Q1.

(a) Energy enters most ecosystems through the light-dependent reaction of photosynthesis. Describe what happens during the light-dependent reaction.

_____

_____

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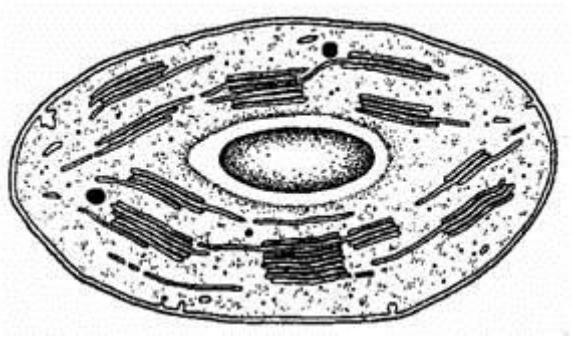
_____

(5)
(Total 5 marks)

Q2.

The diagram shows the structure of a chloroplast.



(a) Label the diagram with an **X** to show where the light-dependent reactions take place and with a **Y** to show where the light-independent reactions take place.

(1)

(b) The photolysis of water is an important part of the process of photosynthesis. Describe what happens in the photolysis of water.

_____

_____

_____

_____

(2)

(c) ATP and reduced NADP are two products of the light-dependent reactions. Describe **one** function of **each** of these substances in the light-independent reactions.

ATP _____

_____

Reduced NADP _____

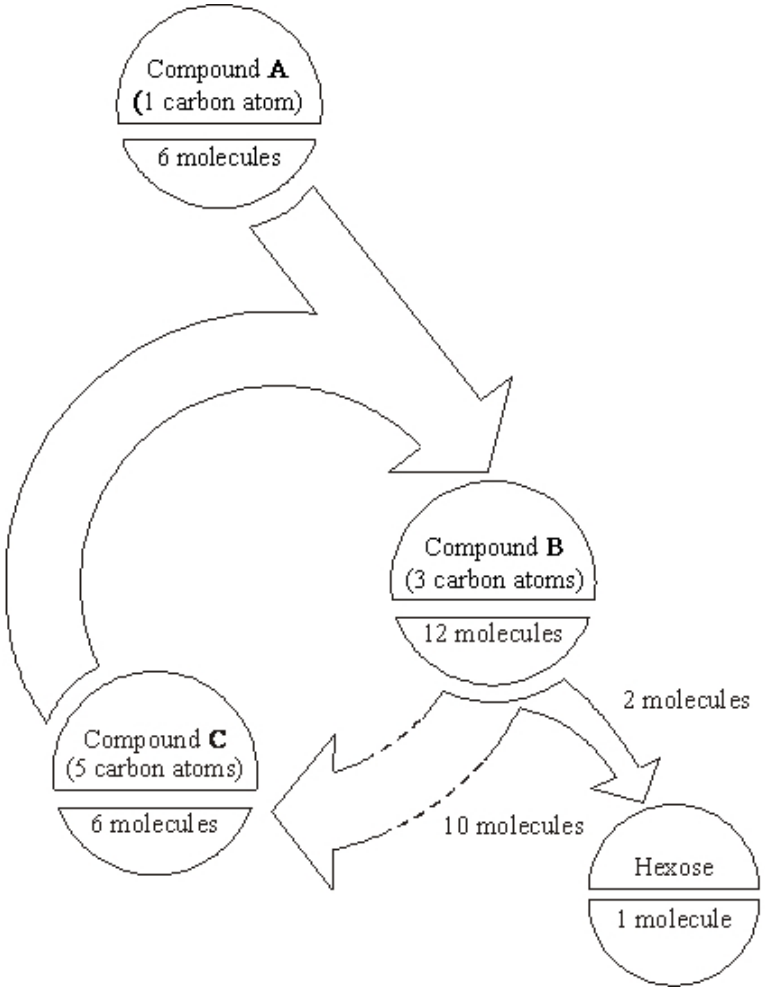
_____

(2)

(Total 5 marks)

Q3.

The diagram represents some of the light-independent reactions of photosynthesis.



(a) Describe the light-independent reactions of photosynthesis and explain how they allow the continued synthesis of hexose sugars.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(6)

(b) Describe the role of electron transport chains in the light-dependent reactions of photosynthesis.

(6)

(c) Explain why the increase in the dry mass of a plant over twelve months is less than the mass of hexose produced over the same period.

(3)
(Total 15 marks)

Q4.

(a) Describe how NADP is reduced in the light-dependent reaction of photosynthesis.

