Photosynthesis 2

Name: _____

Class: _____

Date: _____

Time: **82 minutes**

Marks: **76 marks**

Comments:

1. Plants absorb light for photosynthesis.

(a) Which is the equation for photosynthesis?

Tick (✓) **one** box.

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

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

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

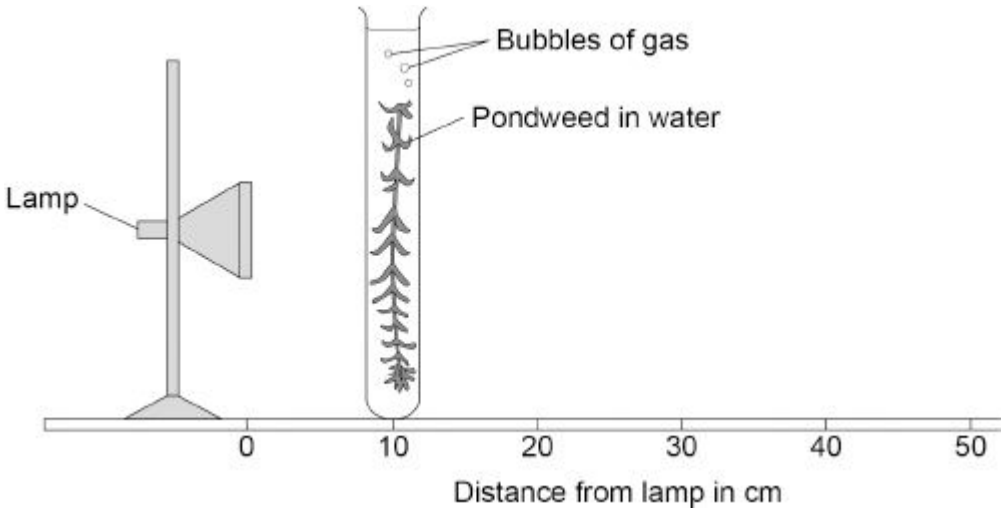
$6\ O_2 + 6\ CO_2 \rightarrow C_6H_{12}O_6 + 6\ H_2O$ ☐

(1)

A student investigated the effect of light intensity on the rate of photosynthesis.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Set up the apparatus as shown in **Figure 1**.
2. Place the pondweed 10 cm away from the lamp.
3. Switch on the lamp.
4. Record the number of bubbles of gas produced in 5 minutes.
5. Repeat steps 2 to 4 with the pondweed at different distances from the lamp.

(b) What was the independent variable in this investigation?

Tick (✓) **one** box.

- Distance of the pondweed from the lamp ☐
- Length of the piece of pondweed ☐
- Number of bubbles of gas produced ☐
- Time taken to collect the gas ☐

(1)

The lamp gets warm when it is on. This causes the temperature of the water to increase.

(c) Explain how an increase in temperature would affect the results of this investigation.

_____

_____

_____

_____

(2)

(d) Suggest **one** way the investigation could be improved so the temperature of the water does **not** increase.

_____

_____

(1)

(e) Suggest **two** improvements to the investigation so the results would be more valid.

Do **not** refer to controlling the temperature of the water.

1 _____

_____

2 _____

_____

(2)

The table below shows the results.

Distance of pondweed from the lamp in cm	**Number of bubbles of gas produced in 5 minutes**
10	120
20	56
30	31
40	16
50	10

(f) Calculate the rate of photosynthesis when the pondweed was 40 cm from the lamp.

Give the rate of photosynthesis as the number of bubbles of gas produced per minute.

_____

_____

Rate = _____ bubbles of gas produced per minute

(1)

(g) Give **one** conclusion that can be made from the table above.

