

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname *StemUp Model Solution*

Forename(s)

Candidate signature

I declare this is my own work.

INTERNATIONAL A-LEVEL BIOLOGY (9610)

Unit 3 Populations and Genes

Monday 22 May 2023

07:00 GMT

Time allowed: 1 hour 30 minutes

Materials

For this paper you must have:

- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- All working must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 75.

For Examiner's Use

Question	Mark
1	
2	
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6	
7	
TOTAL	



J U N 2 3 B L 0 3 0 1

Answer **all** questions in the spaces provided.

0 1

Peatland is a wetland habitat.

Figure 1 shows peatland.

Figure 1



Human activity has affected much of the peatland in the UK.

Table 1 shows the percentage of peatland in different conditions in the UK.

Table 1

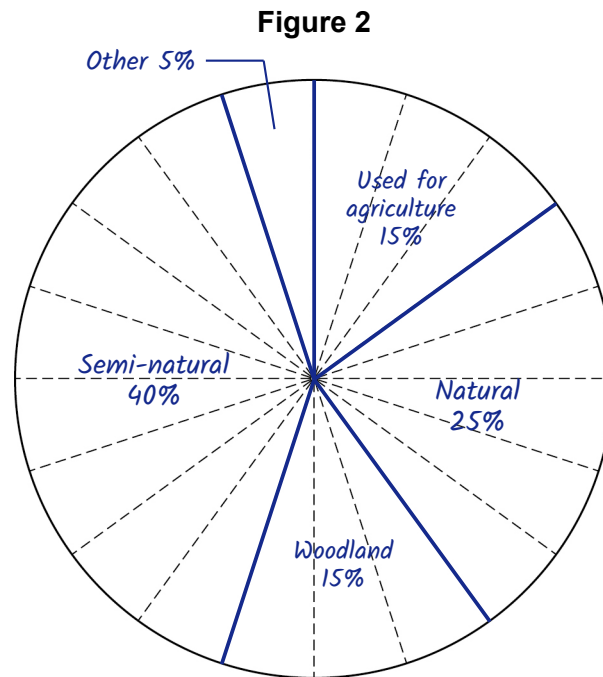
Condition of peatland	Percentage of total UK peatland
Used for agriculture	15
Natural	25
Woodland	15
Semi-natural	40
Other	5



0 1 . 1

Figure 2 shows a pie chart.Complete **Figure 2** to show the percentage of peatland in each condition.Use data from **Table 1**.

Label the pie chart.

[2 marks]**Question 1 continues on the next page****Turn over ►**

0 1 . 2

Peatland has waterlogged soil. This means there are no air spaces in the soil.

Waterlogged conditions prevent plant material from decomposing completely.

Draining the soil removes water.

Explain how draining the soil increases carbon release.

[3 marks]

Draining puts air into the soil (air spaces), so there is more oxygen in the soil.

Decomposers (saprophytes, microorganisms) can then break down the organic substances in the plant material.

Their aerobic respiration releases carbon dioxide, so more carbon is released.

0 1 . 3

The vegetation growing on peatland is mostly mosses and other small plants. Peatland is an important store of carbon.

Peatland conservation reduces the release of stored carbon. Peatland can be conserved by preventing trees from growing.

Suggest how preventing tree growth conserves peatland.

[2 marks]

Trees would change the abiotic conditions, eg trees compete for light and shade the mosses. So preventing tree growth prevents succession, so a climax community (woodland) does not develop.

Trees also increase water loss from the soil, so without trees the soil stays waterlogged and plant material cannot decompose fully.

7



0 2

A student investigates the effect of carbon dioxide concentration on the rate of photosynthesis in spinach leaves.

The student changes the carbon dioxide concentration using sodium hydrogencarbonate solution.

The student:

1. cuts 50 discs out of spinach leaves
2. removes gases from the leaf discs
3. puts 10 discs into a beaker of water
4. puts the beaker next to a lamp
5. measures the time it takes for 50% of the leaf discs to float to the surface
6. repeats steps 1 to 5 four more times with water
7. repeats steps 1 to 6 using different concentrations of sodium hydrogencarbonate solution instead of water.

