain;

4 ATP produced;

5 from ADP and Pi;

6 reduced NADP formed;

7 when electrons (from transport chain) and H^+ combine with NADP;

8 H^+ from photolysis;

6 max

(c) 1 some hexose/biomass/eq. used in respiration;
growth cancels this point

2 CO_2 produced (is lost to air);

3 some parts of the plant are eaten;

4 some parts lost to decomposers / in leaf fall;

3 max

[15]

M13. (a) Excitation of chlorophyll molecule/electrons/ energy of (pairs of) electrons raised to higher energy level;

Electron(s) emitted from chlorophyll molecule;

Electron(s) to electron transport chain;

Loss of energy by electron(s) along electron transport chain;

Energy lost by electron(s) is used to synthesise ATP;

From ADP + Pi;

"By electrons" need not be stated in each marking point if it can be reasonably inferred that the candidate is referring to electrons

max 5

(b) Little green light reaches bottom as absorbed by surface dwellers / water;
Red and blue not absorbed and so penetrate;
Variation in pigments of sediment dwellers;
Bacteria with chlorophyll at an advantage;
As chlorophyll absorbs red and blue;
(Survive to) reproduce in greater numbers;
Pass on advantageous alleles/genes in greater numbers / increase in frequency of advantageous alleles in subsequent generations;
Increase in frequency/numbers of bacteria with chlorophyll;

max. 6

[11]

M14. (a) <u>On diagram, correctly labelled:</u>

Light-dependent: granum/thylakoid membranes – labelled 'X'
AND
Light-independent: stroma – labelled 'Y';

1

(b) <u>Any two from:</u>

(Water) forms H^+ /hydrogen ions <u>and</u> electrons/e^- ;

O_2/oxygen formed; [*NOT* 'O', *NOT* 'O^{-1}']

(Light) excites electrons / raises energy level of electrons / electrons to chlorophyll / to photosystem;

max 2

(c) (ATP) Provides <u>energy</u> for GP → TP / provides <u>P</u> for RuP/TP → RuBP;

(Reduced NADP) Provides <u>H / electrons</u> for GP → TP / <u>reduces</u> GP to TP;

2

[5]

M15. (a) ✓ ✓ x;
x x ✓;
✓ ✓ ✓
✓ x x

4

(b) (i) pyruvate/succinate/any suitable Krebs cycle substrate;

1

(ii) ADP and phosphate forms ATP;
oxygen used to form water / as the terminal acceptor;

2

(iii) Y X W Z;
order of carriers linked to sequence of reduction / reduced carriers cannot pass on electrons when inhibited;

2

[9]