IGCSE BIOLOGY • EXERCISE SHEET

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

Name: _____ Class: _____ Date: _____ **Total: 31 marks**

KEY WORDS photosynthesis 光合作用 • rate 速率 • carbon dioxide 二氧化碳 • temperature 温度 • ions 离子

Objective

Sheet 6.1 taught you the equation and the limiting factors. This sheet is the other half of 6.1, and it is where the practical marks are: **testing a leaf for starch** 淀粉, the three experiments that prove what photosynthesis 光合作用 needs, **hydrogencarbonate indicator** 碳酸氢盐指示剂 with an aquatic plant, and how to describe and explain a rate investigation. Each one is a fixed sequence of steps whose **reasons** carry the marks, so this sheet drills the reasons. This sheet covers syllabus 6.1.

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
- 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

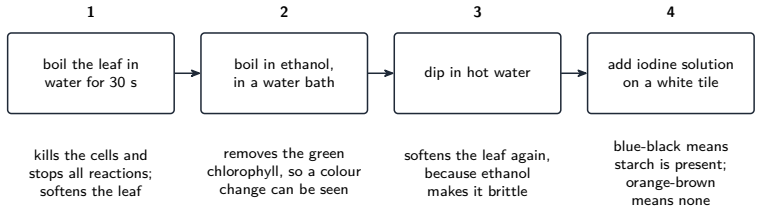
1 Worked examples

Study these first. Each one shows a **method** that a question later on this sheet needs.

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.

Testing a leaf for starch



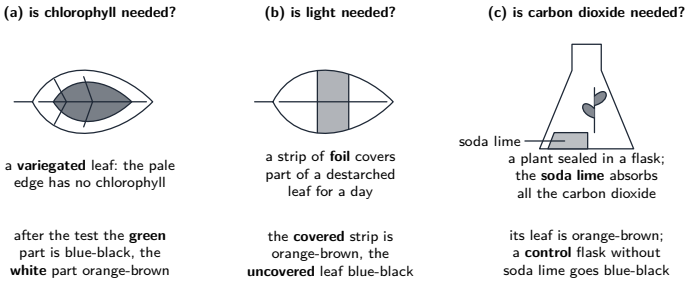
Ethanol catches fire easily, so it is heated in a **water bath** and never over a flame. That is a mark on its own whenever the method is asked for.

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*.

The three experiments, and why each needs a control



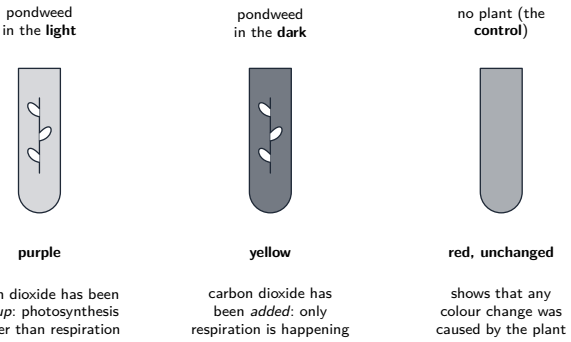
Destarch the plant first, 48 hours in the dark, or the starch you find may have been made before the experiment began.

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.

Hydrogencarbonate indicator: reading gas exchange



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.

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".

Describing a rate investigation

Use the same three words every time:

- the **independent variable** 自变量 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** 因变量 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.
- To make the results **reliable** 可靠, repeat each reading at least three times and

take a **mean** 平均值.

2 Practice

Now use the methods above.

2.1 Name the substance that turns iodine solution blue-black, and state what finding it in a leaf tells you. [2]

2.2 Explain why a leaf is boiled in ethanol during the starch test. [2]

2.3 Explain why the ethanol is heated in a water bath and not over a flame. [1]

2.4 A plant is left in a dark cupboard for two days before an experiment on photosynthesis. Explain why. [2]

2.5 A variegated leaf from a plant kept in bright light is tested for starch. Describe the result, and explain what it shows. [3]

2.6 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. [3]

3 Exam-style questions

3.1 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? [1]

A | B
C | D

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

3.2 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.

(a) State the colour of the indicator in tube **A** at the end, and explain the change. [3]

(b) State the colour in tube **B** at the end, and explain the change. [2]

(c) Explain why tube **C** was included. [1]

3.3 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.

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

(a) Name the gas collected, and describe a test that would confirm it. [2]

(b) Describe the results shown in the table. [3]

(c) Explain the shape of the results above 0.4%. [3]

(d) Explain why the lamp was kept at the same distance throughout. [1]

(e) Describe what the student should do to make her results more reliable. [2]

Solutions

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

2.1

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

2.2

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

2.3

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

2.4

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

2.5

- the **green** parts go **blue-black**; the **white** parts stay **orange-brown**
- starch was made only where there was chlorophyll
- 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

2.6

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

3.1 B

- the covered strip received no light, so no photosynthesis happened there and no starch was made: **orange-brown**
- the uncovered part had light, chlorophyll and carbon dioxide, so it made starch: **blue-black**
- **A** has it the wrong way round; **C** and **D** would show that light made no difference, which is not what happens

3.2

(a)

- **purple**

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

(b)

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

(c)

- 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

3.3

(a)

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

(b)

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

(c)

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

(d)

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

(e)

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