Q1.

A scientist investigated the rate of photosynthesis of one type of tomato plant.

The tomato plants were grown in a greenhouse.

The table below shows the results.

Percentage (%) concentration of carbon dioxide in the air	Rate of photosynthesis in arbitrary units
0.00	0
0.02	5
0.04	16
0.06	19
0.08	20
0.10	20
0.12	20

(a)   Give **two** control variables the scientist should have used in the investigation.

1 _____

2 _____

(2)

(b)   Which range of carbon dioxide concentrations caused the rate of photosynthesis to change the most?

Tick (✓) **one** box.

From 0.00% to 0.02%   ☐

From 0.02% to 0.04%   ☐

From 0.04% to 0.06%   ☐

From 0.06% to 0.08%   ☐

(1)

(c)   How could the scientist have improved the validity of the results?

Tick (✓) **one** box.

Repeat each reading three times and calculate a mean. ☐

Use concentrations of carbon dioxide above 0.12%. ☐

Use different tomato plants for each concentration. ☐

(1)

(d) Explain the change in the rate of photosynthesis when the concentration of carbon dioxide increased between 0.00% to 0.08%.

_____

_____

_____

_____

(2)

(e) A farmer decided **not** to use a concentration of carbon dioxide higher than 0.08% to grow tomato plants.

Suggest **two** reasons for the farmer's decision.

Use information from above table and your own knowledge.

1 _____

_____

2 _____

_____

(2)
(Total 8 marks)

Q2.

This question is about photosynthesis.

(a) Complete the word equation for photosynthesis.

_____ + _____ → _____ + oxygen

(2)

(b) Describe how energy for the photosynthesis reaction is gained by plants.

_____

_____

_____

(2)

Students investigated the effect of temperature on the rate of photosynthesis.

The students shone light from a lamp onto pondweed and measured the volume of oxygen produced per hour.

The table below shows the results.

Temperature in °C	Rate of photosynthesis in cm³/hour			
	Test 1	Test 2	Test 3	Mean
20	18.5	19.3	19.5	**X**
25	32.6	34.1	32.9	33.2
30	41.9	45.2	44.9	44.0
35	38.6	39.8	44.0	40.8
40	23.1	20.5	22.4	22.0
45	1.9	14.2	2.2	2.1

(c)   Calculate mean value **X**.

_____

_____

_____

X = _____ cm³/hour

(2)

The students identified one anomalous result in the table above.

(d)   Draw a ring around the anomalous result in the table above.

(1)

(e)   Suggest **one** possible cause of the anomalous result.

_____

_____

(1)

(f)   How did the students deal with the anomalous result?

_____

_____

(1)

(g)   Give **one** factor the students should have kept constant in this investigation.

_____

(1)

The table above is repeated below.

Temperature in °C	Rate of photosynthesis in cm³/hour			
	Test 1	**Test 2**	**Test 3**	**Mean**
20	18.5	19.3	19.5	**X**
25	32.6	34.1	32.9	33.2
30	41.9	45.2	44.9	44.0
35	38.6	39.8	44.0	40.8
40	23.1	20.5	22.4	22.0
45	1.9	14.2	2.2	2.1

(h) Why did the rate of photosynthesis decrease from 35 °C to 45 °C?

_____

_____

(1)

(i) Complete the graph below using data from the table above.

You should:
- label the y-axis
- use a suitable scale for the y-axis
- plot the mean data from the table above for temperatures from 25 °C to 45 °C
- draw a line of best fit.

25   30   35   40   45
Temperature in °C
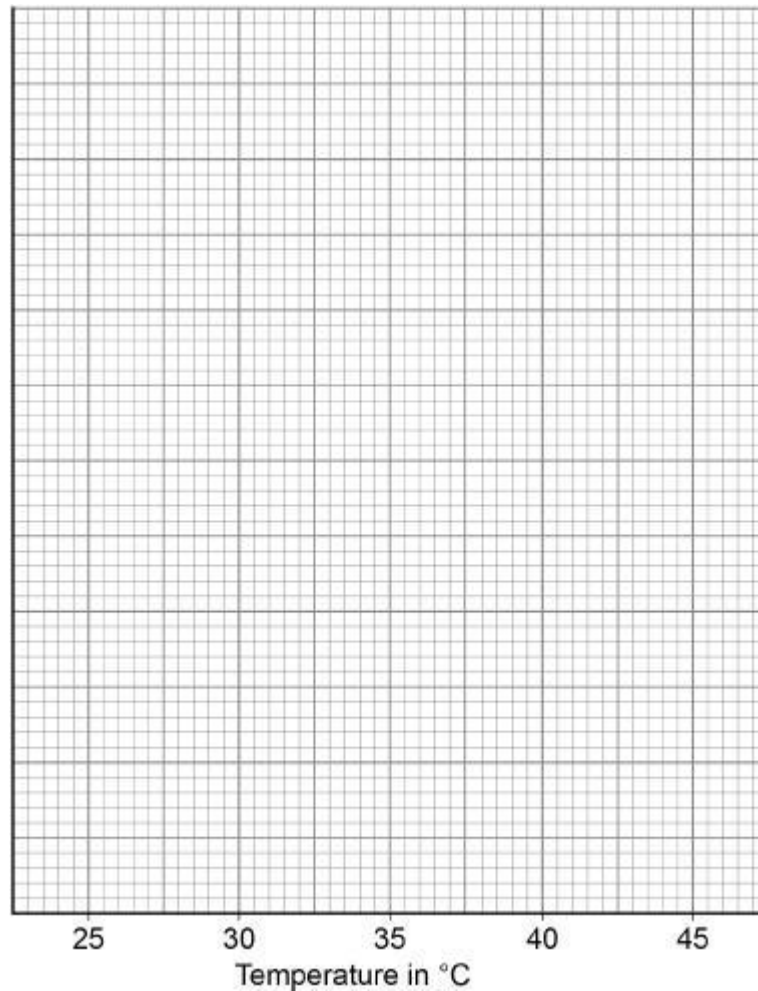
(5)
(Total 16 marks)

Q3.