_____

_____

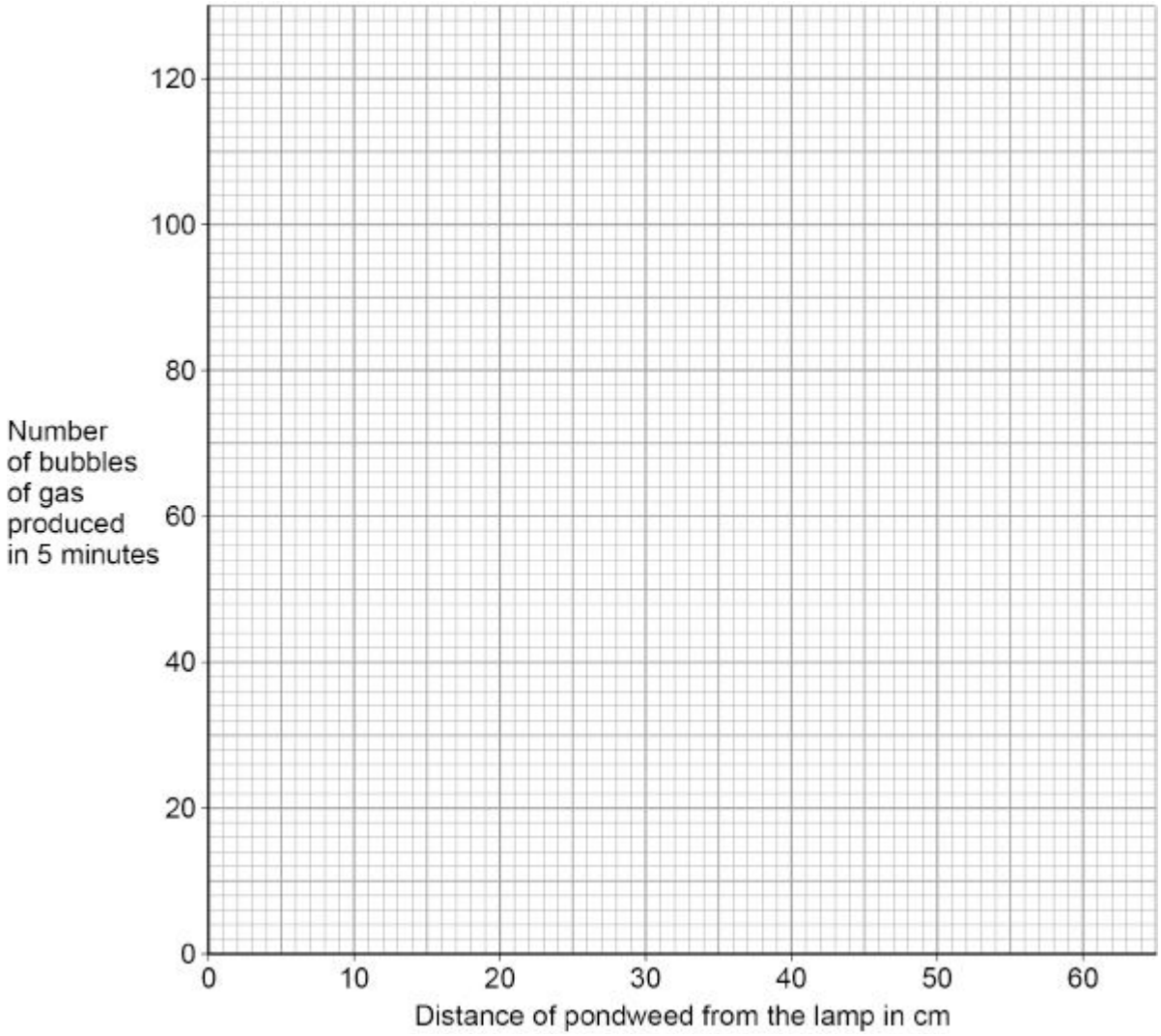
_____

(1)

(h) Plot the data from the table above on **Figure 2**.

Draw a line of best fit.

Figure 2



(3)

(i) Predict the number of bubbles that would be produced in 5 minutes if the pondweed was 60 cm from the lamp.

Use **Figure 2**.

Number of bubbles produced in 5 minutes = _____

(1)

(Total 13 marks)

2. This question is about photosynthesis and food production.

(a) How can oxygen production be used to show the **rate** of photosynthesis?

_____

_____

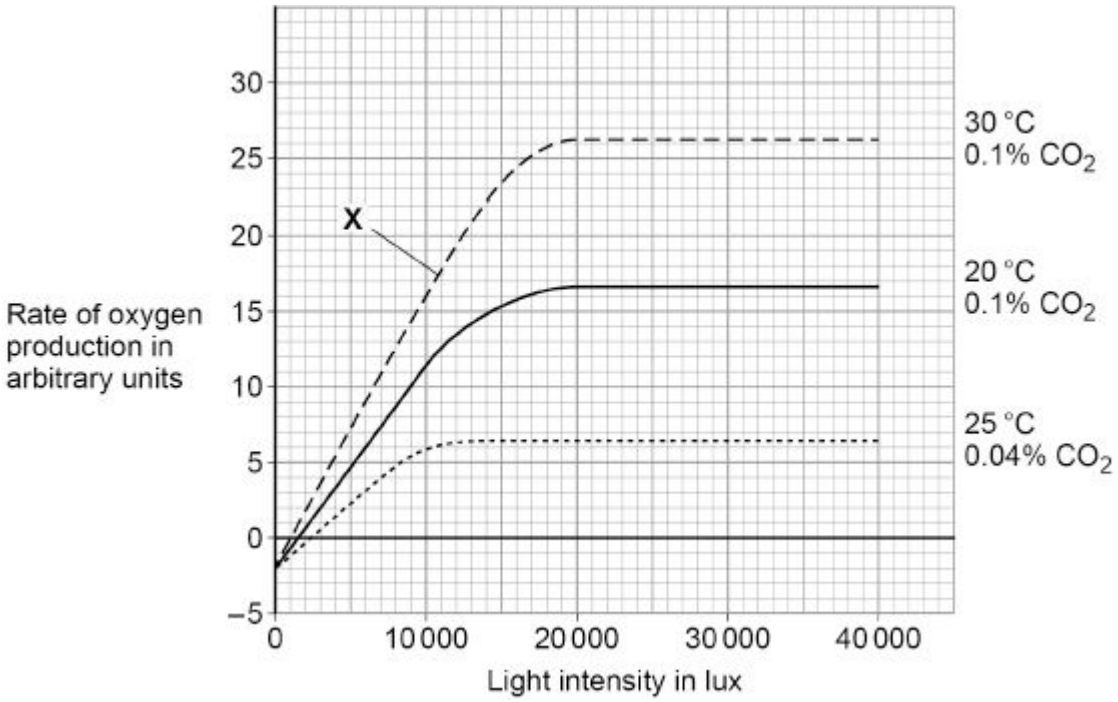
_____

(1)

Scientists investigated factors affecting the rate of photosynthesis in tomato plants.

The tomato plants were growing in a commercial greenhouse in the UK during winter.

The graph below shows the results.



The percentage of carbon dioxide in the Earth's atmosphere is 0.04%

(b) Name the factor that is limiting the rate of photosynthesis at point **X**.

_____

(1)

Farmers growing tomatoes commercially try to control the rate of photosynthesis and make maximum profit.

A farmer can control the temperature and carbon dioxide concentration in a greenhouse.

(c) What is the **minimum** light intensity a farmer should use to get the maximum rate of photosynthesis shown in above graph?

Light intensity = _____ lux

(1)

(d) The light intensity you gave in part (c) may **not** give the farmer maximum profit.

Explain why.

_____

_____

_____

_____

_____

_____

(3)

(e) Explain the results when the light intensity was 0 lux.

Use the diagram above.

