13.2 Investigation of limiting factors

Name: _____ Class: _____ Date: _____ **Total: 13 marks**

KEY WORDS temperature • light intensity • concentration • limiting factor • indicator

Objective

Build the skills to answer exam questions on the **investigation of limiting factors** of photosynthesis – **light intensity** , **carbon dioxide concentration** and **temperature** .

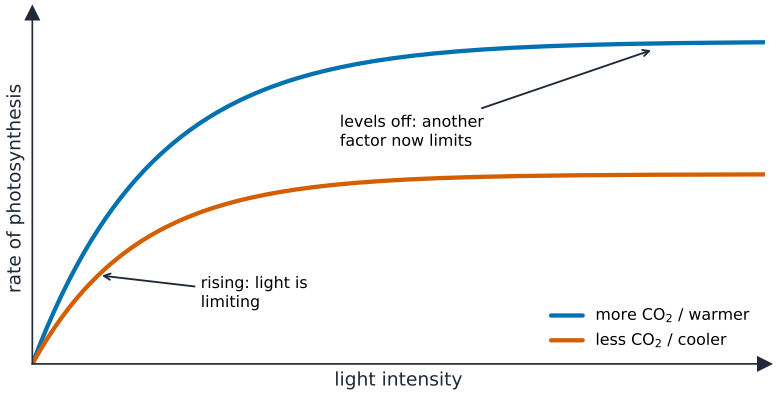
You must be able to:

- explain the effects of light intensity, carbon dioxide concentration and temperature on rate
- read a rate graph to identify which factor is limiting
- describe investigations using redox indicators and whole aquatic plants

1 Key knowledge and worked examples

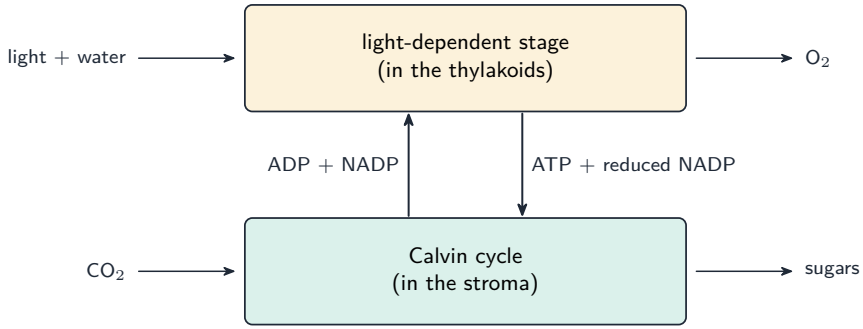
■ Limiting factors

A **limiting factor** is the one in shortest supply that holds back the rate.



the scarcest factor limits the rate · higher plateau: CO_2 or temperature was limiting

While the rate rises, light is limiting; where it levels off, another factor (CO_2 or temperature) is limiting



Limiting factors act on the two stages of photosynthesis

- raising **light intensity** speeds the rate until another factor becomes limiting.
- raising **CO_2 concentration** speeds the rate until another factor becomes limiting.
- raising **temperature** speeds the rate to an optimum; too high and the enzymes denature.

■ Investigations

- a redox **indicator** (DCPIP or methylene blue) with a chloroplast suspension loses colour as the light-dependent stage works – time the colour loss at different light intensities or wavelengths.
- with a whole **aquatic plant** (e.g. *Elodea*), count the oxygen bubbles per minute, or collect the gas, under different conditions. Use a control and repeat for reliability.

2 Practice

2.1 Name **three** factors that can limit the rate of photosynthesis. [3]

2.2 State how you could measure the rate of photosynthesis of pondweed. [1]

3 Exam-style questions

3.1 On a rate-against-light-intensity graph, the curve rises then levels off. At the levelled-off part, the limiting factor is: [1]

- **A** light intensity
- **B** something other than light (e.g. CO_2 or temperature)
- **C** the amount of chlorophyll only
- **D** oxygen concentration

3.2 Why does the rate of photosynthesis fall at very high temperatures? [1]

- **A** too much CO_2 dissolves
- **B** the enzymes denature
- **C** light cannot reach the leaf
- **D** water freezes

3.3 A student counts oxygen bubbles from pondweed at different distances from a lamp.

(a) Explain why moving the lamp closer increases the bubble rate (up to a point). [2]

(b) State **two** variables the student must control to make this a fair test. [2]

3.4 Explain how a redox indicator such as DCPIP can be used to measure the rate of the light-dependent stage. [3]

Solutions

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

2.1

- light intensity; carbon dioxide concentration; temperature

2.2

- count the oxygen bubbles given off per minute (or collect/measure the volume of oxygen)

3.1 B

- When the curve levels off, light is no longer limiting – another factor is

3.2 B

- Above the optimum the enzymes denature, so the rate falls

3.3

(a)

- moving the lamp closer raises the light intensity, so more light energy is available for the light-dependent stage, increasing the rate

(b)

- any two: temperature; CO_2 concentration; same piece of pondweed; same time counted

3.4

- add DCPIP to an illuminated chloroplast suspension; the dye is reduced by the light-dependent stage and loses its blue colour; time how long the colour takes to disappear at each condition – faster loss means a faster rate