(a)   Complete the equation for photosynthesis. Draw a ring around each correct answer.

hydrogen		alcohol	
Carbon dioxide + nitrogen	light energy →	glucose	+ oxygen
water		methane	
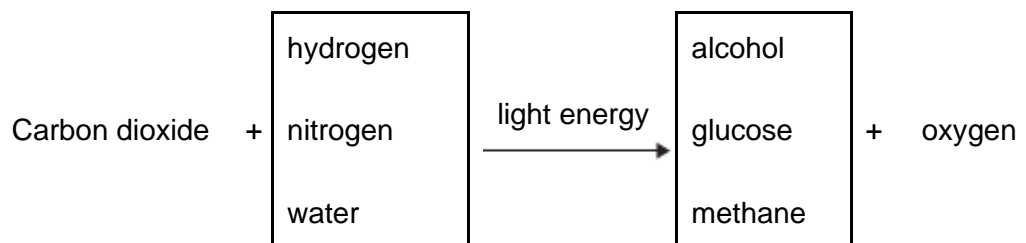
(2)

Some students investigated the effect of light intensity on the rate of photosynthesis in pondweed.

The diagram shows the apparatus the students used.

Thermometer

Glass test tube

Pondweed

Lamp

Water at 20 °C

Glass beaker
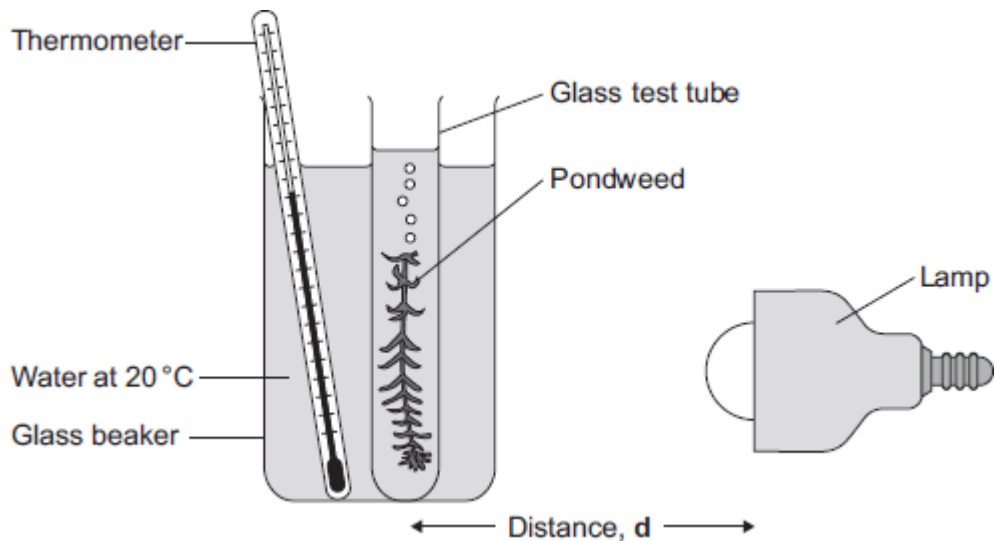
Distance, d

The closer the lamp is to the pondweed, the more light the pondweed receives.

The students placed the lamp at different distances, **d**, from the pondweed.

They counted the number of bubbles of gas released from the pondweed in 1 minute for each distance.

(b)   A thermometer was placed in the glass beaker.

Why was it important to use a thermometer in this investigation?

_____

_____

_____

_____

_____

_____

(3)

(c)   The students counted the bubbles four times at each distance and calculated the correct mean value of their results.

The table shows the students' results.

| Distance d in cm	Number of bubbles per minute				
	1	2	3	4	Mean
10	52	52	54	54	53
20	49	51	48	52	50
30	32	30	27	31	30

40	30	10	9	11	

(i) Calculate the mean number of bubbles released per minute when the lamp was 40 cm from the pondweed.

_____

_____

Mean number of bubbles at 40 cm = _____

(2)

(ii) On the graph paper below, draw a graph to show the students' results:

- add a label to the vertical axis
- plot the **mean values** of the number of bubbles
- draw a line of best fit.
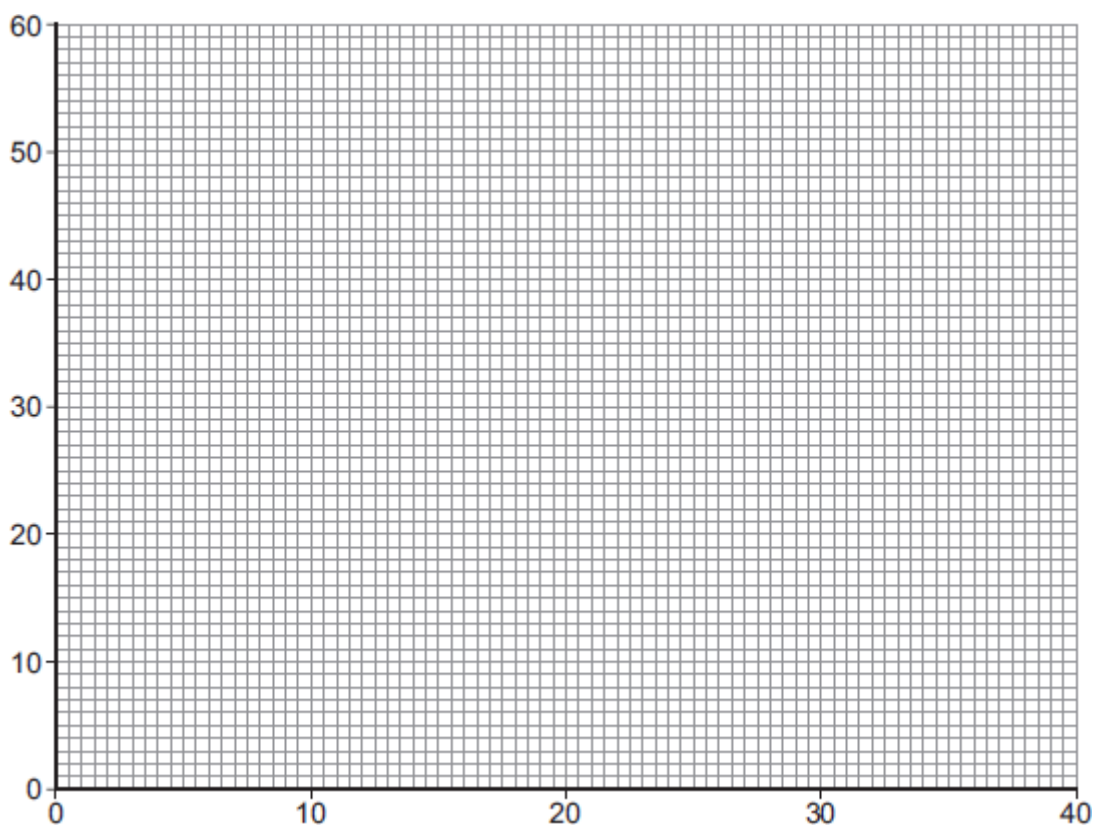
Distance **d** in cm

(4)

(iii) One student concluded that the rate of photosynthesis was inversely proportional to the distance of the lamp from the plant.
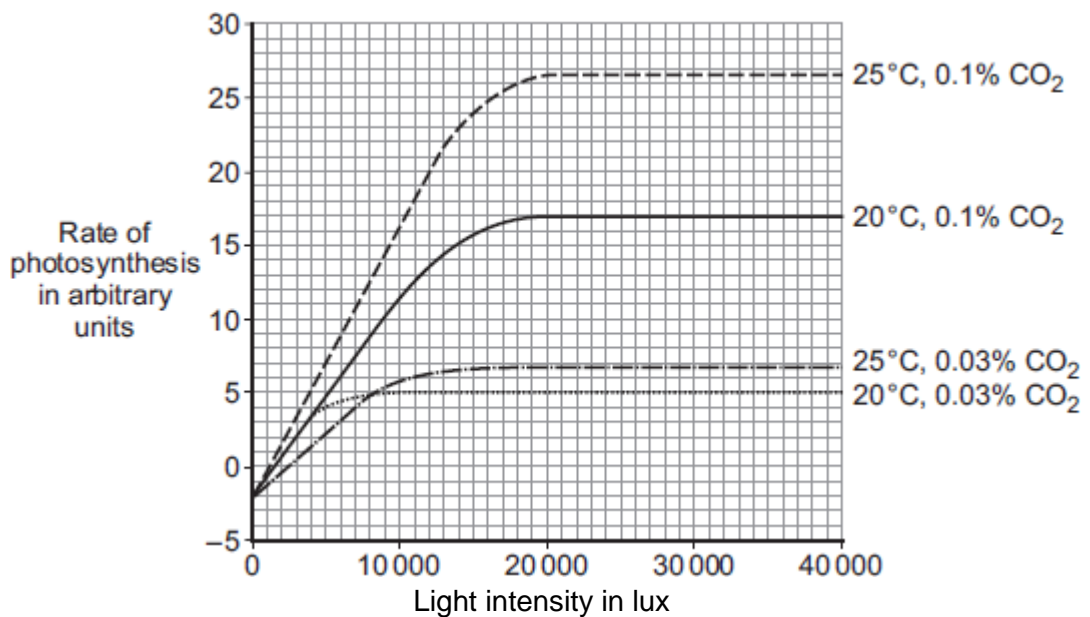
Does the data support this conclusion?

Explain your answer.

_____

_____

_____

_____

_____

_____

(2)

(d)   Light intensity, temperature and concentration of carbon dioxide are factors that affect the rate of photosynthesis.

Scientists investigated the effects of these three factors on the rate of photosynthesis in tomato plants growing in a greenhouse.

The graph below shows the scientists' results.

A farmer in the UK wants to grow tomatoes commercially in a greenhouse.

The farmer read about the scientists' investigation.

During the growing season for tomatoes in the UK, natural daylight has an intensity higher than 30 000 lux.

The farmer therefore decided to use the following conditions in his greenhouse during the day:

*   20°C

*   0.1% CO_2

*   no extra lighting.

Suggest why the farmer decided to use these conditions for growing the tomatoes.

You should use information from the scientists' graph in your answer.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 17 marks)

Q4.

(a)   Plants take up water from the soil through their roots.

Some of the water is used for photosynthesis.

Complete the word equation for photosynthesis.

