6.1 Photosynthesis

Name: _____ Class: _____ Date: _____ **Total: 27 marks**

KEY WORDS photosynthesis • rate • ions • carbon dioxide • temperature

Objective

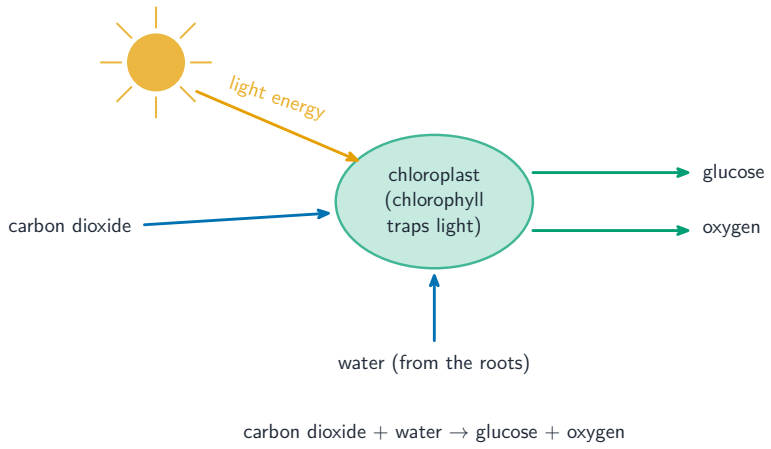
Build the skills to answer exam questions on **photosynthesis** – the equation, the role of **chlorophyll**, uses of glucose, minerals, and **limiting factors**.

You must be able to:

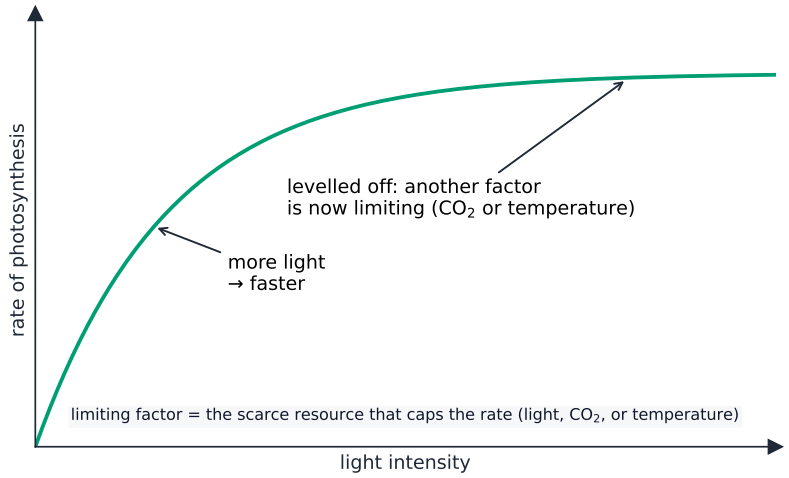
- write the word (and balanced) equation for photosynthesis
- state the uses of glucose and the roles of nitrate and magnesium ions
- describe how light, CO_2 and temperature affect the rate

1 Key knowledge and worked examples

Equation and rate



carbon dioxide + water → glucose + oxygen (in light, with chlorophyll)



More light → faster, until another factor becomes limiting

- glucose → starch (store), cellulose (walls), respiration, sucrose (transport).
- nitrate → amino acids; magnesium → chlorophyll.

The equation, the factors, and reading the graph

$$\text{carbon dioxide} + \text{water} \xrightarrow[\text{chlorophyll}]{\text{light}} \text{glucose} + \text{oxygen}$$

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

Chlorophyll is not a reactant: it absorbs the light energy and transfers it to the reaction, which is why it is written over the arrow.

A limiting factor is the factor in shortest supply, which holds the rate back. Three matter: **light intensity**, **carbon dioxide concentration** and **temperature**.

Reading a rate graph, which the exam asks every year. Where the line **rises**, the factor on the x-axis is limiting: more of it gives more photosynthesis. Where the line **levels off**, that factor is no longer limiting, so something else is – for a light-intensity graph, usually carbon dioxide concentration or temperature. If the line **falls** at high temperature, the reason is different in kind: the enzymes have been **denatured**, so their active sites no longer fit the substrate.