_____

_____

_____

_____

_____

_____

_____

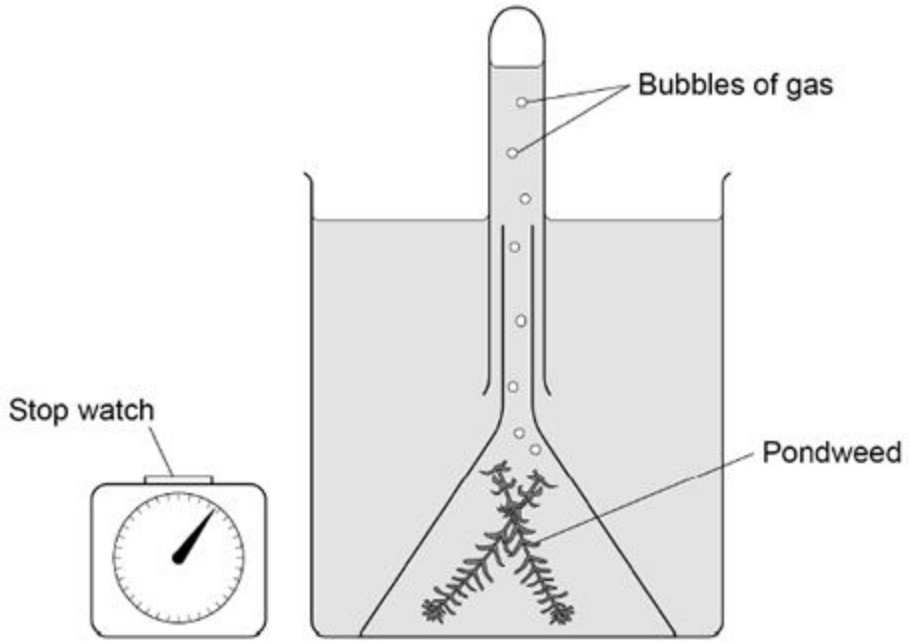
(4)

(Total 10 marks)

3. A student investigated the effect of light intensity on the rate of photosynthesis.

Figure 1 shows some of the apparatus used.

Figure 1



(a) Name the gas produced by the pondweed in the light.

_____

(1)

(b) Describe **one** way the student could change the intensity of light reaching the pondweed.

_____

_____

_____

(2)

(c) Describe how the student could use the apparatus in **Figure 1** to measure the rate of photosynthesis.

_____

_____

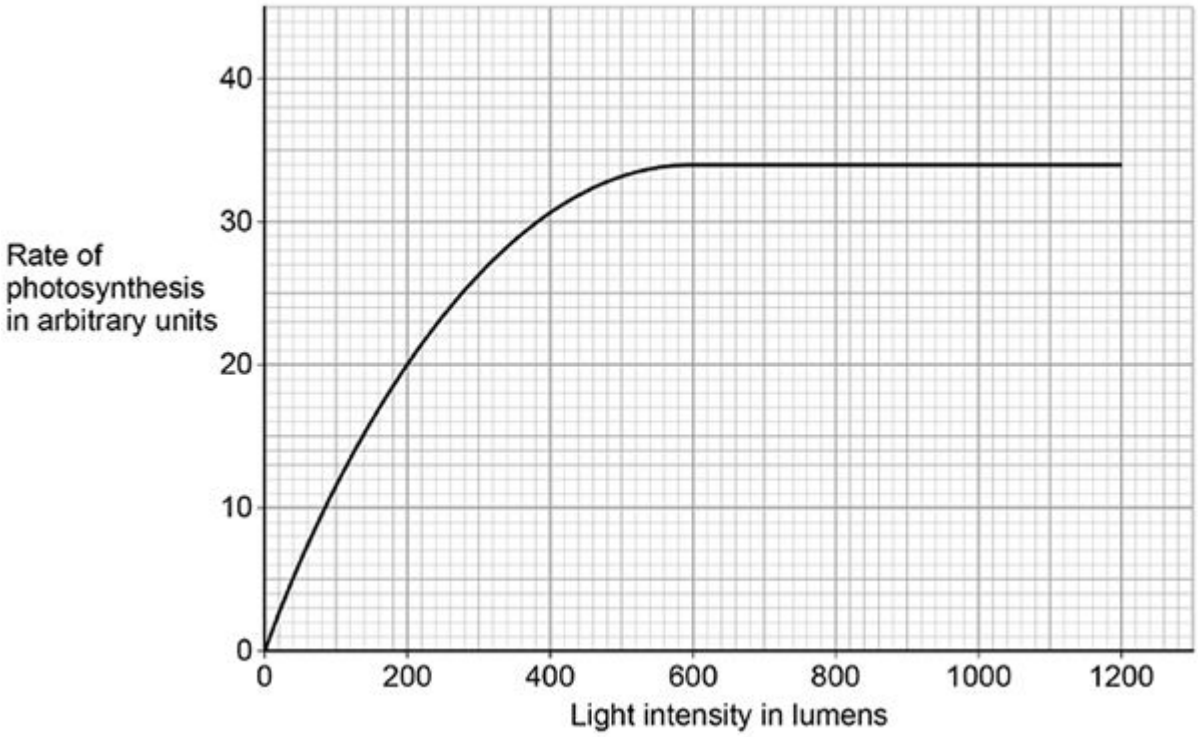
_____

_____

(2)

Figure 2 shows the student's results.

Figure 2



(d) What was the maximum rate of photosynthesis?

Maximum rate = _____ arbitrary units

(1)

(e) At which light intensity was light a limiting factor?

Tick (✓) **one** box.

200 lumens ☐

600 lumens ☐

1200 lumens ☐

(1)

(f) Light intensity can affect the rate of photosynthesis.

Give **one** other factor that can affect the rate of photosynthesis.

