Exercise walk-through

6.1.1 Testing a leaf for starch, and the experiments behind the equation

IGCSE Biology

You must be able to

- describe photosynthesis, and state the word equation and the balanced chemical equation
- state that **chlorophyll** 叶绿素 is a green **pigment** 色素 found in **chloroplasts** 叶绿体, and that it transfers energy from light into chemicals
- outline how the carbohydrate made is used and stored: starch, **cellulose** 纤维素, respiration, **sucrose** 蔗糖 in the phloem, and **nectar** 花蜜
- explain why **nitrate ions** 硝酸根离子 and **magnesium ions** 镁离子 matter to a plant
- investigate the need for chlorophyll, light and carbon dioxide, using appropriate **controls** 对照
- investigate and describe the effects of light intensity, carbon dioxide concentration and temperature on the rate

You must be able to

- investigate and describe the effect of light and dark on gas exchange in an aquatic plant using hydrogencarbonate indicator solution
- identify and explain the **limiting factor** 限制因素 in different conditions

1 The method

Method — What you already need from sheet 6.1

- **Word equation:** carbon dioxide + water → glucose + oxygen, **in the presence of light and chlorophyll**. The last phrase is a marking point; leave it out and the equation is incomplete.
- **Balanced equation:** $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$.
- Chlorophyll is a **green pigment** inside the **chloroplasts**. It transfers energy from light into energy in chemicals.
- The glucose is used for **respiration 呼吸作用**, stored as **starch**, built into **cellulose** for cell walls, carried as **sucrose** in the phloem, and made into **nectar** to attract insects.
- **Nitrate ions** are needed to make **amino acids 氨基酸**, and so proteins; **magnesium ions** are needed to make **chlorophyll**. A plant short of magnesium has yellow leaves; a plant short of nitrate grows poorly and is stunted.

Method — Testing a leaf for starch

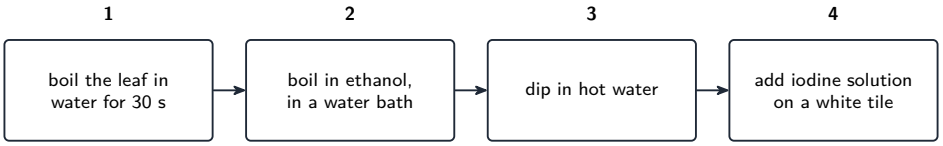
The examiner wants the **reason**, not the action. Learn the four reasons:

1. **Boil in water** – kills the cells so no further reaction happens, and softens the leaf.
2. **Boil in ethanol** 乙醇, standing in a hot water bath – this removes the green chlorophyll, so that the iodine colour can be seen. Ethanol catches fire easily, so it is **never** heated over a flame.
3. **Dip in hot water** – ethanol leaves the leaf brittle, and this softens it again.
4. **Add iodine solution** on a white tile – **blue-black** means starch is present, **orange-brown** means there is none.

- Starch is the store, so *starch present* means *photosynthesis happened here*.

Method — Testing a leaf for starch

The examiner wants the reason , not the action.



Ethanol catches fire easily, so it is heated in a **water bath** and never over a flame. That is a mark on its own whenever the method is asked for.

Method — The three experiments, and why each needs a control

Each experiment removes **one** thing and leaves everything else as it was. That is what makes the result mean something.

what is being tested	how it is removed	the control
chlorophyll	use a **variegated** 花叶 leaf, whose pale edge has none	the green part of the **same** leaf
light	cover a strip with **foil** 锡箔	the uncovered part of the **same** leaf
carbon dioxide	seal the plant in a flask with **soda lime** 碱石灰, which absorbs it	a second plant in a flask with **no** soda lime

- **Destarch the plant first** – leave it in the dark for about 48 hours so that any starch already there is used up. Without this step, starch found at the end proves nothing.
- A control differs in **one** thing only. "I used another plant" is not a control unless everything else about it is the same.

Method — The three experiments, and why each needs a control

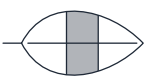
Each experiment removes one thing and leaves everything else as it was.

(a) is chlorophyll needed?

a **variegated** leaf: the pale edge has no chlorophyll

after the test the **green** part is blue-black, the **white** part orange-brown

(b) is light needed?



a strip of **foil** covers part of a destarched leaf for a day

the **covered** strip is orange-brown, the **uncovered** leaf blue-black

(c) is carbon dioxide needed?

a plant sealed in a flask; the **soda lime** absorbs all the carbon dioxide

its leaf is orange-brown; a **control** flask without soda lime goes blue-black

Destarch the plant first, 48 hours in the dark, or the starch you find may have been made before the experiment began.