_____

_____

_____

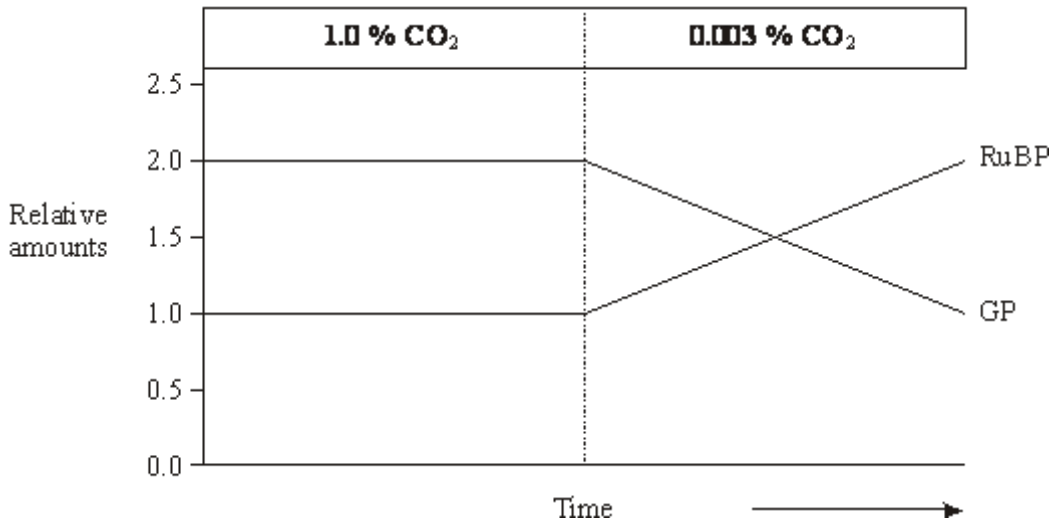
_____

(2)

(b) In an investigation of the light-independent reaction, the amounts of glycerate 3-phosphate (GP) and ribulose bisphosphate (RuBP) in photosynthesising cells were measured under different environmental conditions.

Figure 1 shows the effect of reducing the carbon dioxide concentration on the amounts of glycerate 3-phosphate and ribulose bisphosphate in photosynthesising cells.

Figure 1



(i) Explain why there is twice the amount of glycerate 3-phosphate as ribulose bisphosphate when the carbon dioxide concentration is high.

_____

_____

(1)

(ii) Explain the rise in the amount of ribulose bisphosphate after the carbon dioxide concentration is reduced.

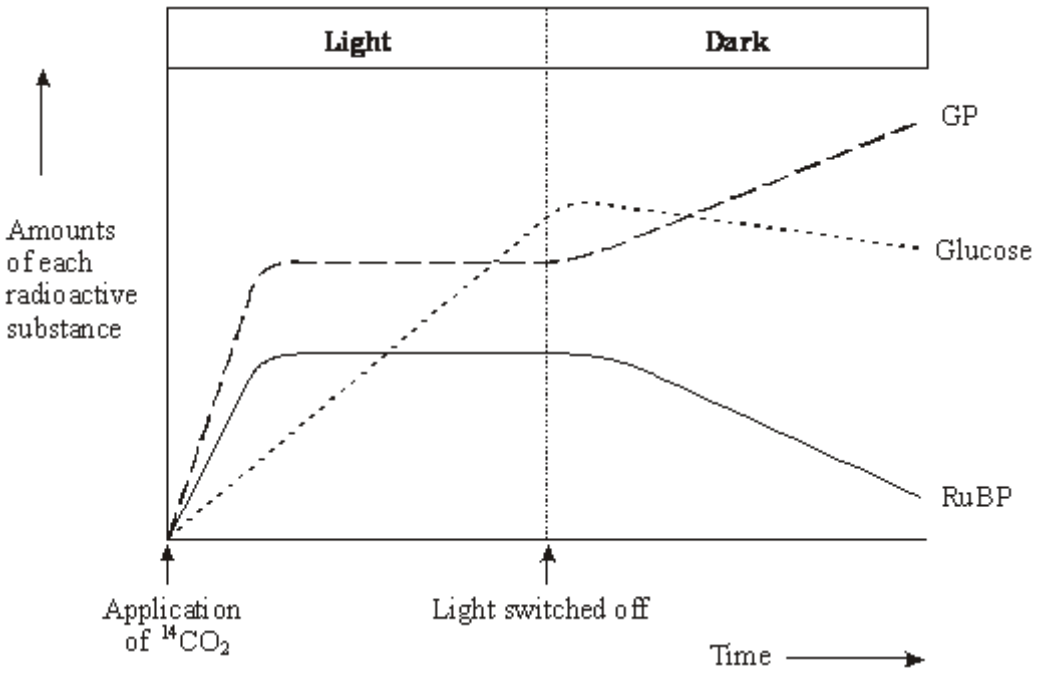
_____

_____

(1)

(c) **Figure 2** shows the results of an experiment in which photosynthesising cells were kept in the light and then in darkness.