Choose answers from the box.

fat	glucose	nitrogen	oxygen	protein

carbon dioxide + water → _____ + _____

(2)

(b)   Water and dissolved substances are transported through a plant.

Complete the sentences.

Choose answers from the box.

epidermis	guard cells	palisade cells
phloem	stomata	xylem

Water moves from the roots to the leaves in the _____.

Water is lost from leaves through pores called _____.

Dissolved sugars are transported in the _____.

(3)

The table below shows the rate of transpiration in four different plant species.

Plant species	Rate of transpiration in arbitrary units
A	310
B	254
C	87
D	192

(c) Calculate how many times greater the rate of transpiration of species **A** is than the rate of transpiration of species **B**.

Give your answer to 2 significant figures.

_____

_____

_____

_____

_____

Number of times greater (2 significant figures) = _____

(3)

(d) Which factor could cause species **A** to have a higher rate of transpiration than species **B**?

Tick (✓) **one** box.

Each flower of species **A** has more petals. ☐

Each leaf of species **A** has more stomata. ☐

Each plant of species **A** has shorter roots. ☐

(1)

(e) Which environmental change would cause an increase in the rate of transpiration?

Tick (✓) **one** box.

Decreased light intensity ☐

Decreased wind speed ☐

Increased humidity ☐

Increased temperature ☐

(1)

(f) Which plant species in the table in part (c) is most likely to live in a dry desert?
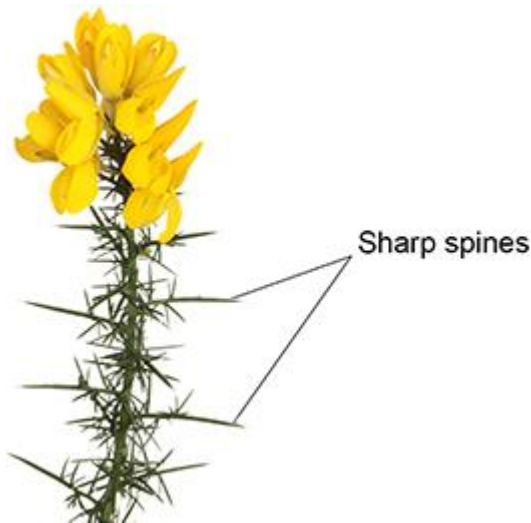
Tick (✓) **one** box.

A ☐   B ☐   C ☐   D ☐

(1)

(g) Some plants have adaptations that help them survive.

Figure 1 shows part of a gorse plant.

Figure 1

Sharp spines

How will the sharp spines help the gorse plant survive?

_____

_____

(1)

(h) Animals also have adaptations to help them survive.

Figure 2 shows two insects.

Figure 2

Hornet   Hornet Moth

Hornets are insects that sting other animals and cause pain.
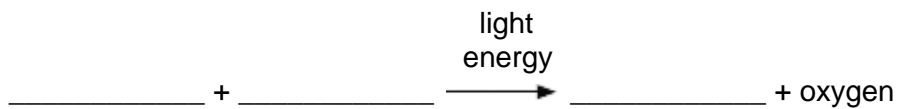
Hornet moths do **not** sting other animals.

Explain why animals avoid eating the **hornet moth**.

_____

_____

_____

_____

(2)
(Total 14 marks)

Q5.

(a)   Complete the equation for photosynthesis.

$$_____ + _____ \xrightarrow{\text{light energy}} _____ + \text{oxygen}$$

(2)

(b)   Scientists investigated how temperature affects the rate of photosynthesis.
The scientists grew some orange trees in a greenhouse.
They used discs cut from the leaves of the young orange trees.

The scientists used the rate of oxygen production by the leaf discs to show the rate of photosynthesis.

(i)   The leaf discs did not produce any oxygen in the dark.

Why?

_____

_____

(1)

(ii)   The leaf discs took in oxygen in the dark.

Explain why.