Method — Hydrogencarbonate indicator: reading gas exchange

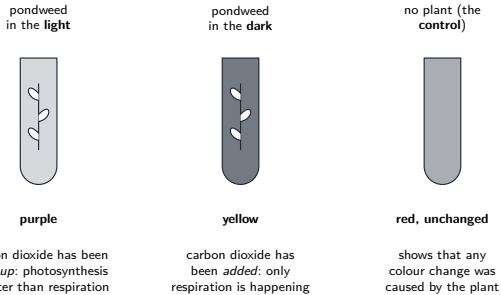
The indicator reports the **carbon dioxide concentration of the water**, not photosynthesis directly:

colour	carbon dioxide	what it means
purple	lower than normal	the plant has **taken in** more than it gave out: photosynthesis is faster than respiration
red	normal	no overall change
yellow	higher than normal	the plant has **given out** more than it took in: only respiration is happening

- In the light a plant **respires as well**. The colour tells you about the *net* result, so write "more carbon dioxide taken in than given out", never "the plant does not respire in the light".

Method — Hydrogencarbonate indicator: reading gas exchange

The indicator reports the carbon dioxide concentration of the water , not photosynthesis directly: center



The indicator measures **carbon dioxide in the water**, so it reports the *net* exchange. In the light the plant respires as well; it simply takes in more carbon dioxide than it gives out.

Method — Describing a rate investigation

Use the same three words every time:

- the **independent variable 自変量** is what you change – light intensity (by moving a lamp), carbon dioxide concentration (by using hydrogencarbonate solutions), or temperature (with a water bath);
- the **dependent variable 因変量** is what you measure – the volume of gas collected in a set time is better than counting bubbles, because bubbles vary in size;
- the **control variables** are the other two of the three, plus the mass of pondweed and the time.
- △ A lamp warms the water as well as lighting it, so put a **beaker of water between the lamp and the plant** as a heat shield, or temperature stops being controlled.

Method — Describing a rate investigation

- To make the results **reliable** 可靠, repeat each reading at least three times and take a **mean** 平均值.

2 Practice

Practice 2.1 ▪ 2 marks

Name the substance that turns iodine solution blue-black, and state what finding it in a leaf tells you.

Solution 2.1

Method: Testing a leaf for starch — p.6

Worked steps

- **starch** B1
- starch is the store made from the glucose produced, so finding it shows that **photosynthesis has taken place** in that part of the leaf B1

Practice 2.2 ▪ 2 marks

Explain why a leaf is boiled in ethanol during the starch test.

Solution 2.2

Method: Testing a leaf for starch — p.6

Worked steps

- to remove the green **chlorophyll** from the leaf B1
- so that the colour of the iodine solution can be seen against a pale leaf B1

Practice 2.3 ▪ 1 mark

Explain why the ethanol is heated in a water bath and not over a flame.

Solution 2.3

Method: Testing a leaf for starch — p.6

Worked steps

- ethanol is **flammable** and would catch fire over a flame B1

Practice 2.4 ▪ 2 marks

A plant is left in a dark cupboard for two days before an experiment on photosynthesis. Explain why.

Solution 2.4

Worked steps

- to **destarch** it: any starch already in the leaves is used up or moved away B1
- so that any starch found at the end of the experiment must have been made **during** the experiment B1

Practice 2.5 ▪ 3 marks

A variegated leaf from a plant kept in bright light is tested for starch. Describe the result, and explain what it shows.

Solution 2.5

Method: The three experiments, and why each needs a control — p.8

Worked steps

- the **green** parts go **blue-black**; the **white** parts stay **orange-brown** B1
- starch was made only where there was chlorophyll B1
- so **chlorophyll is needed** for photosynthesis; the white part of the same leaf acts as the control, because everything else about it is the same B1

Practice 2.6 ▪ 3 marks

Pondweed is left in red hydrogencarbonate indicator in bright light for two hours. State the colour of the indicator at the end, and explain the change.

