

13.2 Investigation of limiting factors

Name: _____ Class: _____ Date: _____

Total: 13 marks

KEY WORDS temperature 温度 • light intensity 光照强度 • concentration 浓度
• limiting factor 限制因素 • indicator 指示剂

Objective

Build the skills to answer exam questions on the **investigation of limiting factors** of photosynthesis — **light intensity** 光照强度, **carbon dioxide concentration** 浓度 and **temperature** 温度.

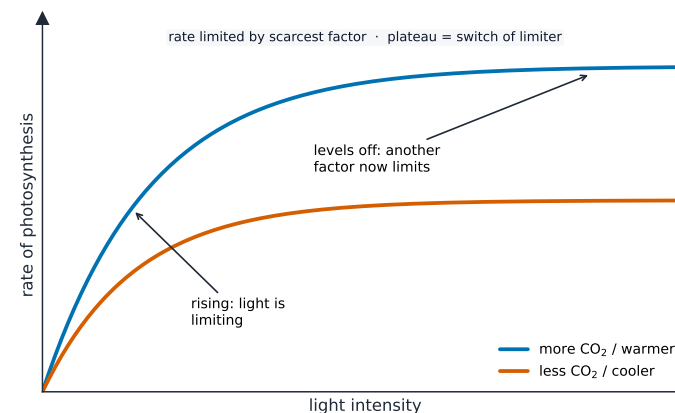
You must be able to:

- 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

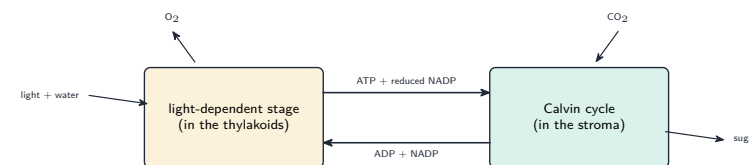
1 Worked examples

■ Limiting factors

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



While the rate rises, light is limiting; where it levels off, another factor (CO₂ 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 **CO₂ 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** 指示剂 (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** 水生植物 (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. CO₂ 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 CO₂ 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

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.