_____

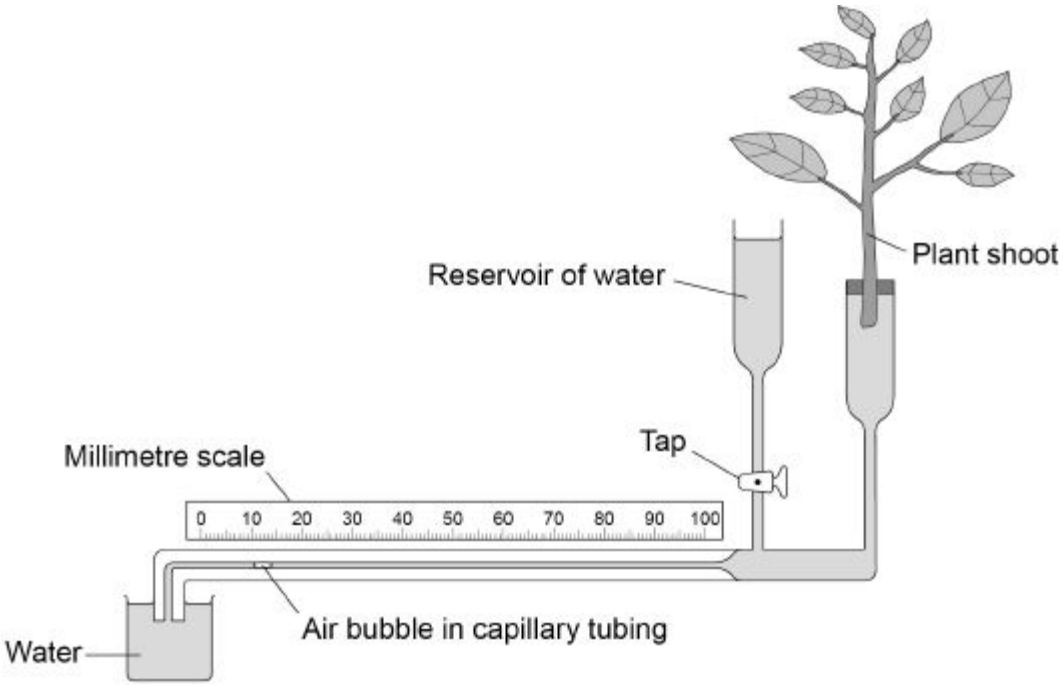
(1)

(Total 8 marks)

4. A student used a potometer to investigate the rate of water uptake in a plant shoot.

Figure 1 shows a potometer.

Figure 1



As the shoot takes in water the air bubble moves.

The rate of water uptake is the distance the air bubble moves in a given time.

This is the method used.

1. Place the potometer in moist air at 25 °C
2. Position the air bubble at 0 mm in the capillary tube.
3. Record the position of the air bubble in the capillary tube every minute for 5 minutes.
4. Repeat steps 2 and 3 with the potometer in different conditions.

Table 1 shows the conditions used.

Table 1

Investigation	Conditions
A	Moist air at 25 °C
B	Dry air at 15 °C
C	Dry air at 25 °C

(a) After investigation **A** the air bubble had moved part way along the capillary tube.

Suggest how the student moved the air bubble back to 0 mm for the start of investigation **B**.

_____

_____

(1)

(b) Capillary tubing is very narrow.

Explain why narrow tubing was used.

_____

_____

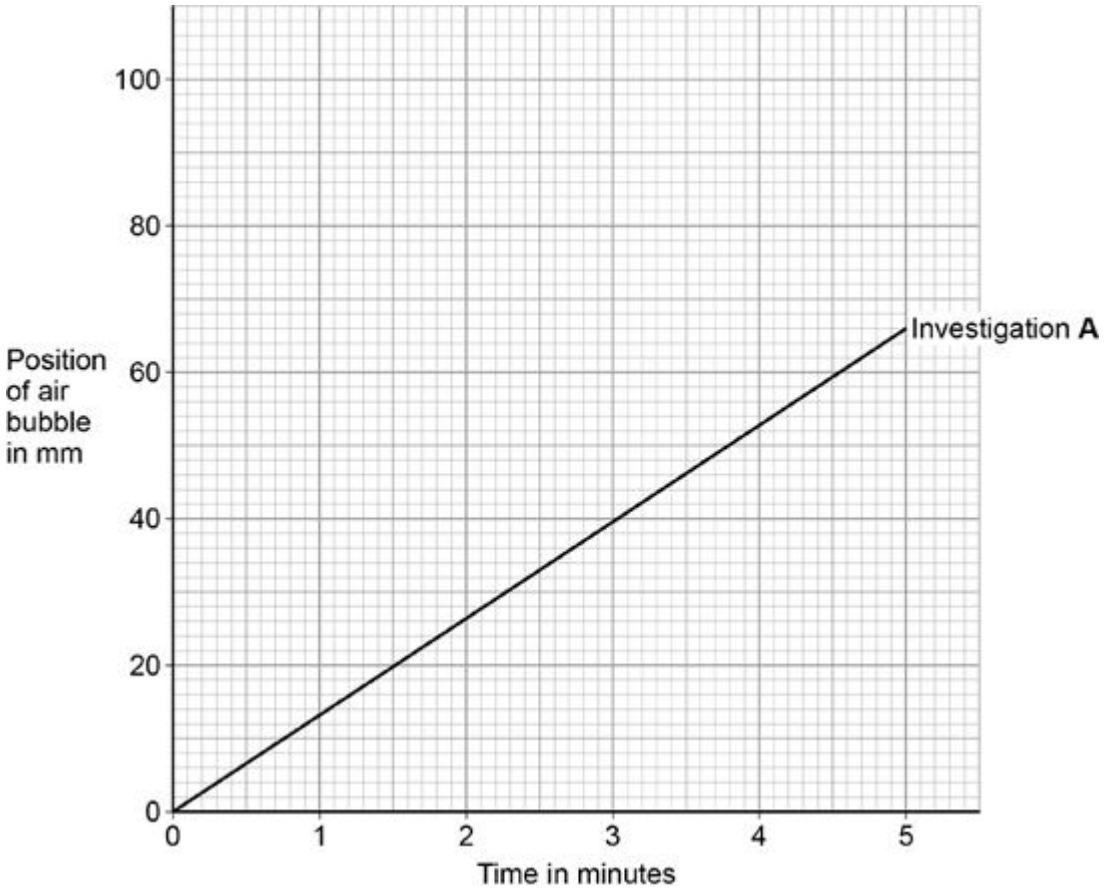
_____

_____

(2)

Figure 2 shows the results for investigation **A**.