Figure 2



(i) In the experiment the cells were supplied with radioactively labelled $^{14}CO_2$. Explain why the carbon dioxide used was radioactively labelled.

_____

_____

(1)

(ii) Explain how lack of light caused the amount of radioactively labelled glycerate 3-phosphate to rise.

_____

_____

_____

_____

(2)

(iii) Explain what caused the amount of radioactively labelled glucose to decrease after the light was switched off.

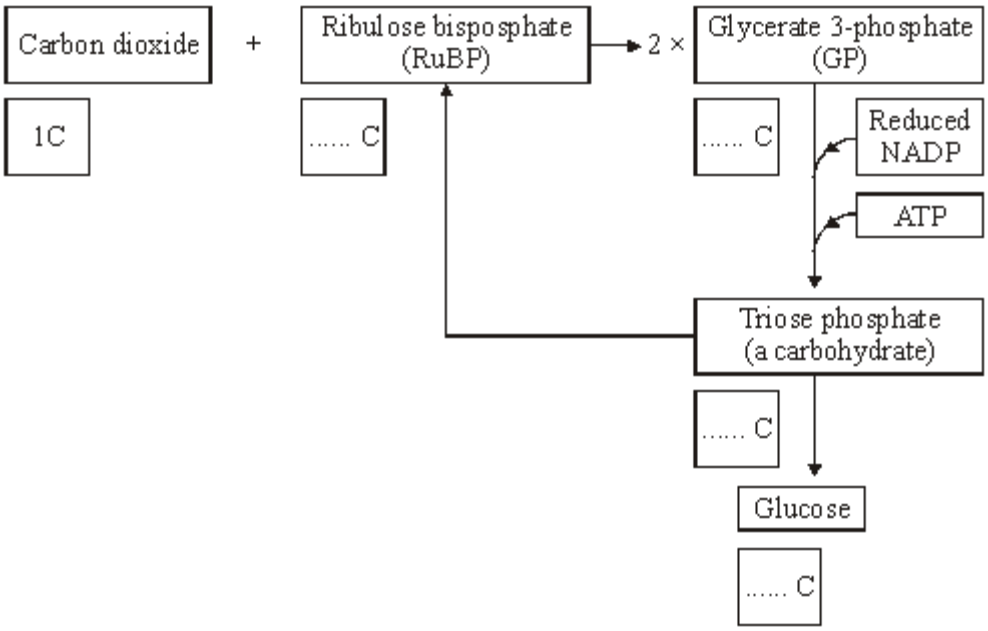
_____

_____

(1)
(Total 8 marks)

Q5.

The diagram shows a summary of the light-independent reaction of photosynthesis.



(a) (i) Complete the boxes to show the number of carbon atoms in the molecules.

(2)

(ii) In which part of a chloroplast does the light-independent reaction occur?

_____

(1)

(iii) Which process is the source of the ATP used in the conversion of glycerate 3-phosphate (GP) to triose phosphate?

_____

(1)

(iv) What proportion of triose phosphate molecules is converted to ribulose bisphosphate (RuBP)?

_____

(1)

(b) Lowering the temperature has very little effect on the light-dependent reaction, but it slows down the light-independent reaction. Explain why the light-independent reaction slows down at low temperatures.