0 2**1**

Suggest why the student removes gases from the leaf discs (step 2).

[1 mark]

So that all the leaf discs sink at the start of the experiment.

Question 2 continues on the next page

Turn over ►



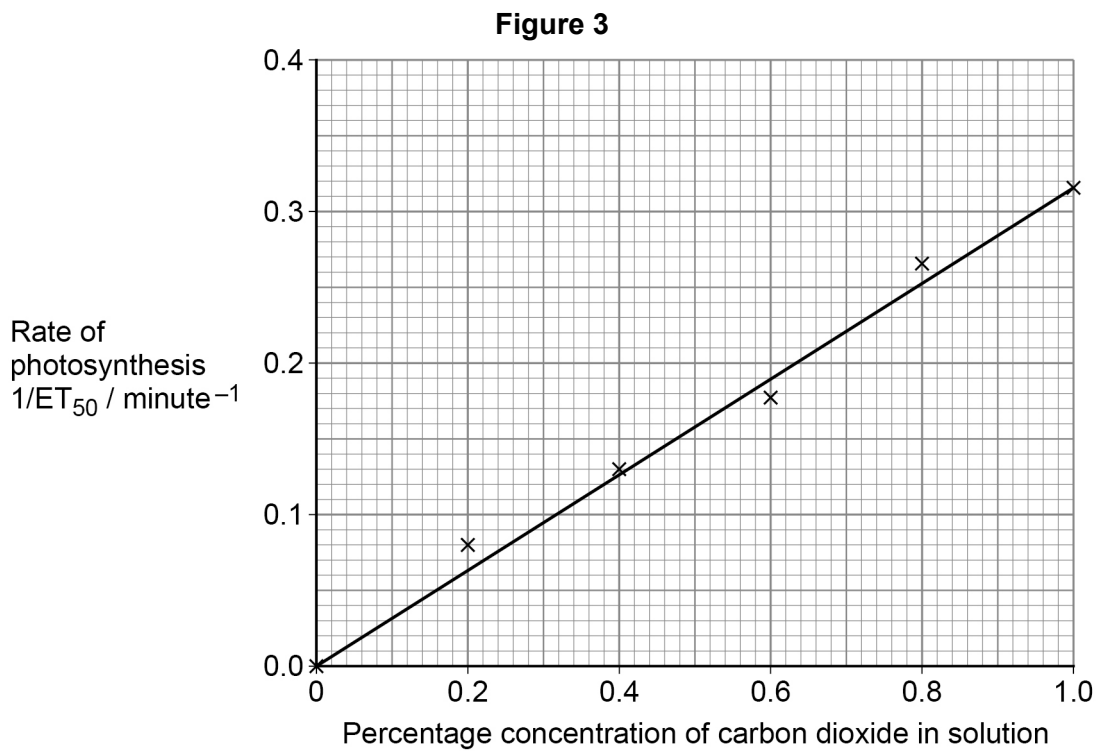
0 2 . 2

The ET_{50} is the effective time for 50% of the leaf discs to float.

The student calculates $1/ET_{50}$ for different concentrations of carbon dioxide.

$1/ET_{50}$ is used as a measure of the rate of photosynthesis.

Figure 3 shows the student's results.



The student concludes that there is a direct relationship between carbon dioxide concentration and the rate of photosynthesis in spinach leaves.

Evaluate the student's conclusion.

[4 marks]

Supports: the data shows a positive correlation, as the carbon dioxide concentration increases, the rate of photosynthesis increases (it is directly proportional).

The experiment was repeated five times for each concentration, and the points are all close to the line of best fit.

Against: temperature, light intensity and colour of light also affect the rate of photosynthesis and may not have been controlled.

The rate may plateau (level off) at higher carbon dioxide concentrations, above 1%. No statistical test was carried out.