Figure 2



(c) The cross-sectional area of the capillary tube was 0.8 mm^2

Calculate the rate of water uptake for investigation **A** in mm^3/min

_____

_____

_____

_____

_____

Rate = _____ mm^3/min

(3)

(d) **Table 2** shows the results from investigation **B**.

Table 2

Time in minutes	Position of air bubble in mm
0	0
1	6
2	16
3	22
4	30
5	42

Plot the data from **Table 2** on **Figure 2**.

You should:

- draw a line of best fit
- label the line **B**.

(3)

(e) Investigation **C** was carried out in dry air at 25 °C

Draw a line on **Figure 2** to show the results you would expect for investigation **C**.

Label the line **C**.

(1)

(f) The investigations were carried out in daylight.

The air bubble would **not** move if the investigations were done in the dark.

Explain why.

_____

_____

_____

_____

_____

_____

(3)

(Total 13 marks)

5. Plants make glucose by photosynthesis.

(a) Complete the word equation for photosynthesis.

_____ + _____ → glucose + _____

(1)

(b) What is the name of the chemical that makes a leaf look green?

Tick **one** box.

Cellulose	☐
Chlorophyll	☐
Chloroplast	☐
Chromosome	☐

(1)

(c) A test for starch is used to show that a plant has photosynthesised.

How does the presence of starch show that photosynthesis has taken place?

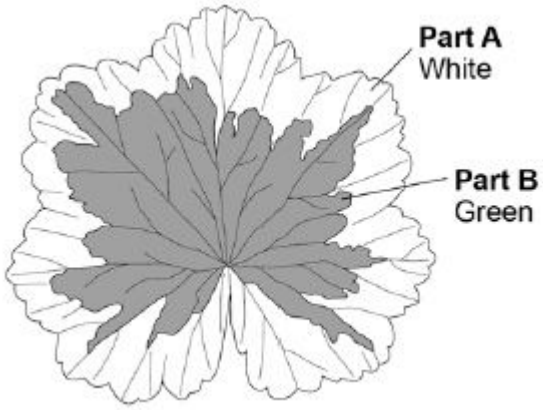
_____

_____

(1)

A student investigated where starch was made in a leaf.

She used a leaf that was part green and part white as shown in the diagram.



This is the method used.

1. Put the leaf in boiling water for 1 minute.
   Reason: stops all chemical reactions in the leaf.

2. Transfer the leaf to boiling ethanol for 5 minutes.
   Reason: removes the green colour.

3. Dip the leaf in hot water.
   Reason: softens the leaf.

4. Spread the leaf on a white tile and test with iodine solution.
   Reason: stains any starch.

(d) If the chemical reactions in the leaf were not stopped, the amount of starch in the leaf would decrease.

Give the reason why.

_____

_____

(1)

(e) Suggest why it is important to remove the green colour from the leaf before adding iodine solution.

_____

_____

(1)

(f) Ethanol is flammable.

The student wore safety goggles when testing the leaf for starch.

Give one other safety precaution the student should have taken.

_____

_____

(1)

(g) Look at the leaf in the diagram.

What colour would part **A** and part **B** stain with iodine solution after the starch test?

A _____

B _____

(2)

(Total 8 marks)

6. This question is about photosynthesis.

(a) What is the correct balanced equation for photosynthesis?

Tick **one** box.

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

$O_2 + H_2O \longrightarrow C_6H_{12}O_6 + CO_2$ ☐

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

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

(1)

(b) What type of reaction is photosynthesis?

Tick **one** box.

Aerobic ☐

Endothermic ☐

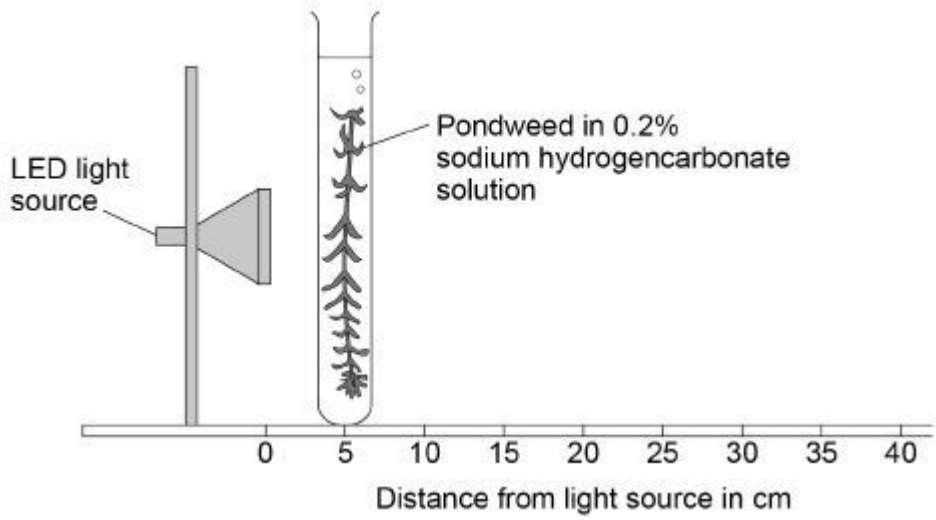
Exothermic ☐

Oxidation ☐

(1)

A student investigated the effect of light intensity on the rate of photosynthesis.

The diagram below shows the apparatus used.



Sodium hydrogencarbonate solution releases carbon dioxide gas for the pondweed.