_____

_____

_____

_____

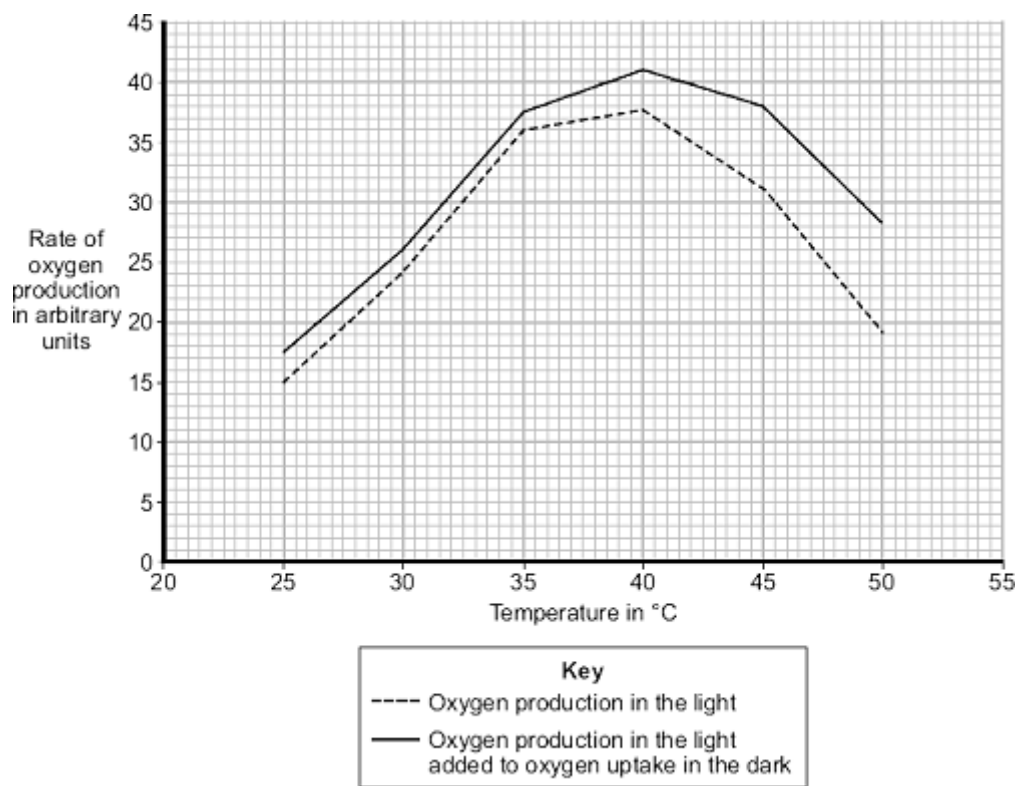**(2)**

(c)   In their investigation, the scientists measured the rate of oxygen release by the leaf discs in the light. The scientists then measured the rate of oxygen uptake by the leaf discs in the dark.

The graph shows the effect of temperature on

- oxygen production in the light

- oxygen production in the light added to oxygen uptake in the dark.

Use the information from the graph to answer each of the following questions.

(i)   Describe the effect of temperature on oxygen production in the light.

_____

_____

_____

_____

(2)

(ii)   Explain the effect of temperature on oxygen production in the light when the

temperature is increased:

from 25 °C to 35 °C

_____

_____

_____

from 40 °C to 50 °C.

_____

_____

_____

(2)

(d)   A farmer in the UK wants to grow orange trees in a greenhouse. He wants to sell the oranges he produces at a local market.
He decides to heat the greenhouse to 35 °C.

Explain why he should **not** heat the greenhouse to a temperature higher than 35 °C.
Use information from the graph in your answer.

_____

_____

_____

_____

_____

_____

_____

_____

(3)
(Total 12 marks)

Q6.

(a)   Complete the equation for photosynthesis.

                                    light energy
_____ + water ⎯⎯⎯⎯⎯⎯→ _____ + _____

(3)

(b)   The rate of photosynthesis in a plant depends on several factors in the

environment.
These factors include light intensity and the availability of water.

Describe and explain the effects of **two other** factors that affect the rate of photosynthesis.

You may include one or more sketch graphs in your answer.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(5)
(Total 8 marks)

Q7.

This question is about photosynthesis.

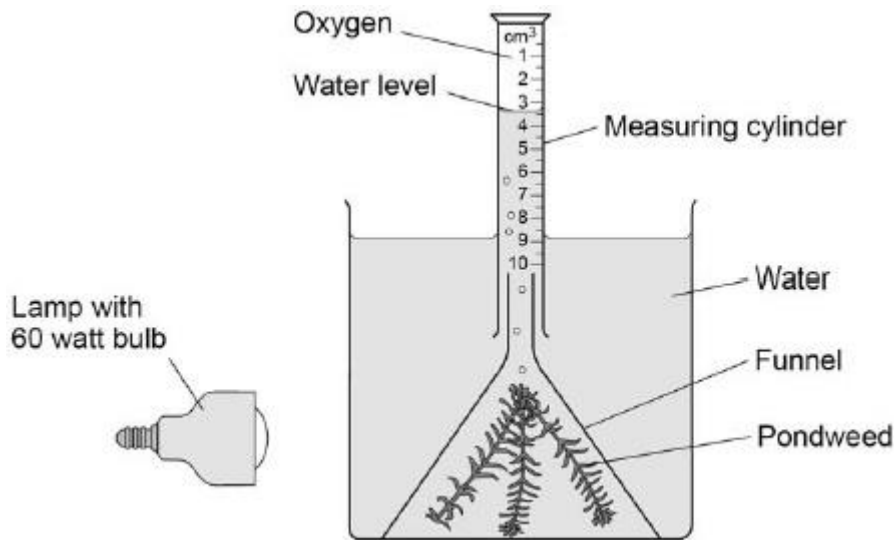(a)   Complete the word equation for photosynthesis:

_____ + _____ → _____ + oxygen

(2)

A student investigated photosynthesis using pondweed.

Figure 1 shows the apparatus the student used.

Figure 1

This is the method used.

1. Set up the apparatus as shown in **Figure 1**.

2. Switch on the lamp.

3. After 20 minutes, record the volume of oxygen collected in the measuring cylinder.

4. Repeat steps 1–3 using bulbs of different power output.

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

Tick (✓) **one** box.

Power output of bulb ☐

Rate of photosynthesis ☐

Time to collect oxygen ☐

Volume of oxygen collected ☐

(1)

(c)   Suggest **two** ways the method could be improved so the results would be more valid.

1 _____

_____

2 _____

_____

The table below shows the student's results.

Power output of bulb in watts	Volume of oxygen collected in 20 minutes in cm³	Rate of photosynthesis in cm³/hour
60	0.5	1.5
100	0.8	2.4
150	1.1	**X**
200	1.2	3.6
250	1.2	3.6

(d)   Calculate value **X** in the table above.