What the plant does with the glucose: respiration, to release energy; converted to starch for storage; converted to cellulose for cell walls; converted to sucrose for transport in the phloem; used with nitrate ions to make amino acids and then proteins.

Mineral ions. Nitrate ions are needed to make amino acids and so proteins; without them growth is stunted and older leaves turn yellow. **Magnesium ions** are needed to make chlorophyll; without them the leaves turn yellow between the veins.

Worked example. A graph shows the rate of photosynthesis against carbon dioxide concentration at 20 °C and at 30 °C. Both level off, but the 30 °C line levels off higher. Explain. At low concentrations the rate rises because carbon dioxide is the limiting factor. Both level off when carbon dioxide is no longer limiting. The 30 °C line levels off at a higher rate because the enzymes controlling photosynthesis work faster at the higher temperature, so temperature was the factor limiting the 20 °C line.

2 Practice

2.1 Write the word equation for photosynthesis. [2]

2.2 State the role of magnesium ions in a plant. [1]

2.3 Explain why a plant lacking nitrate ions grows poorly. [2]

2.4 State what is meant by a limiting factor. [1]

2.5 Give the balanced symbol equation for photosynthesis. [2]

3 Exam-style questions

3.1 Photosynthesis can only take place where there is light and: [1]

- ☐ **A** nitrate
- **B** chlorophyll
- **C** oxygen
- **D** protein

3.2 A graph shows photosynthesis rate rising with light intensity, then levelling off.

(a) Explain why the rate levels off at high light intensity. [2]

(b) Name one other factor that could then be limiting. [1]

3.3 State two uses a plant makes of the glucose produced in photosynthesis. [2]

3.4 A student measures the rate of photosynthesis of pondweed by counting the bubbles of gas released each minute at different light intensities, at two temperatures.

(a) Name the gas being collected, and explain why counting its bubbles measures the rate of photosynthesis. [2]

(b) At low light intensity both lines rise steeply and lie on top of each other. Explain what this shows. [2]

(c) At high light intensity the 25 °C line levels off higher than the 15 °C line. Explain why. [3]

(d) The student repeats the experiment at 45 °C and the rate is very low. Explain this result. [2]

(e) Suggest two variables the student must keep constant for the comparison to be valid. [2]

(f) Estimate what would happen to the rate if the student added sodium hydrogencarbonate solution, which releases carbon dioxide, at high light intensity. Explain your answer. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

- **carbon dioxide + water → glucose + oxygen**

2.2

- magnesium ions are needed to make **chlorophyll**

2.3

- nitrate is needed to make **amino acids and proteins**
- without proteins the plant cannot build new cells, so **growth is stunted**

2.4

- a limiting factor is the factor in **shortest supply**, which holds back the rate

2.5

- $6\mathbf{CO_2} + 6\mathbf{H_2O} \rightarrow \mathbf{C_6H_{12}O_6} + 6\mathbf{O_2}$

3.1 B

- photosynthesis needs **chlorophyll** (and light)
- A is a mineral; C is a product; D is not required for the reaction itself

3.2

(a)

- another factor is now **limiting**
- e.g. CO_2 concentration or temperature

(b)

- **carbon dioxide concentration** (or temperature)

3.3

- any **two** of: stored as starch / made into cellulose / used in respiration / converted to sucrose

3.4

(a)

- the gas is **oxygen**
- it is a product, so more bubbles mean a **faster rate**

(b)

- **light intensity** is limiting
- temperature makes no difference because it is **not limiting** here

(c)

- light is no longer limiting, so both lines **level off**
- at 25 °C the enzymes work **faster** than at 15 °C
- **temperature** was limiting the 15 °C line

(d)

- enzymes are **denatured** at 45 °C
- active sites change shape, so the reaction **almost stops**

(e)

- any **two** of: lamp distance / CO_2 concentration / pondweed mass / volume of water / time counted

(f)

- the rate would **increase**
- at high light, CO_2 is limiting, so supplying more **removes that limit**