_____

_____

_____

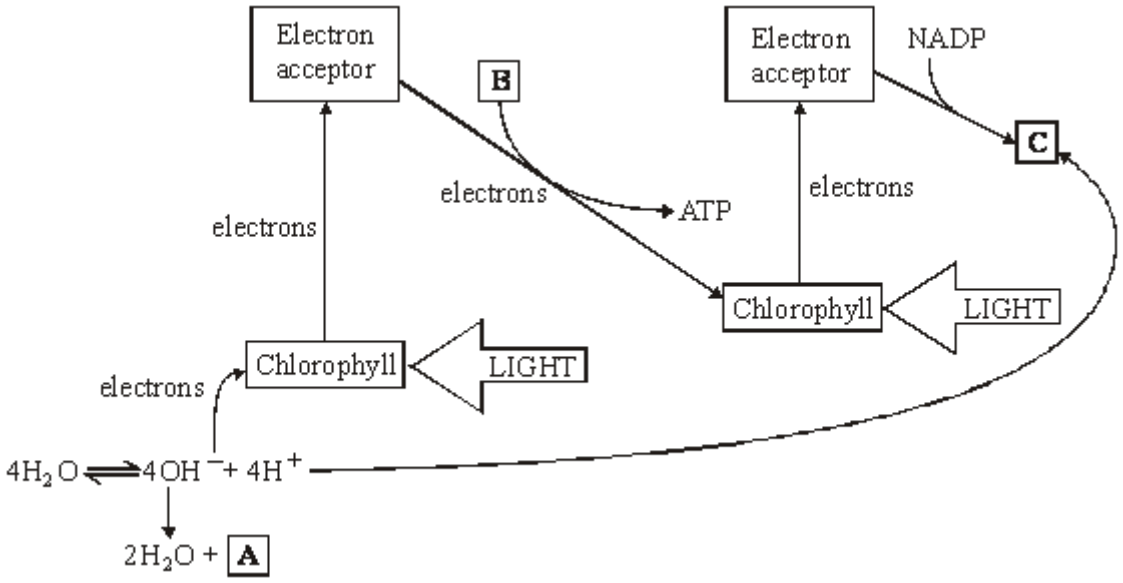
_____

(2)

(Total 7 marks)

Q6.

The diagram shows the light-dependent reactions of photosynthesis.



(a) In which part of a chloroplast do the light-dependent reactions occur?

_____

(1)

(b) Name the substances in boxes **A**, **B** and **C**.

A _____

B _____ + _____

C _____

(3)

(c) Use information in the diagram to explain

(i) the role of chlorophyll in photolysis;

---

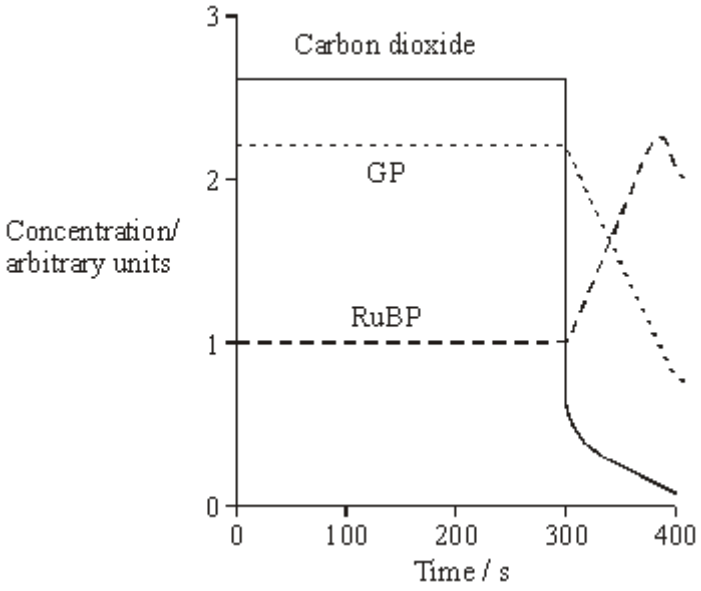
(3)

(ii) how the energy of light is converted into chemical energy in the light-dependent reactions.

---

(3)

(d) In an investigation, single-celled algae were kept in bright light and were supplied with carbon dioxide containing radioactive carbon atoms. After 300 seconds, the carbon dioxide supply was turned off. The graph shows how the concentrations of carbon dioxide, glycerate 3-phosphate (GP) and ribulose bisphosphate (RuBP) changed.



(i) Explain why, between 0 seconds and 300 seconds, the concentration of radioactive GP remained constant.

---

(3)

(ii) Explain why, between 300 seconds and 380 seconds, the concentration of radioactive RuBP increased.

---

(2)

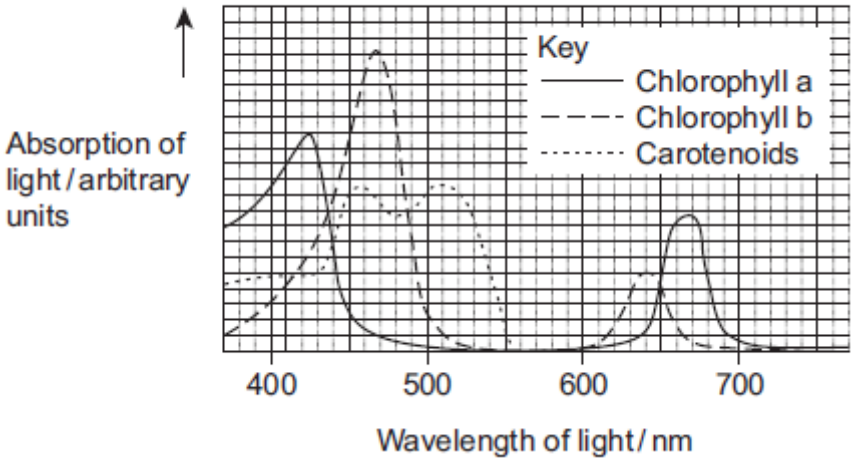
(Total 15 marks)

Q7.