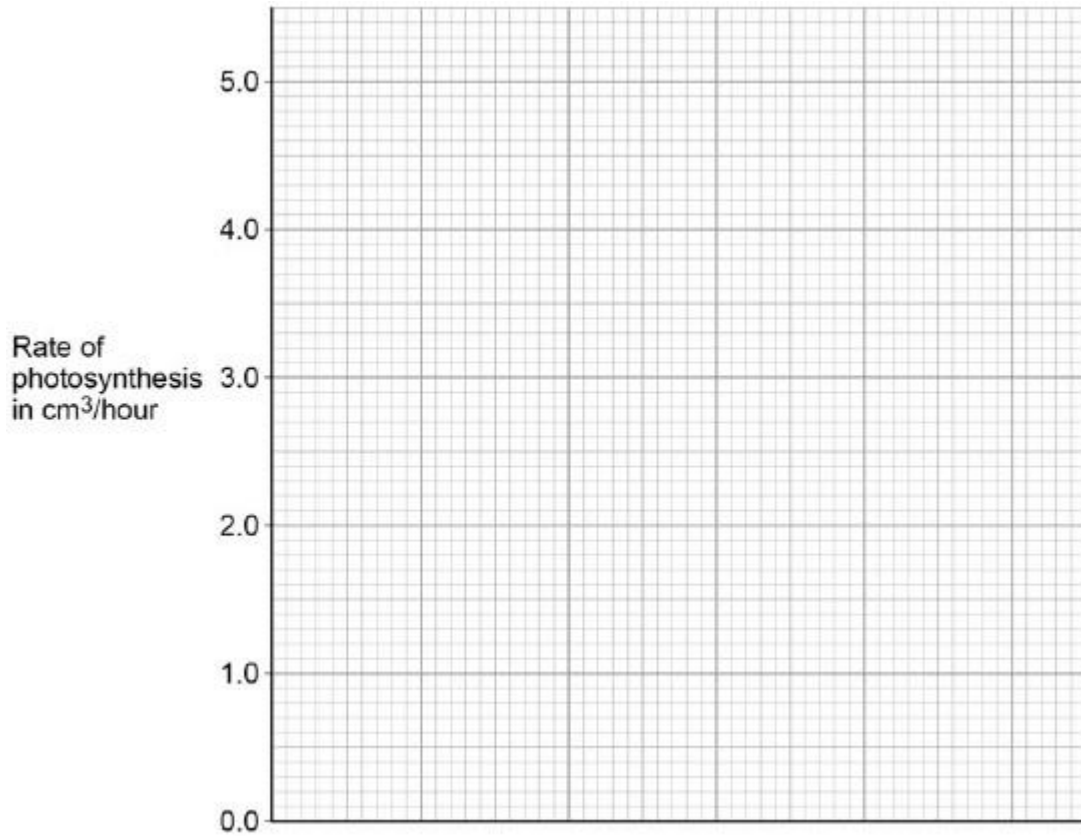_____

_____

X = _____ cm³/hour

(1)

(e)   Complete **Figure 2**.

You should:

•   label the x-axis
•   use a suitable scale
•   plot the data from the table above and your answer to part (d)
•   draw a line of best fit.

Figure 2

(4)

(f)   Determine the expected rate of photosynthesis with a bulb of power output 75 watts.
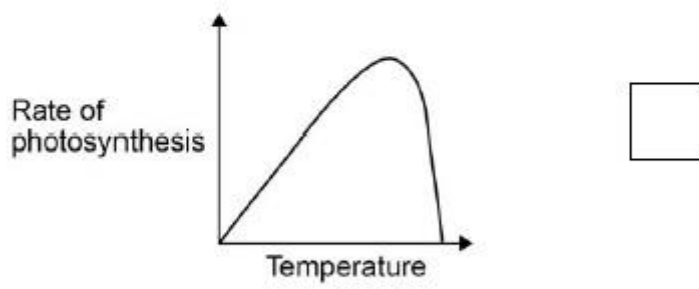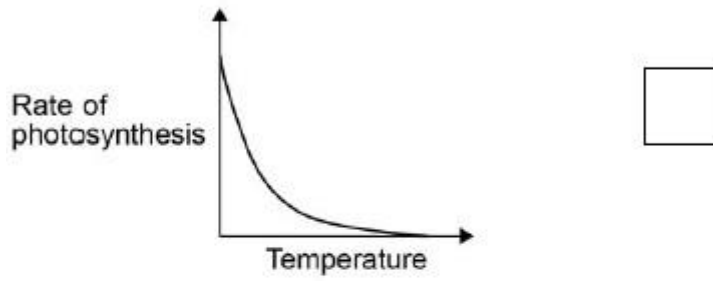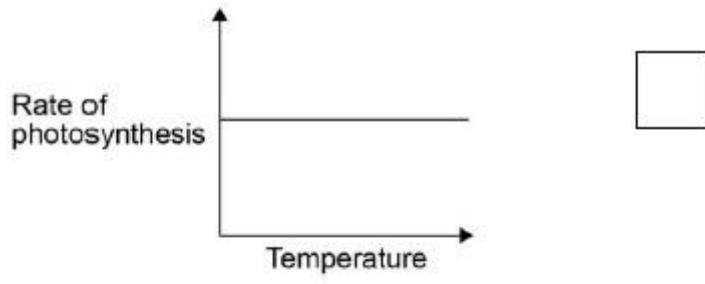
Use **Figure 2**.

_____

Rate of photosynthesis at 75 watts = _____cm³/hour

(1)

(g)   Which graph shows the effect of temperature on the rate of photosynthesis?

Tick (✓) **one** box.