0 2 . 3

The student puts the beaker next to a lamp (step 4).

Explain what would happen if the student put the beaker of leaf discs in the dark.

[3 marks]

There would be no photosynthesis, only respiration.

So there is no net gain of oxygen: oxygen uptake is balanced by carbon dioxide production, so oxygen cannot collect in the air spaces of the leaf discs.

So the leaf discs would not float (they stay at the bottom).

Turn over for the next question

Turn over ►



0 3

The transfer of energy through the trophic levels in food chains is not efficient.

Farmers use different methods to make energy transfer more efficient and increase productivity.

0 3**. 1**

Productivity in plants can be determined by calculating the net primary production (NPP).

Give the definition of NPP and the equation to calculate NPP.

[2 marks]

Definition The chemical energy stored in plants minus the energy lost in respiration (the energy available to consumers).

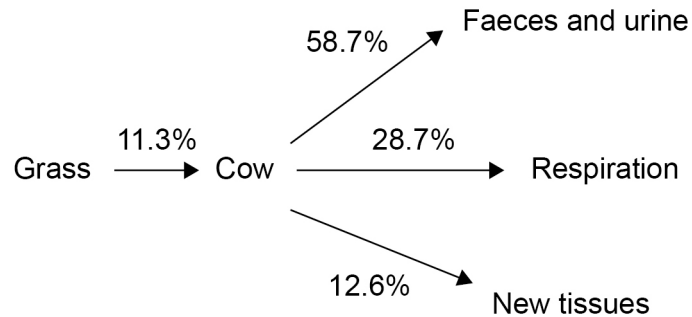
Equation NPP = GPP - R (R = respiratory losses)



The NPP of a plant is available to the next organism in a food chain.

Figure 4 shows the percentage of energy transferred from grass to a cow, and how this energy is used in the cow.

Figure 4



0 3 . 2

The NPP of the grass is $21\,135\text{ kJ m}^{-2}\text{ year}^{-1}$

Calculate the energy stored in new tissues of the cow in $\text{kJ m}^{-2}\text{ year}^{-1}$

Use information from **Figure 4**.

Give your answer to 3 significant figures.

[2 marks]

$$\text{Energy to cow} = 11.3/100 \times 21\,135 = 2388.3\text{ kJ m}^{-2}\text{ year}^{-1}$$

$$\text{New tissues} = 12.6/100 \times 2388.3 = 300.92\text{ kJ m}^{-2}\text{ year}^{-1}$$

$$= 301\text{ (3 significant figures)}$$

$$\text{Energy stored in new tissues} = \underline{301} \text{ kJ m}^{-2}\text{ year}^{-1}$$

Question 3 continues on the next page

Turn over ►



Dairy cows are used for producing milk.

A feed conversion ratio (FCR) can be used to measure how efficiently dairy cows convert their food into milk. FCR can be calculated using:

$$\frac{\text{mass of food ingested}}{\text{mass of milk produced}}$$

A lower FCR means a more efficient food conversion.

Scientists investigate the FCR for two different types of food.

The scientists:

- randomly put 18 cows in either a control group or a test group
- feed the control group a standard grass-based diet
- feed the test group a diet containing a mixture of crop plants
- measure the milk yield of the cows every day
- compare the FCR of the two groups after 7 weeks.

0 3 . 3

Suggest **two** variables the scientists should control to give valid results.