Plants have pigments that absorb light energy for photosynthesis. These pigments include two types of chlorophyll and a group of pigments known as carotenoids. Different species of plant contain different amounts of these pigments. The pigments that each plant species has are adaptations to where and how they live; their ecological niche.

Figure 1 shows the absorption of light of different wavelengths by chlorophyll a, chlorophyll b and carotenoids.

Figure 1

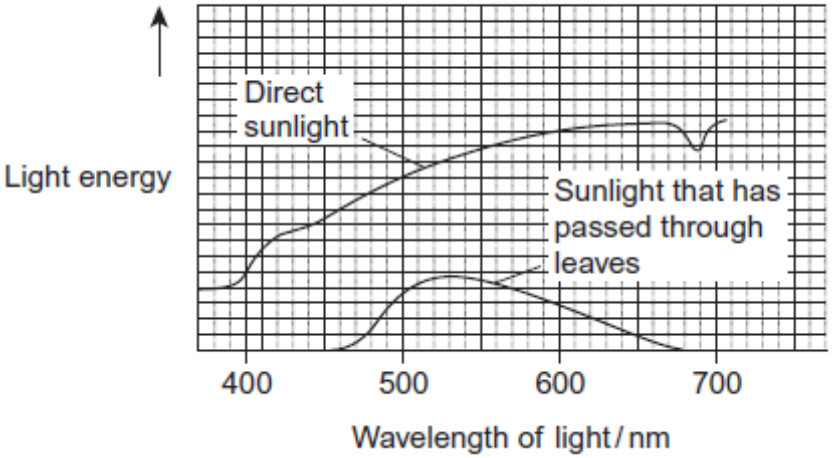


A scientist investigated the energy in light of different wavelengths reaching the ground in a forest. She measured the energy in

- direct sunlight
- sunlight that had passed through the leaves of trees.

Figure 2 shows her results.

Figure 2



(a) Use **Figure 1** to describe the absorption of light of different wavelengths by chlorophyll a.

_____

_____

_____

_____

_____

(2)

(b) Few species of plant can live below large trees in a forest.
Use the information in **Figure 1** and **Figure 2** to suggest why.

_____

_____

_____

_____

_____

_____

_____

(3)

(c) In leaves at the top of trees in a forest, carbon dioxide is often the limiting factor for photosynthesis.
Use your knowledge of photosynthesis to suggest and explain **one** reason why.

_____

_____

_____

_____

_____

(2)
(Total 7 marks)

Q8.

Heat stress is a condition that often occurs in plants exposed to high temperatures for a prolonged period of time. Heat stress is a major factor in limiting the rate of photosynthesis.

(a) Heat stress decreases the light-dependent reaction of photosynthesis.

Explain why this leads to a decrease in the **light-independent reaction**.

_____

_____

_____

_____

_____

_____

(2)

(b) Another effect of heat stress is a decrease in the activity of the enzyme rubisco. A decrease in the activity of an enzyme means that the rate of the reaction it catalyses becomes slower.

A decrease in the activity of the enzyme rubisco would limit the rate of photosynthesis.

Explain why.

_____

_____

_____

_____

_____

(2)

(c) Where precisely is rubisco found in a cell?

_____

_____

(1)

Scientists investigated the effect of temperature on the activity of two enzymes isolated from the leaf cells of cotton plants.

- Rubisco
- Rubisco activase – an enzyme that activates rubisco

Figure 1 and **Figure 2** show their results.