Solution 2.6

Method: Hydrogencarbonate indicator: reading gas exchange — p.10

Worked steps

- it turns **purple** B1
- the pondweed has taken in more carbon dioxide for photosynthesis than it gave out in respiration B1
- so the carbon dioxide concentration of the water has **fallen** below normal B1

3 Exam-style

Exam-style 3.1 ▪ 1 mark

A destarched plant is left in the light for a day with one leaf partly covered by foil. That leaf is then tested for starch. Which result is correct?

A the covered part is blue-black, the uncovered part is orange-brown

B the covered part is orange-brown, the uncovered part is blue-black

C both parts are blue-black

D both parts are orange-brown

Solution 3.1

Method: The three experiments, and why each needs a control — p.8

A the covered part is blue-black, the uncovered part is orange-brown

B the covered part is orange-brown, the uncovered part is blue-black ✓

C both parts are blue-black

D both parts are orange-brown

Worked steps

B

- the covered strip received no light, so no photosynthesis happened there and no starch was made: **orange-brown** B1
- the uncovered part had light, chlorophyll and carbon dioxide, so it made starch: **blue-black**

Exam-style 3.2 ▪ 6 marks

A student set up three boiling tubes, each containing red hydrogencarbonate indicator solution. Tube **A** held pondweed and was left in bright light. Tube **B** held pondweed and was wrapped in foil. Tube **C** held no pondweed. All three were left for two hours at the same temperature.

Exam-style 3.2 (a) ▪ 3 marks

State the colour of the indicator in tube **A** at the end, and explain the change.

Solution 3.2 (a)

Method: Hydrogencarbonate indicator: reading gas exchange — p.10

Worked steps

- **purple** B1
- the pondweed photosynthesised faster than it respired, so it took in more carbon dioxide than it gave out B1
- the carbon dioxide concentration of the water fell below normal, and the indicator shows this as purple B1

Exam-style 3.2 (b) ▪ 2 marks

State the colour in tube **B** at the end, and explain the change.

Solution 3.2 (b)

Worked steps

- **yellow** B1
- in the dark there is no photosynthesis, but the pondweed still respires, so carbon dioxide was added to the water B1

Exam-style 3.2 (c) ▪ 1 mark

Explain why tube **C** was included.

Solution 3.2 (c)

Worked steps

- it is the **control**: it shows that any colour change in A and B was caused by the pondweed and not by the light, the tube or the indicator itself B1

Exam-style 3.3 ▪ 11 marks

A student investigated how carbon dioxide concentration affects the rate of photosynthesis. She placed the same mass of pondweed in tubes of sodium hydrogencarbonate solution of different concentrations, which supplies carbon dioxide. The lamp stayed at the same distance and the temperature was kept at 20 °C. She collected the gas given off and measured its volume after 10 minutes.

Exam-style 3.3 ▪ 11 marks

concentration of solution / %	volume of gas / cm^3
0.0	0.2
0.1	1.4
0.2	2.6
0.4	4.1
0.8	4.4
1.6	4.5

Exam-style 3.3 (a) ▪ 2 marks

Name the gas collected, and describe a test that would confirm it.

Solution 3.3 (a)

Method: Describing a rate investigation — p.12

Worked steps

- **oxygen** B1
- it **relights a glowing splint** B1

Exam-style 3.3 (b) ▪ 3 marks

Describe the results shown in the table.

Solution 3.3 (b)

Worked steps

- the volume of gas **rises steeply** between 0.0% and 0.4%, from 0.2 cm^3 to 4.1 cm^3 B1
- above 0.4% the volume **levels off** at about 4.5 cm^3 B1
- so the rate rises with carbon dioxide concentration at first, and then stops rising B1

Exam-style 3.3 (c) ▪ 3 marks

Explain the shape of the results above 0.4%.

Solution 3.3 (c)

Worked steps

- above 0.4%, carbon dioxide is no longer the **limiting factor** B1
- something else is limiting the rate – here the **light intensity** or the **temperature**, because both were held constant B1
- so adding more carbon dioxide cannot make the reaction go any faster B1

Exam-style 3.3 (d) ▪ 1 mark

Explain why the lamp was kept at the same distance throughout.

Solution 3.3 (d)

Worked steps

- light intensity is a **control variable**: if it changed, a change in the rate could not be blamed on the carbon dioxide B1

Exam-style 3.3 (e) ▪ 2 marks

Describe what the student should do to make her results more reliable.

Solution 3.3 (e)

Worked steps

- **repeat** each concentration at least three times B1
- calculate a **mean** volume for each, ignoring any anomalous result B1