TT

The Light Independent Reaction : The Calvin Cycle

1 2 3 4 5

Calvin Cycle _____ _____ :

The Calvin Cycle

→

→

→

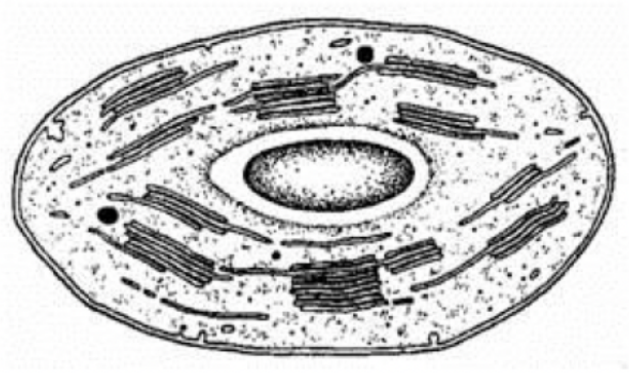
→

→

LIGHT INDEPENDENT REACTION

Q1.

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)

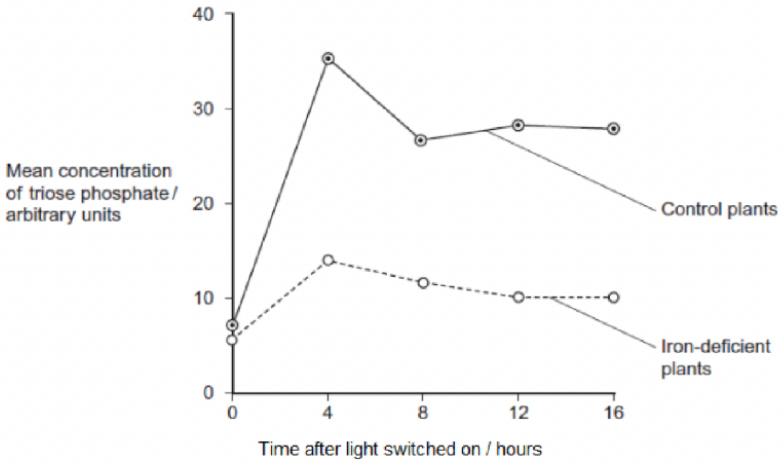
(Total 5 marks)

Q3.

Scientists investigated the effect of iron deficiency on the production of triose phosphate in sugar beet plants. They grew the plants under the same conditions with their roots in a liquid growth medium containing all the necessary nutrients. Ten days before the experiments, they transferred half the plants to a liquid growth medium containing no iron. The scientists measured the concentration of triose phosphate produced in these plants and in the control plants:

- at the end of 6 hours in the dark
- then for 16 hours in the light.

Their results are shown in the graph.



(a) (i) The experiments were carried out at a high carbon dioxide concentration. Explain why.

_____

_____

_____

(1)

(b) Iron deficiency reduces electron transport. Use this information and your knowledge of photosynthesis to explain the decrease in production of triose phosphate in the iron-deficient plants.

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(c) Iron deficiency results in a decrease in the uptake of carbon dioxide. Explain why.

_____

_____

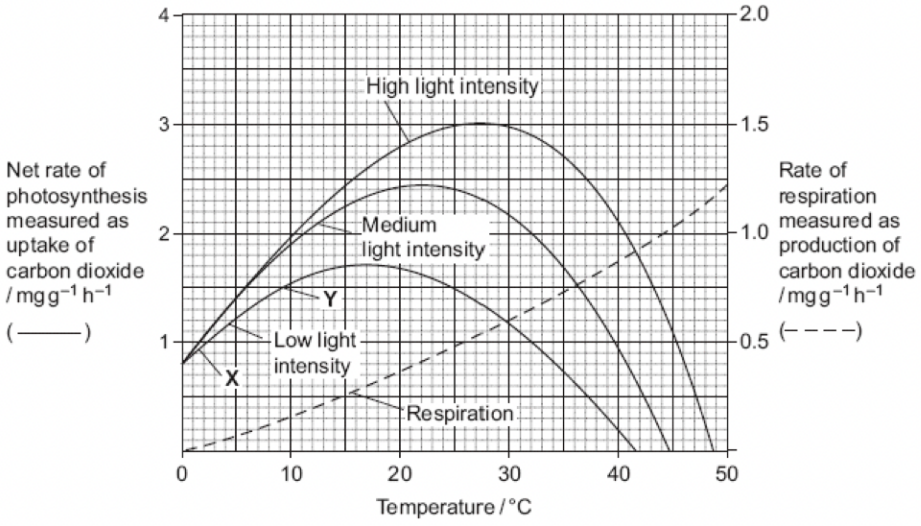
_____

_____

(2)

Q5.