This is the method used.

1. Place the pondweed at 5 cm from the light source.
2. Measure the rate of photosynthesis by counting the number of bubbles produced in 1 minute.
3. Repeat with the pondweed at 10 cm and at 20 cm from the light source.

(c) Counting the number of bubbles produced in 1 minute is not an accurate way to measure the rate of photosynthesis.

Suggest **two** ways the method could be improved to measure the rate of photosynthesis more accurately.

1. _____

_____

2. _____

_____

(2)

(d) The LED light source does **not** get hot.

Explain why it is important that the pondweed remains at a constant temperature.

_____

_____

_____

_____

(2)

(e) Light intensity can be calculated using the inverse square law:

$$I \propto \frac{1}{d^2}$$

Where I is light intensity and d is the distance of the pondweed from the light source.

The student placed the pondweed at 5, 10 and 20 cm from the light source.

Explain how light intensity changes as the distance of the pondweed from the light source is doubled.

You **must** include calculations in your answer.

_____

_____

_____

_____

_____

_____

(3)

(f) The student's results are shown in the table below

Distance of the pondweed from the light source in cm	Number of bubbles produced in 1 minute
5	129
10	31
20	8

Predict how many bubbles of gas would be produced in 1 minute if the pondweed was placed 40 cm from the light source.

Give a reason for your prediction.

_____

_____

_____

_____

(2)

(g) Describe how the student could change the method to investigate the effect of carbon dioxide concentration on the rate of photosynthesis.

You should include:

- how to change the independent variable
- **two** control variables.

Use the diagram above to help you answer this question.

_____

_____

_____

_____

_____

_____

(3)

(Total 14 marks)

7. This question is about photosynthesis.

(a) What are the **two** products of photosynthesis?

Tick **two** boxes.

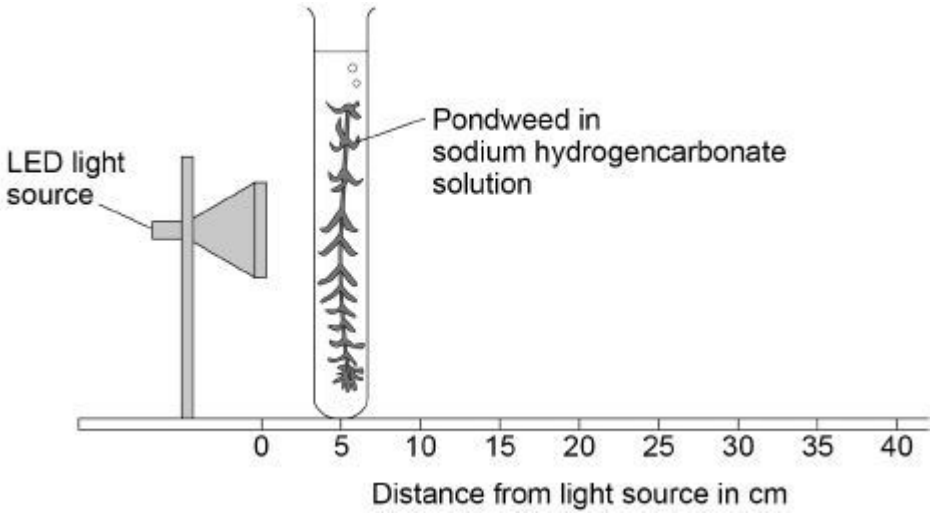
- Carbon dioxide ☐
- Chlorophyll ☐
- Glucose ☐
- Oxygen ☐
- Water ☐

(2)

A student investigated the effect of light intensity on the rate of photosynthesis.

Figure 1 shows the apparatus.

Figure 1



This is the method used.

1. Place the pondweed at 5 cm from the light source.
2. Measure the rate of photosynthesis by counting the number of bubbles produced in 30 seconds.
3. Repeat the investigation with the pondweed at different distances from the light source.

(b) How could the student measure the rate of photosynthesis more accurately?

Tick **two** boxes.

- Count the number of bubbles produced in 1 minute ☐
- Measure the change in mass of the pondweed in 30 seconds ☐
- Measure the volume of gas produced in 30 seconds ☐
- Place the pondweed further from the light source ☐
- Use water instead of sodium hydrogencarbonate solution ☐

(2)

(c) The LED light source does **not** get hot.

Why is this important?

_____

_____

_____

(1)

The table below shows the student's results.

Distance of light source from pondweed in cm	**Number of bubbles produced in 30 seconds**
5	40
10	13
15	5
20	2
25	1
30	0

(d) Calculate the number of bubbles produced in 2 minutes when the light source was 10 cm from the pondweed.