Figure 1

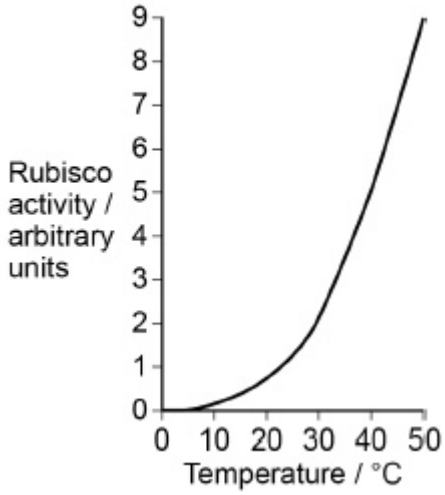
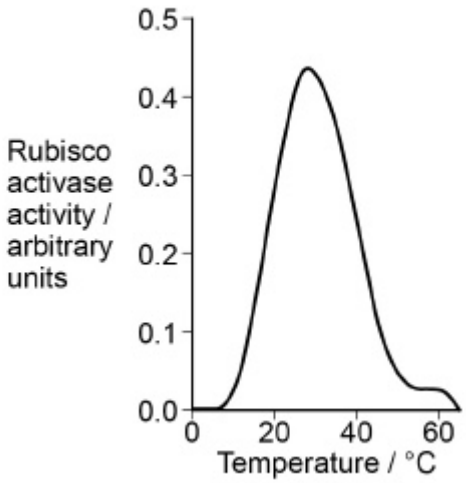


Figure 2



(d) The scientists concluded that heat stress reduces the activity of rubisco in plant leaves by affecting rubisco activase.

Use all the information to evaluate their conclusion.

_____

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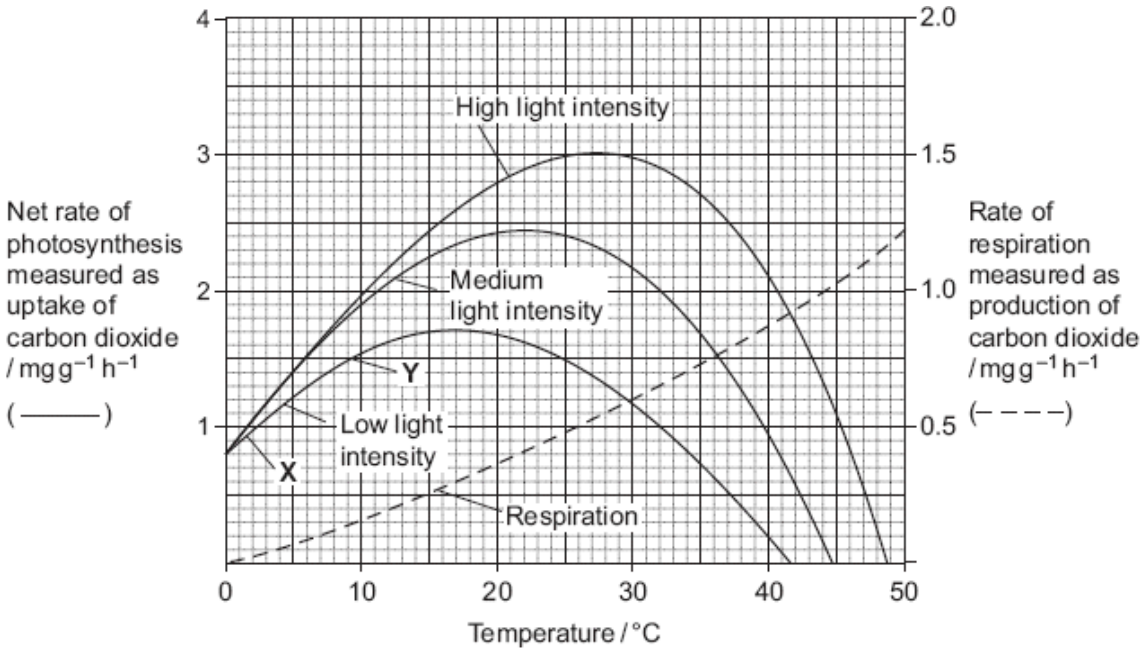
_____

_____

(4)
(Total 9 marks)

Q9.

Scientists investigated the effects of temperature and light intensity on the rate of photosynthesis in creeping azalea. They investigated the effect of temperature on the net rate of photosynthesis at three different light intensities. They also investigated the effect of temperature on the rate of respiration. The graph shows the results.



(a) (i) Name the factors that limited the rate of photosynthesis between **X** and **Y**.

_____

(1)

(ii) Use information from the graph to explain your answer.

_____

_____

_____

_____

_____

(2)

(b) Use information from the graph to find the gross rate of photosynthesis at 20°C and medium light intensity.

Answer _____

(1)

(c) Creeping azalea is a plant which grows on mountains. Scientists predict that in the area where this plant grows the mean summer temperature is likely to rise from 20 °C to 23 °C. It is also likely to become much cloudier. Describe and explain how these changes are likely to affect the growth of creeping azalea.