[2 marks]

1 *The breed (type) of cow.*

2 *The age of the cows (or the amount of food and water given).*



Question 3 continues on the next page

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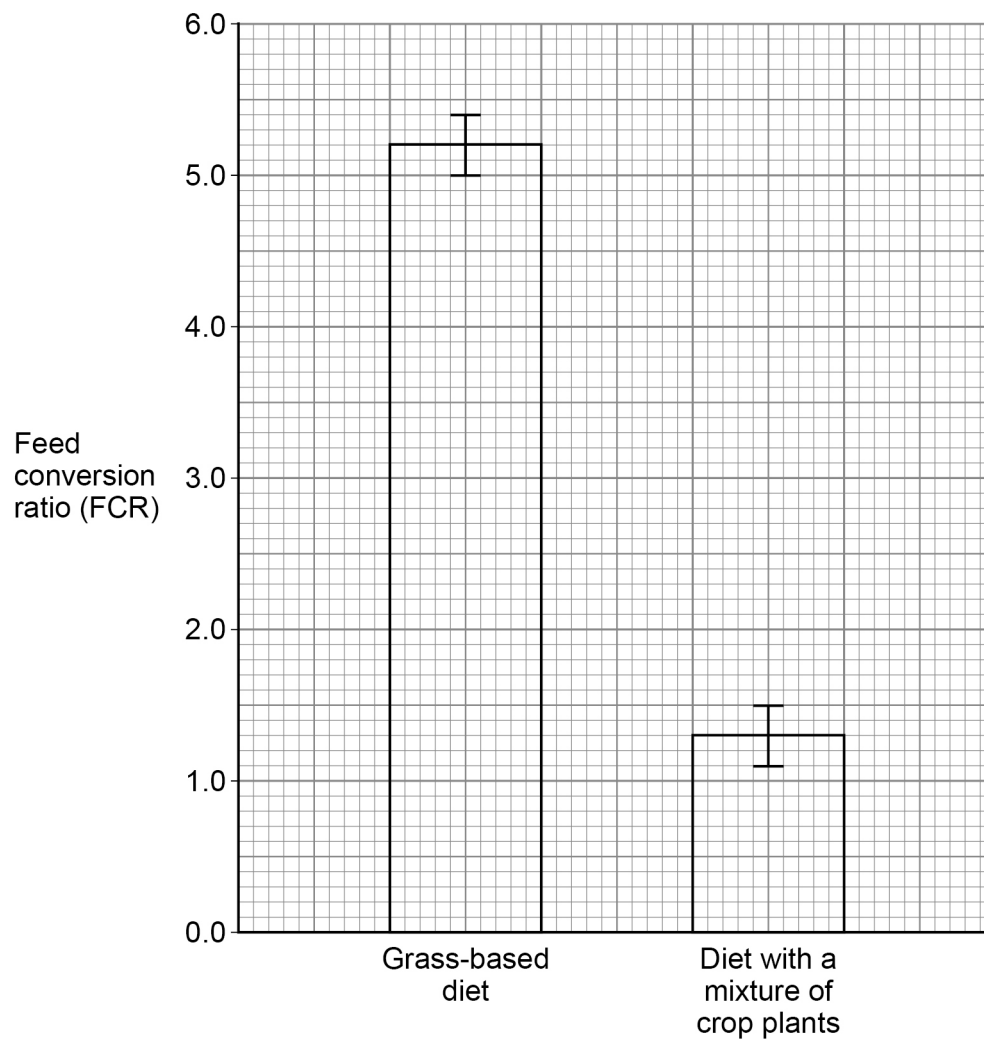
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Figure 5 shows the scientists' results.

The error bars show $\pm$ standard error.

Figure 5



0 3 . 4

A dairy farmer concludes from the scientists' results that cows should be fed a diet containing a mixture of crop plants instead of the standard grass-based diet.

Evaluate this conclusion.

Use the scientists' method (on page 10) and data from **Figure 5**.

[4 marks]

Supports: the FCR is about 4 times lower with the diet containing a mixture of crop plants (1.3 compared with 5.2), so food conversion is more efficient.

The difference in FCR is significant, as the error bars ($\pm$ standard error) do not overlap.

Against: only 18 cows were used (9 per group), a small sample size, and there was only one trial. The breed and age of the cows were not specified.

The study lasted only 7 weeks. There is no information about the cost of the food or profit, or about the quality of the milk or the health of the cows.

10

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0 4

Some genetic conditions are sex-linked.