Rate of photosynthesis / Temperature ☐

Rate of photosynthesis / Temperature ☐

Rate of photosynthesis / Temperature ☐

Rate of photosynthesis / Temperature ☐
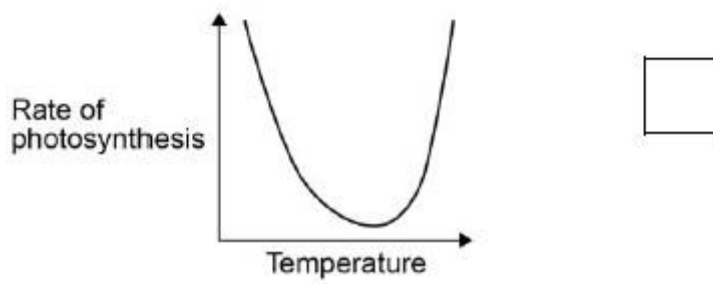
(1)
(Total 12 marks)

Mark schemes

Q1.

(a) any **two** from:
- temperature
- size of tomato plants **or** size / number of leaves
  allow age of plant
- light
- (volume of) water
  allow (amount of) water
- (amount / type of) fertiliser / minerals / ions / nutrients (given to plants)
  allow (type of) compost / soil
  allow named example of mineral ion such as nitrate / magnesium
- time before rate readings are taken
  ignore time unqualified
  ignore type of tomato plant
  ignore type of greenhouse

2

(b) from 0.02% to 0.04%

1

(c) repeat each reading three times and calculate a mean

1

(d) (the rate of photosynthesis) increases
     ignore values

1

(because) carbon dioxide is needed for photosynthesis
     *allow **2** marks for (there is) more carbon dioxide for (more) photosynthesis*

1

(e) any **two** from:

- it would not increase the rate (of photosynthesis)
  allow it would not change the rate (of photosynthesis)
  allow photosynthesis would not increase
- it would not increase the growth of tomatoes
- it would cost more
  allow idea of profit will not increase
  allow reference to avoiding global warming

2

[8]

Q2.

(a) *before arrow*
carbon dioxide **and** water
     allow correct chemical symbols

ignore any attempt at balancing equation
ignore light / chlorophyll
either order

1

after arrow

glucose

ignore sugar / carbohydrate
*do **not** accept starch*

1

(b)   <u>light</u>

ignore description of subsequent parts of the photosynthesis reaction
allow sun<u>light</u>
ignore sun

1

(light) is captured / trapped / absorbed by chlorophyll / chloroplasts
allow (light) is used by chlorophyll / chloroplasts

1

(c)

$$\frac{(18.5 + 19.3 + 19.5)}{3}$$

or

$$\frac{57.3}{3}$$

1

19.1 (cm^3/hour)

allow an answer correctly calculated using only two correct values

1

(d)   a ring around 14.2

allow clear indication of correct result

1

(e)   any **one** from:

- scale / value was misread

     ignore human error
     ignore references to counting bubbles or time
     allow measurement error

- there was air / oxygen in the syringe / measuring cylinder / apparatus

- the lamp / light was moved

     allow light intensity changed ignore different bulb / lamp unqualified

- temperature changed

- had different mass / length of pondweed

- pondweed had not acclimatised

1

(f)　did not use it in calculation (of mean)

1

(g)　any **one** from:

- light (intensity)
  *do **not** accept temperature*
  ignore time
  allow distance / power / colour of lamp / light

- carbon dioxide (concentration)

- pondweed size / amount

- pondweed species
  allow same (piece of) pondweed

1

(h)　enzyme(s) lose the shape of the active site
  allow enzyme(s) (start to) denature
  allow enzyme(s) destroyed / damaged
  *do **not** accept enzyme(s) killed*

1

(i)　y-axis labelled '(rate of) photosynthesis in cm^3/hour'

1

suitable scale on y-axis
  must take up half or more of grid provided

1

all points plotted to within ± ½ small square
  *allow 3 or 4 correct plots for **1** mark*
  ignore any attempt to plot a point at 20 ℃

2

correct curved line of best fit
  ignore line joined point to point with straight lines
  ignore extrapolation

1

[16]

Q3.

(a)　LHS = water

1

RHS = glucose

1

(b)   any **three** from:

- (measure) temperature
    ignore reference to fair test
- to check that the temperature isn't changing
- rate of reaction changes with temperature
- temperature is a variable that needs to be controlled
    allow lamp gives out heat

3

(c)   (i)   10

*correct answer = **2** marks*

*allow **1** mark for:* $\dfrac{(10+9+11)}{3}$

*allow **1** mark for correct calculation without removal of anomalous result ie 15*

2

(ii)   graph:
    *allow ecf from **(c)(i)***

label on y-axis as 'number of bubbles per minute'

1

three points correct = **1** mark
    allow ± 1 mm

four points correct = **2** marks

2

line of best fit = smooth curve

1

(iii)   as distance increases, rate decreases – pro
    allow yes between 20 – 40

1

but should be a straight line / but line curves – con / not quite pro
    allow not between 10 – 20
    if line of best fit is straight line, allow idea of poor fit

1

(d)   any **four** from:

- make more profit / cost effective
- raising temp. to 25 °C makes very little difference at 0.03% CO_2
- (at 20 °C) with CO_2 at 0.1%, raises rate
- (at 20 °C with CO_2 at 0.1%) → >3x rate / rises from 5 to 17
- although 25 °C → higher rate, cost of heating not economical
- extra light does not increase rate / already max. rate with daylight
    accept ref to profits c.f. costs must be favourable

4

[17]

Q4.