_____

_____

_____

_____

_____

_____

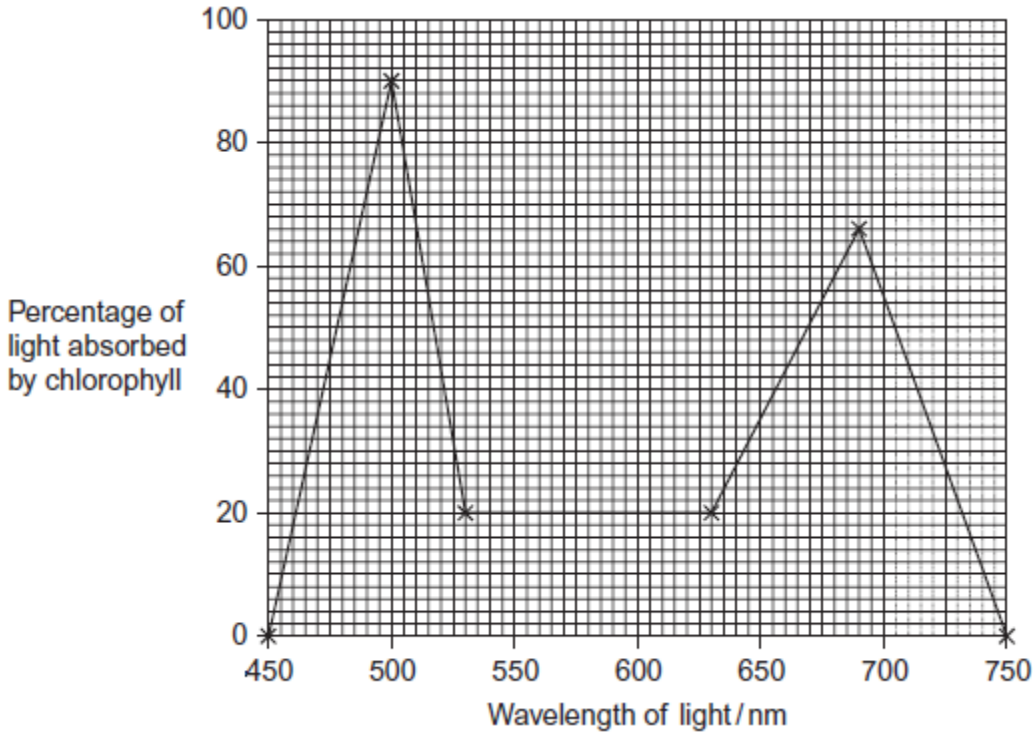
(3)

(Total 7 marks)

Q10.

Figure 1 shows the effect of wavelength on the percentage of light absorbed by the chlorophyll from these seaweeds.

Figure 1



Some scientists investigated the growth of these seaweeds in artificial conditions.
They investigated the effect of different lamps on the rate of photosynthesis of the seaweeds.

- Lamp **P** produced light containing all wavelengths of visible light. (450 to 750 nm)
- Lamp **Q** only produced light of wavelength 460 nm.

The scientists measured photosynthesis by recording the rate of oxygen production. Their results are shown in **Figure 2**.

Figure 2

	Mean rate of photosynthesis/arbitrary units (± standard deviation)	
Species	Lamp **P** Light of all wavelengths of visible light	Lamp **Q** Light of wavelength 460nm
Ulva pertusa	1300.9 (± 125.4)	776.6 (± 105.6)
Mastocarpus yendoi	318.9 (± 69.5)	299.6 (± 83.2)

(a) Between 500 and 700 nm, what range of wavelengths of light is absorbed least by chlorophyll?

_____

(1)

(b) The scientists measured the oxygen produced by the light-dependent reaction of photosynthesis. Name **two** other substances produced by the light-dependent reaction.

1. _____

2. _____

(2)

(c) (i) The scientists measured the rate of photosynthesis of the seaweeds in this investigation in terms of oxygen produced.
Suggest the units they should use.

_____

(2)

(ii) This investigation was carried out in bright light. Explain why reducing the light intensity would affect the amount of oxygen released by the seaweeds.

_____

_____

_____

_____

_____

_____

_____

(3)

(d) In this investigation, the scientists kept the temperature at 15 °C. A student suggested that repeating the investigation at 20 °C would not affect the amount of oxygen released by the seaweed. Evaluate this suggestion.

_____

_____

_____

_____

_____

_____

_____

(3)

(e) (i) Did the type of lamp used affect the rate of photosynthesis in *M. yendoi*? Explain the evidence for your answer.

---

(2)

(ii) The different lamps resulted in different rates of photosynthesis by *U. pertusa*. Explain why there was a higher rate of photosynthesis when the seaweed was illuminated with lamp **P**.

---

(3)

(Total 16 marks)

Mark scheme

Q1.