0 4 . 1

Explain what a sex-linked condition is.

[2 marks]

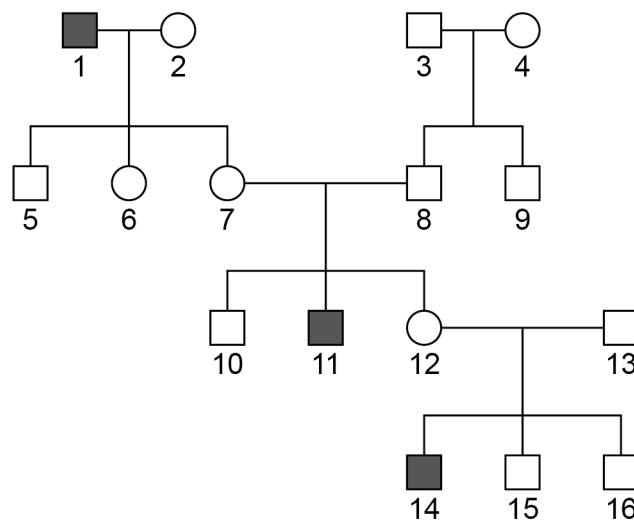
*A condition that occurs mainly in one sex (usually in males),
because the gene (allele) is on the X chromosome, one of the sex
chromosomes, so males have only one copy of the allele.*

Ocular albinism (OA) is a genetic condition that prevents pigment production in the eyes.

OA is a sex-linked condition.

Figure 6 shows the inheritance of OA in one family.

Figure 6



Key

- Male with ocular albinism
- Male with pigment production
- Female with pigment production



0 4 . 2

Give evidence from **Figure 6** that the allele for OA is recessive.

[1 mark]

Two unaffected parents have offspring with OA: 7 and 8 (both with pigment production) produce 11 with OA, and 12 and 13 produce 14.

0 4 . 3

Individuals **12** and Individuals **13** have another child.

Draw a genetic diagram to show the expected ratio of phenotypes.

Use the following symbols:

 X^A = X chromosome with allele for pigmentation X^a = X chromosome with allele for OA Y = Y chromosome

[4 marks]

	Individual 12	Individual 13
Parental phenotypes	Female with pigment production	Male with pigment production

Parental genotypes

 $X^A X^a$ $X^A Y$

Genotypes of gametes

 X^A X^a X^A Y

gametes	X^A	X^a
X^A	$X^A X^A$	$X^A X^a$
Y	$X^A Y$	$X^a Y$

Offspring genotypes $X^A X^A$ $X^A X^a$ $X^A Y$ $X^a Y$

Offspring phenotypes *2 females with pigment production : 1 male with pigment production : 1 male with OA*

Question 4 continues on the next page

Turn over ►



0 4 . 4

A student uses the chi-squared test on the results of a genetic cross.

The calculated value of chi-squared gives $P = 0.1$

Explain what the student can conclude from this P value.

[2 marks]

There is no significant difference between the observed and expected ratios, so the null hypothesis is accepted (we would expect this much variation by chance in 10% of cases), because $P = 0.1$, which is greater than 0.05 ($P > 0.05$).

9



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0 5

Leopard complex spotting (LCS) is a coat colour in horses.

Figure 7 shows a horse with LCS.