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)

LIGHT INDEPENDENT REACTION

A scientist investigated the uptake of radioactively labelled carbon dioxide in chloroplasts. She used three tubes, each containing different components of chloroplasts. She measured the uptake of carbon dioxide in each of these tubes.
Her results are shown in the table.

Tube	Contents of tube	Uptake of radioactively labelled CO_2 / counts per minute
A	Stroma and grana	96 000
B	Stroma, ATP and reduced NADP	97 000
C	Stroma	4 000

(a) Name the substance which combines with carbon dioxide in a chloroplast.

_____

(1)

(b) Explain why the results in tube **B** are similar to those in tube **A**.

_____

_____

(1)

(c) Use the information in the table to predict the uptake of radioactively labelled carbon dioxide if tube **A** was placed in the dark. Explain your answer.

_____

_____

_____

_____

(2)

(d) Use your knowledge of the light-independent reaction to explain why the uptake of carbon dioxide in tube **C** was less than the uptake in tube **B**.

_____

_____

_____

_____

(2)

(e) DCMU is used as a weed killer. It inhibits electron transfer during LIGHT DEPENDENT REACTION. The addition of DCMU to tube **A** decreased the uptake of carbon dioxide. Explain why.

_____

_____

_____

_____

(2)
(Total 8 marks)

LIGHT INDEPENDENT REACTION

Q4.

(a) Crops use light energy to produce photosynthetic products.
Describe how crop plants use light energy during the light-dependent reaction.

(5)

Q6.

During the light-independent reaction of photosynthesis, carbon dioxide is converted into organic substances.
Describe how.

(Total 6 marks)

Q1.

(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^-']

(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) (i) So it / CO_2 is not a limiting factor (on growth / photosynthesis)
Accept: CO_2 is a limiting factor

1

(ii) So any difference is due to iron (deficiency)
Accept: iron is the variable

1

(iii) Amount of triose phosphate / TP will be similar / same / low (at start)
Accept: to allow triose phosphate to stabilise / become constant
Reject: so all triose phosphate is used up
Reject: so no triose phosphate

1

(b) 1. (Less) ATP produced
Accept: alternatives for reduced NADP ie NADP with hydrogen / s attached

2. (Less) reduced NADP produced

3. ATP / reduced NADP produced during light-dependent reaction

4. (Less) GP to triose phosphate / TP

4

(c) 1. Less triose phosphate converted to RuBP
Accept: less triose phosphate so less RuBP

2. CO_2 combines with RuBP

2
[9]

Q5.

(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]

Q2.

(a) Ribulose bisphosphate / RuBP

Accept Ribulose biphosphate or Ribulose diphosphate

Accept phonetic spellings

Accept any variation in upper or lower case for RuBP

1

(b) ATP and reduced NADP are produced in grana / thylakoids / present in A / both tubes

Must be reduced NADP but accept any alternative which show hydrogen attached to NADP

Must be reduced NADP not reduced NAD

1

(c) 1. 4 000

Accept 'same as in (tube) C', but not 'same' on its own

2. Light-dependent reaction does not occur / ATP and reduced NADP are not produced

Accept converse for mark point 2

2

(d) 1. (Less) GP converted to TP

GP = glycerate 3-phosphate

TP = triose phosphate but abbreviations are sufficient

2. (Less) TP converted to RuBP

Accept GALP as TP

2

(e) 1. No / less ATP / ATP produced (during electron transport)

Must be reduced NADP but accept any alternative which shows hydrogen attached to NADP

2. No / less reduced NADP / reduced NADP produced (during electron transport)

2

[8]

Q4.

(a) 1. Excites electrons / electrons removed (from chlorophyll)

Accept: higher energy level as 'excites'.

2. Electrons move along carriers/electron transfer chain releasing energy

Accept: movement of H^+/protons across membrane releases energy.

Reject: 'produces energy' for either mark but not for both.

3. Energy used to join ADP and Pi to form ATP

Reject: 'produces energy' for either mark but not for both.

Accept: energy used for phosphorylation of ADP to ATP

Do not accept P as Pi but accept phosphate.

4. Photolysis of water produces protons, electrons and oxygen
5. 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 its own.

5

Q6.

1. Carbon dioxide combines with ribulose bisphosphate / RuBP

2. Produces two glycerate (3-)phosphate / GP

Accept: any answer which indicates that 2 x as much GP produced from one RuBP.

3. GP reduced to triose phosphate / TP

Must have idea of reduction. This may be conveyed by stating m.p. 4.

4. Using reduced NADP

***Reject**: Any reference to reduced NAD for m.p.4 but allow reference to reduction for m.p. 3.*

5. Using <u>energy</u> from ATP

Must be in context of GP to TP.

6. Triose phosphate converted to glucose / hexose / RuBP / ribulose bisphosphate / named organic substance

[6]