_____

_____

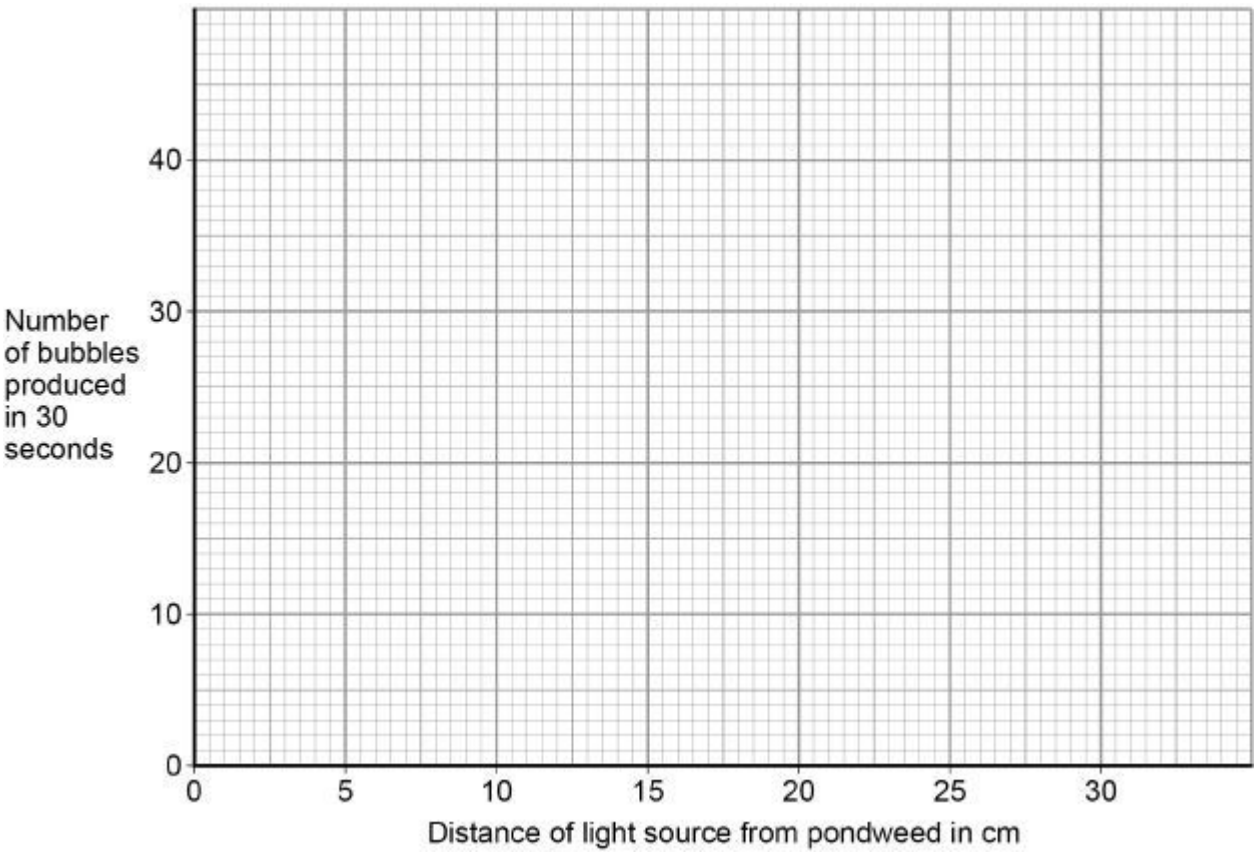
Number of bubbles produced in 2 minutes = _____

(1)

(e) Plot the data from the table above on **Figure 2**

Draw a line of best fit.

Figure 2



(3)

(f) Give **one** conclusion that can be made from these results.

_____

_____

(1)

(Total 10 marks)

Mark schemes

1. (a) $6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2$

1

(b) distance of the pondweed from the lamp

1

(c) bubbles (of gas) would be produced faster

allow more / bigger bubbles of gas would be produced (in a given time)

1

(because) enzymes work faster

allow (because) photosynthesis is controlled by enzymes

allow (because) photosynthesis would be faster

1

(d) any **one** from:

- use an LED (lamp)

  allow use a light that does not emit (a lot of) infrared / thermal radiation
- place a tank / beaker of water between the lamp and tube / pondweed
- put the tube in a beaker of water
- put the tube in a (thermostatically controlled) water bath
- place a piece of glass between the lamp and tube / pondweed

  allow place a heat shield between the lamp and tube / pondweed

1

(e) any **two** from:

- measure the volume of gas produced

  allow amount for volume allow use a cylinder / gas syringe to collect the gas

- allow the pondweed time to equilibrate

  allow a description of this

- repeat **and** calculate a mean

or

repeat **and** remove anomalies

ignore repeat unqualified

- control the concentration of carbon dioxide (in the water)

  *allow put the pondweed in sodium hydrogen carbonate (solution) **or** sodium bicarbonate (solution)*

- use the same bulb / lamp

  allow use the same type / size / age / piece of pondweed

  allow record the number of bubbles of gas produced in a longer period of time

2

(f) 3 (bubbles of gas produced per minute)

*allow 3.2 (bubbles of gas produced per minute) do **not** accept 3.0 (bubbles of gas produced per minute)*

1

(g) as light intensity decreases the rate of photosynthesis decreases

allow as distance from lamp increases rate of photosynthesis decreases

allow as distance from lamp increases number of bubbles produced decreases

1

(h) all points plotted correctly

allow tolerance of ± ½ a small square

*allow **1** mark for four points plotted correctly*

2

line of best fit through their points

*do **not** accept line extended to 0, 0*

ignore extrapolations of line

1

(i) 8

allow correct value from their line ± ½ a small square

allow value in range 6 to 9 if a curved line of best fit is not drawn

1

[13]

2. (a) measure the volume of oxygen produced in a given time

or

when more oxygen is produced in a given time the rate of photosynthesis is faster

a reference to rate is needed

allow gas for oxygen

allow when oxygen is produced faster the rate of photosynthesis is faster

ignore the faster the rate of photosynthesis, the more oxygen is produced

allow the slower the oxygen is produced the slower the rate of photosynthesis

or

less oxygen being produced in a given time, the slower the rate of photosynthesis

1

(b) light (intensity)

ignore temperature

1

(c) 20 000 (lux)

allow answers in range 19 500 to 20 500 (lux)

1

(d) there is a cost for heating the greenhouse

1

there is a cost for increasing the carbon dioxide in the atmosphere (of the greenhouse)

allow there is a cost for lighting (in winter)

1

(therefore) the additional costs might exceed the (additional) sale price / profit
or
(additional) costs could not be recovered by increasing the sale price of the tomatoes

ignore these additional costs would reduce profits unqualified

1

(e) when there is no light there is no photosynthesis

1

(so) no oxygen is produced

1

(but) respiration happens (all the time) and oxygen is used

1

(therefore) the net / overall oxygen production is negative / - 2 (arbitrary units)

*do **not** accept an answer of -2 (arbitrary units)*

unqualified

1

[10]

3. (a) oxygen

name takes precedence

allow O_2

ignore O^2 / O / O2

1

(b) (use) a lamp / light (source)

1

(and) move away and / or towards pondweed

*allow use different power ratings **or** use a dimmer switch*

*allow change the opacity of the beaker for **2** marks*

1

(c) count the number of bubbles

allow measure the volume of gas collected

1

in a given time

*allow for **2** marks measure time taken to collect a specific number of bubbles*

1

(d) 34 (arbitrary units)

allow a value in the range 33.5 – 34.5 (arbitrary units)

1

(e) 200 lumens

1

(f) any **one** from:

- temperature
- carbon dioxide (concentration)
- amount of chlorophyll

ignore light (intensity)

ignore heat
ignore oxygen

allow light colour / wavelength
allow water
ignore pH

1

[8]

4.