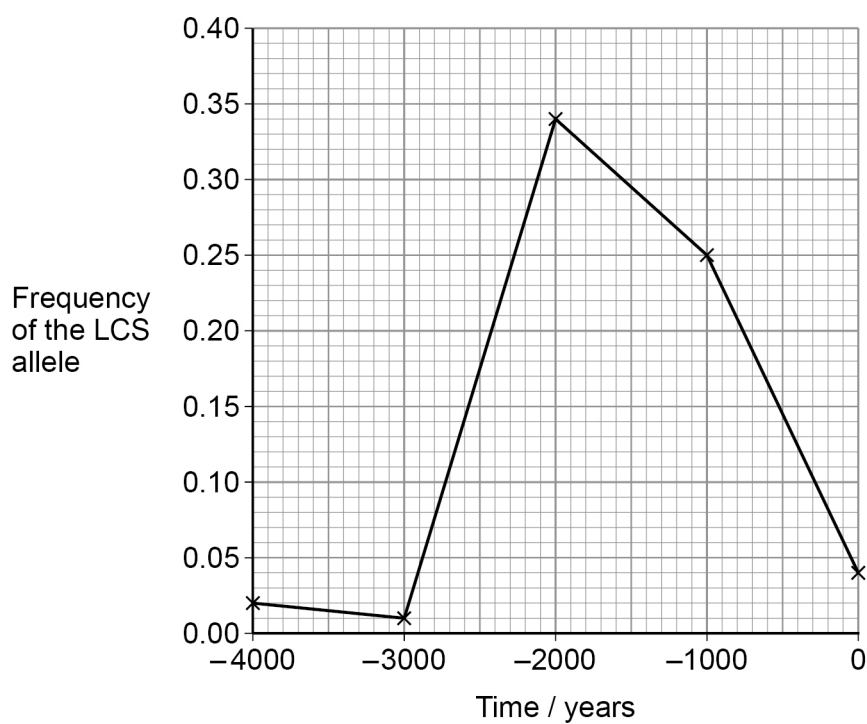
Figure 7



LCS is caused by a dominant allele.

Figure 8 shows the frequency of the LCS allele in a population of horses for the last 4000 years.

Figure 8



0 5 . 1

Calculate the percentage of the horse population with LCS 2000 years ago.

Use the Hardy–Weinberg equation and data from **Figure 8**.

[3 marks]

$$p \text{ (LCS allele)} = 0.34 \text{ (from Figure 8)}$$

$$q = 1 - 0.34 = 0.66 \quad q^2 = 0.66^2 = 0.4356$$

$$\text{With LCS} = p^2 + 2pq = 1 - q^2$$

$$= 1 - 0.4356 = 0.5644$$

$$0.5644 \times 100 = 56.44\%$$

Percentage of horse population with LCS 2000 years ago = 56.44 %

0 5 . 2

Horses with the LCS coat colour have been popular with humans for thousands of years.

Horses homozygous for the LCS allele cannot see well in the dark.

Explain the change in frequency of the LCS allele:

- between 4000 and 3000 years ago
- between 3000 and 2000 years ago.

Use information from **Figure 8**.

[3 marks]

Between 4000 and 3000 years ago The allele frequency decreases (is low, 0.02 to 0.01) because the allele is disadvantageous: homozygous horses cannot see well in the dark, so it increases the chance of predation and decreases the chance of survival.

Between 3000 and 2000 years ago The allele frequency increases (0.01 to 0.34) because humans selected horses with LCS for breeding, as the coat colour was popular.

So the LCS allele is passed on to more offspring.

Question 5 continues on the next page

Turn over ►



0 5 . 3

All domesticated horses are the same species but there are different breeds.

Suggest how allopatric speciation in wild horses could result in a new species of horse.

[5 marks]

Populations of wild horses become geographically isolated, eg by a mountain range or river, so there is no interbreeding and no gene flow between them.

Variation arises in each population due to mutation, producing new alleles.

The environments are different, so there are different selection pressures, eg different climate, food or predators.

In each population, horses with favourable phenotypes are more likely to survive and reproduce,

so they pass on their favourable alleles to their offspring, and the allele frequencies change in each population over many generations.

Eventually the populations are so different that they cannot interbreed to produce fertile offspring, so they are a new species.



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0 6

A student uses methylene blue solution to investigate the effect of temperature on the rate of respiration in yeast.

Methylene blue is a blue dye. The dye can accept hydrogen atoms and become reduced.

Reduced methylene blue solution is colourless.

The reduced dye can also be oxidised by oxygen.