(a) oxygen

　　　　allow O$_2$

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　1

　　　glucose

　　　　allow C$_6$H$_{12}$O$_6$

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　1

　　　　in either order

(b) xylem

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　1

　　　stomata

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　1

　　　phloem

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　1

　　　　must be in this order

(c) $\dfrac{310}{254}$

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　1

　　　1.22047…

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　1

　　　1.2

　　　　*allow an answer of 0.82 if numerator and denominator
　　　　reversed*

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　1

(d) each leaf of species **A** has more stomata

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　1

(e) increased temperature

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　1

(f) C

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　1

(g) (spines) stop the plant being eaten

　　　or

　　　(spines) prevent animals damaging the plant
　　　　　　allow any named animal
　　　　　　allow to reduce water loss

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　1

(h) it looks like the hornet
　　　　　　allow animals think it is a hornet

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　1

　　　(so) animals avoid the risk of being stung
　　　　　　allow (so) animals avoid the risk of pain

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　1

　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　　[14]

Q5.

(a)   LHS: carbon dioxide **AND** water

in either order
accept CO_2 and H_2O
allow CO2 and H2O
if names given ignore symbols
*do **not** accept CO^2 / H^2O / Co / CO*
ignore balancing

1

RHS: sugar(s) / glucose / starch / carbohydrate(s)

accept $C_6H_{12}O_6$
allow C6H12O6
*do **not** accept $C^6H^{12}O^6$*

1

(b)   (i)   light is needed for photosynthesis

or

no photosynthesis occurred (so no oxygen produced)

1

(ii)   oxygen is needed / used for (aerobic) respiration

full statement
*respiration occurs **or** oxygen is needed for anaerobic*
*respiration gains **1** mark*

2

(c)   (i)   (with increasing temperature) rise then fall in rate

1

use of figures, ie

max. production at 40 °C
or maximum rate of 37.5 to 38

1

(ii)   <u>25 – 35 °C</u>

either   faster movement of particles / molecules / more collisions
or particles have more energy / enzymes have more energy

1

or temperature is a limiting factor over this range

<u>40 – 50 °C</u>

denaturation of proteins / enzymes

ignore denaturation of cells
ignore stomata

1

(d)   above 35 °C (to 40 °C) – little increase in rate
or > 40 °C – causes decrease in rate

1

so waste of money **or** less profit / expensive

1

because respiration rate is higher at > 35 °C
or
respiration reduces the effect of photosynthesis

1

[12]

Q6.

(a)   LHS – carbon dioxide / CO_2

allow CO2

ignore CO^2

1

RHS

in either order

glucose / carbohydrate / sugar

allow starch

allow $C_6H_{12}O_6$ / C6H12O6

ignore $C^6H^{12}O^6$

1

oxygen

allow O_2 / O2

ignore O^2 / O

1

(b)   any **five** from:

- factor 1: CO^2 (concentration)

- effect - as CO_2 increases so does rate and then it levels off or shown in a graph

- explanation:
  (graph increases) because CO_2 is the raw material or <u>used</u> in photosynthesis / converted to organic substance / named eg
  or
  (graph levels off) when another factor limits the rate.

  accept points made via an annotated / labelled graph

- factor 2: temperature

  allow warmth / heat

- effect – as temperature increases, so does the rate and then it decreases or shown in a graph

  allow 'it peaks' for description of both phases

- explanation:
  (rise in temp) increases rate of chemical reactions / more kinetic energy

  allow molecules move faster / more collisions

or

(decreases) because the enzyme is denatured.

>*context must be clear = high temperature*

>*allow other factor plus effect plus explanation:*
>
>*eg light wavelength / colour / pigments / chlorophyll / pH / minerals / ions / nutrients / size of leaves*
>
>*2nd or 3rd mark can be gained from correct description and explanation*

5

[8]

Q7.

(a)

>*words take precedence over symbols*

LHS:

1

carbon dioxide **and** water

RHS:
glucose

1

>*allow correct symbols (ignore balancing)*
>*in any order*
>*do **not** accept starch*
>*ignore carbohydrates / sugar*

(b) power output of bulb

1

(c) any **two** from:
- repeat **and** calculate a mean
  or
  repeat **and** to eliminate anomalies
  >*ignore do a control experiment unqualified*
- control the (water) temperature
  >*allow a method of controlling (water) temperature*
- control the concentration of carbon dioxide
  >*allow a method of controlling carbon dioxide concentration*
- control the distance of the bulb from the pondweed
- control the mass / length / species / age of the pondweed
  >*allow use the same piece of pondweed*
- give pondweed time to equilibrate
  >*allow do experiment with the bulb off / in the dark*

2

(d) 3.3 (cm³/hour)

1

(e)

>*max **3** marks for bar chart*

correct scale **and** axis labelled

all points plotted correctly
> *allow points plotted to within ± ½ small square*
> *allow 3 or 4 correct plots for **1** mark*
> *allow correct plot from incorrect value calculated*
> *in part **(d)***

correct curved line of best fit
> *ignore line extended beyond 60 / 250 (W)*
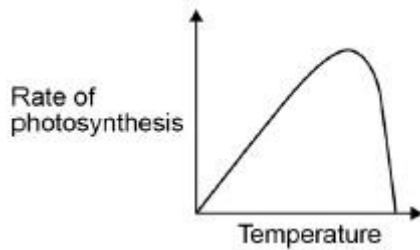> *ignore line joined point to point with straight lines*

(f)   correct answer from their line drawn on **Figure 2**
> *allow ± ½ small square tolerance*
> *allow 1.8 / 1.9 if no line of best fit or incorrect*
> *graph is drawn*

(g)

[12]