(a) opened and closed the tap (so water enters from reservoir)

allow opened the tap (carefully / gently)

1

(b) air bubble moves further (in a given time)

allow air bubble moves faster

1

(so) resolution is improved

allow it is easier to see a small change (in volume)
ignore is easier to measure unqualified
allow measurements are more accurate
ignore to make test more accurate
ignore references to precision or validity

1

(c)

*an answer of 10.56 (mm^3/min) scores **3** marks*

$\frac{66}{5}$

or

13.2 (mm/min)

allow tolerance of $\pm\frac{1}{2}$ *square allow full marks from calculation from other **correct** pairs of readings*

allow value in range 13 to 13.4 for $\frac{66}{5}$ *only*

ignore $\frac{66}{5}$ *or 12.6*

1

13.2 × 0.8

allow their calculated value in the range from 12 to 14 × 0.8

1

10.56 (mm^3/min)

allow 10.6 or 11

1

(d) points plotted correctly

allow +/- $\frac{1}{2}$ a square

allow 1 mark for 4/5 correct plots

2

suitable line of best fit

1

(e) straight line starting at 0,0 with a steeper gradient than A

1

(f) no photosynthesis

allow plants need light for photosynthesis

1

(so) stomata closed (as no carbon dioxide needed)

1

(so) no transpiration

*allow very little transpiration **or** little water lost*

1

[13]

5. (a) carbon dioxide + water → (glucose) + oxygen

allow reactants in either order

allow correct formulae, balancing not required

1

(b) chlorophyll

1

(c) glucose (produced in photosynthesis) is converted into starch

1

(d) starch could be broken down (into sugar)

1

(e) so the colour of the iodine solution / result can be seen

1

(f) any **one** from:

- turn off Bunsen / flame before collecting ethanol
- use a water bath to heat the ethanol

allow idea that there are no naked flames near the ethanol

1

(g) **A** orange / brown

1

B black / blue-black

1

[8]

6. (a) $6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$

1

(b) endothermic

1

(c) measure the volume of gas released

allow use a measuring cylinder / capillary tube / (gas) syringe

1

increase length of time

allow sensible length of time

allow video the investigation so you could re-count the bubbles later

*allow repeat the measurement at each distance several times **and** calculate a mean*

ignore references to using other distances

1

(d) temperature affects **rate** of photosynthesis
or
temperature affects **rate** of bubble production

allow correct description of effect of temperature on rate

1

(because) reaction / photosynthesis is controlled by **enzymes**

allow high temperatures denature enzymes

enzymes being denatured must be linked to high temperature

1

(e) evidence of squaring for **two** distances that double:
25 **and** 100
or
100 **and** 400

1

calculate $1/d^2$ for **two** distances that double:
0.04 **and** 0.01
or
1/25 **and** 1/100
or
0.01 **and** 0.0025
or
1/100 **and** 1/400

*allow **2** marks for these calculations without working*

ignore calculations for a third distance as long as two where the distance doubles are correct

1

(therefore as distance doubles) light intensity is quartered

1

(f) 2 (bubbles would be produced)

1

(as) very little light / energy for photosynthesis to occur

*do **not** accept no light*

1

*allow **2** marks for a quarter of the bubbles are produced as light distance doubles so 2 bubbles would be expected*

(g) (independent variable)
use different concentrations of sodium hydrogencarbonate solution

allow three concentration values

ignore different concentrations of carbon dioxide

1

(control variables)

***max 2** marks for control variables*

any **two** from:

- distance from light source

  allow light intensity
  ignore light unqualified
  ignore same lamp

- temperature of solution
- same plant

  allow type / size of plant

- time for plant to equilibrate

  allow time for plant to adjust to different solution
  ignore time unqualified

2

[14]

7. (a) glucose

1

oxygen

1

extra ticks negates marks

(b) count the number of bubbles produced in 1 minute

1

measure the volume of gas produced in 30 seconds

1

extra ticks negates marks

(c) any **one** from:

- to control the temperature

  allow so pondweed / solution did not warm up

- temperature affects the rate of photosynthesis

  allow correct description of effect of temperature on rate
  allow high temperatures denature enzymes
  ignore references to limiting factors

1

ignore reference to 'it'

(d) 52

1

(e) all points plotted correctly

allow ± ½ a square
*allow **1** mark for three points correctly plotted*

2

smooth curve drawn through all points

ignore extensions of line / curve unless inconsistent with line / curve drawn

1

(where a bar chart has been plotted)
*allow **1** mark for all bars plotted correctly*
if points are plotted as well as bars, ignore bars

(f) any **one** from:

- the nearer the light source to the pondweed the faster the rate of photosynthesis

  allow the nearer the light source to the pondweed the faster the bubbles produced

- the greater the light intensity the faster the rate of photosynthesis

  allow the greater the light intensity the faster the bubbles produced

  allow the closer the light source the more the plant photosynthesises

  ignore more bubbles are produced with no reference to rate

  allow oxygen for bubbles

  *do **not** accept carbon dioxide*

1

allow converse statements for all marking points

[10]