The student:

1. adds 2 cm³ of glucose solution containing yeast to a test tube
2. adds 2 cm³ of methylene blue solution to a second test tube
3. puts both test tubes in a water bath at 10 °C for 5 minutes
4. pours the methylene blue solution into the glucose and yeast solution and then shakes the test tube containing the mixture
5. puts the test tube containing the mixture back in the water bath and does not shake the tube again
6. starts a stopwatch and measures the time it takes for the methylene blue to become colourless
7. repeats steps 1 to 6 at 20, 30, 40 and 50 °C

0 6 . 1

The student puts both test tubes in a water bath for 5 minutes (step 3).

Explain how the student could determine if 5 minutes in the water bath is a suitable time.

[2 marks]

Measure the temperature of the contents of the test tubes with a thermometer, and check whether it equals the temperature of the water bath (10 °C) after 5 minutes, or time how long the contents take to reach the required temperature.

0 6 . 2

Explain why the student did **not** shake the test tube containing the mixture again after putting it back in the water bath (step 5).

[2 marks]

Shaking would mix oxygen (air) into the mixture, so the reduced methylene blue would be oxidised. So it would stay blue or turn blue again, and would not decolourise.



0 6 . 3

The student measures the time it takes for methylene blue to become colourless (step 6).

Describe how the student could produce a colour standard so that the end-point of the reaction can be determined.

[2 marks]

Set up a test tube containing glucose solution, yeast and methylene blue,

and leave it to fully decolourise, then use this colour to compare with.

0 6 . 4

Explain why the student did **not** use temperatures above 50 °C

[2 marks]

Enzymes (proteins) in the yeast would be denatured, so the yeast is killed.

So there is no (or less) respiration, so the methylene blue would not decolourise.

0 6 . 5

The student sets up a control experiment by adding 2 cm³ of methylene blue to a test tube containing 2 cm³ of boiled yeast and glucose solution.

Suggest why the student sets up this control experiment.

[1 mark]

To show that yeast respiration (enzymes) causes the decolourisation, not glucose.

Question 6 continues on the next page

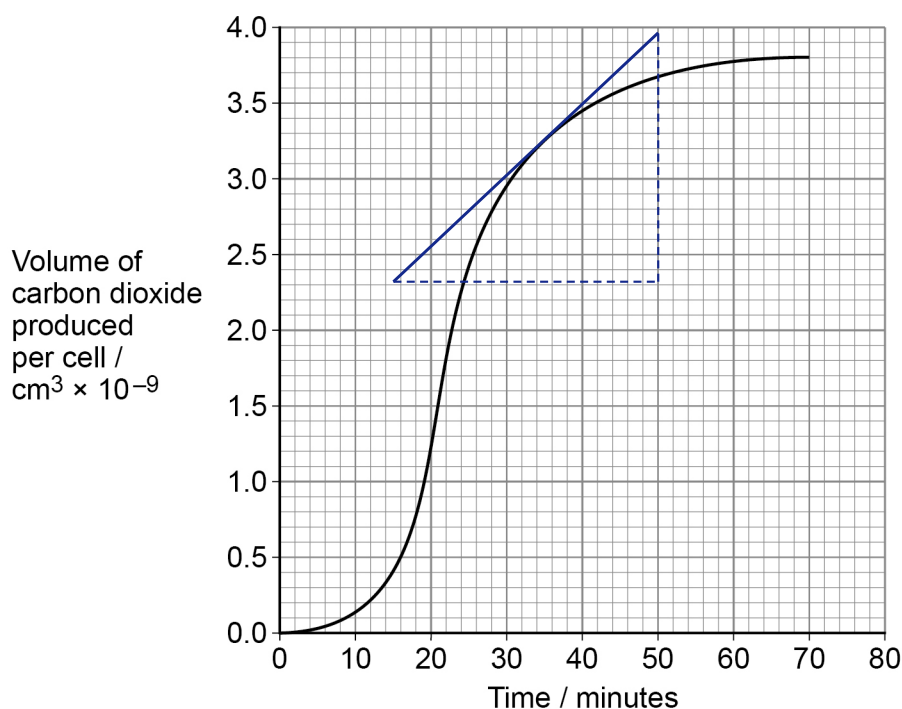
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Another student investigates the optimum temperature for yeast respiration. The student measures the total volume of carbon dioxide produced by the yeast for 70 minutes.