(a) 1. Chlorophyll absorbs light energy;
Accept light energy 'hits' chlorophyll
Accept photon for light energy

2. Excites electrons / electrons removed (from chlorophyll);
Accept higher energy level as 'excites'

3. Electrons move along carriers / electron transport chain releasing energy;
Accept movement of H^+ / protons across membrane releases energy

4. Energy used to join ADP and Pi to form ATP;
Negate 'produces energy' for either mark but not for both
Accept energy used for phosphorylation of ADP to ATP
Do not accept P as Pi

5. Photolysis of water produces protons, electrons and oxygen;
3. and 4.

6. NADP reduced by electrons / electrons and protons / hydrogen;
Accept NADP to NADPH (or equivalent) by addition of electrons / hydrogen
Do not accept NADP reduced by protons on their own

5 max

[5]

Q2.

(a) On diagram, correctly labelled:

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

1

(b) Any two from:

(Water) forms H^+ / hydrogen ions and 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 energy for GP → TP / provides P for RuP / TP → RuBP;

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

2

[5]

Q3.

(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 / some parts lost to decomposers / in leaf fall;

3

[15]

Q4.

(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]

Q5.

(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]

Q6.

(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^- which causes more water to dissociate / pulls equilibrium to the right;

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

2

[15]

Q7.

(a) 1. Peaks at 420-430 and 660-670;

2. No absorption of light between approximately 500 and 600;

3. Highest peak at 420-430;

2 max

(b) 1. Less (light) energy passes through leaves / reaches ground;

2. Smaller range of wavelengths passes through leaves;
Accept reference to only green (and yellow) light pass through

3. Little light for chlorophyll to absorb;
Accept carotenoids can absorb this light

4. So insufficient photosynthesis (for growth);
Sufficient photosynthesis for plants with carotenoids

5. Photosynthesis unlikely to exceed respiration;

3 max

(c) 1. Light not limiting / lots of light (as no shading);

2. Light-dependent reaction not limiting / fast;

OR

3. Temperature not limiting / Warm (as no shading);

4. Fast reactions of enzymes in light-independent reaction;

OR

5. High use of CO_2;

6. Light-independent reaction is limiting;
Mark as a pair

2

[7]

Q8.

(a) 1. (Less/no) ATP;

2. (Less/no) reduced NADP;
Accept NADPH, NADPH + H, $NADPH_2$ $NADPH + H^+$
Reject reduced NAD, NADH etc,

2

(b) 1. (Less/no) carbon dioxide (reacts) with RuBP;

2. (Less/no) GP;

2

(c) 1. Stroma (of/in chloroplast);
Reject: stoma
Reject stroma of cytoplasm/chlorophyll
Reject stroma of mitochondrion
Ignore references to Calvin cycle or the light-independent reaction

1

(d) 1. Rubisco activity increases with temperature
OR
Rubisco optimum temperature is above (**rubisco activase**);

2. (Rubisco) **activase** activity decreases at high temperatures (allow any temperature above 25 ºC.)
OR
(Rubisco) **activase** optimum (allow in range) 25 to 30 ºC.;
Accept denatures at high temperature (allow any temperature above 25 ºC)

3. (Results/graphs suggest) **activase** cannot/does not affect activity of rubisco;

4. (Results are) only for cotton;
Accept may not be the same in other species/types of plant
Ignore: only one study

5. (Results are) for isolated enzymes;

6. No stats test;

4 max

[9]

Q9.

(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]

Q10.

(a) 530 to 630;

1

(b) 1. Reduced NADP;
Accept NADPH or rNADP

2. ATP;
Reduced NAD is incorrect

2

(c) (i) 1. Unit of volume <u>and</u> unit of time;
Accept any reasonable unit of volume
E.g. cm^3 or ml
Accept any reasonable unit of time
E.g. s, min or h

2. Unit of area / mass;
Accept any reasonable unit of area or mass
E.g. cm^2 or g
Symbols should be correct. Do not accept m for minutes.

2

(ii) 1. (Light intensity) limiting factor;

2. Fewer electrons (released) from chlorophyll;

3. Less photolysis therefore (less) oxygen from water;

3

(d) Will not affect (no mark):

1. Photolysis / splitting of water does not use enzymes;

Will affect (no mark):

2. May increase respiration;

3. Respiration uses oxygen;

3

(e) (i) 1. Overlap in standard deviations;

2. Unlikely that any difference is significant;

2

(ii) 1. **P** / visible light has more wavelengths;

2. **Q** has only light of wavelength 460 nm;

3. Wavelengths over 460 nm can also be used for photosynthesis / wavelengths over 460 nm can also be absorbed;

3

[16]