Figure 9 shows the student's results for 30 °C

Figure 9



0 6 . 6

Figure 9 shows the volume of carbon dioxide produced per cell.

Suggest how the student calculates the volume per cell.

[2 marks]

Measure the volume of carbon dioxide produced, and count the number of yeast cells in a known volume (using a haemocytometer).

Then divide the volume of carbon dioxide by the number of cells.



0 6 . 7

The rate of carbon dioxide production at 25 minutes is
 $1.4 \times 10^{-10} \text{ cm}^3 \text{ per cell minute}^{-1}$

Draw a tangent on the curve on **Figure 9** at 35 minutes.

Calculate the rate of carbon dioxide production at 35 minutes using the tangent.

Give your answer in standard form.

[2 marks]

$$\text{Gradient} = (3.96 - 2.32) \times 10^{-9} \div (50 - 15)$$

$$= 1.64 \times 10^{-9} \div 35 = 4.69 \times 10^{-11}$$

Rate of carbon dioxide production = 4.7×10^{-11} $\text{cm}^3 \text{ per cell minute}^{-1}$

0 6 . 8

Suggest **two** reasons why the rate of carbon dioxide production at 35 minutes is different from the rate at 25 minutes.

[2 marks]

1 The yeast is running out of substrates (glucose and oxygen).

2 Build-up of waste products, such as ethanol and carbon dioxide, which changes the pH.

15

Turn over for the next question

Turn over ►



07.1

Glycolysis is a process in both aerobic and anaerobic respiration.

Describe glycolysis.

[6 marks]

Glycolysis takes place in the cytoplasm and does not need oxygen.

Glucose is phosphorylated; two phosphate groups are added to glucose, using two molecules of ATP, to form hexose biphosphate (glucose phosphate).

This splits into two molecules of triose phosphate (TP).

Each triose phosphate is oxidised to pyruvate: hydrogen is removed and NAD is reduced, so reduced NAD is formed (2 per glucose).

4 ATP are produced by substrate-level phosphorylation, so there is a net gain of 2 ATP per glucose (2 ATP used, 4 ATP produced).

So overall one glucose gives 2 pyruvate, a net gain of 2 ATP and 2 reduced NAD.



0	7	2
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Anaerobic respiration can occur in muscle cells during exercise.

Anaerobic respiration in muscle cells produces lactate.

Explain why lactate production is important during exercise.

[5 marks]

During exercise there is insufficient oxygen for aerobic respiration, so oxygen is not available as the final electron acceptor and oxidative phosphorylation stops.

Pyruvate is reduced to lactate, and the formation of lactate requires reduced NAD.

So reduced NAD is oxidised and NAD is regenerated.

The NAD can accept hydrogen in glycolysis, which allows glycolysis to continue.

So some ATP is still produced (net 2 ATP per glucose) for muscle contraction.

Question 7 continues on the next page

Turn over ►



0 7 3

Two biochemical cycles are:

- the Krebs cycle in aerobic respiration
- the Calvin cycle in the light-independent reaction of photosynthesis.

Contrast the reactants and products of the Krebs cycle with those of the Calvin cycle.

[4 marks]

Carbon dioxide is produced in the Krebs cycle, but carbon dioxide is used (is a reactant) in the Calvin cycle.

Reduced coenzymes (reduced NAD and reduced FAD) are produced in the Krebs cycle, but reduced coenzymes (reduced NADP) are used (oxidised) in the Calvin cycle.

ATP is produced in the Krebs cycle, but ATP is used in the Calvin cycle.

Acetyl coenzyme A enters the Krebs cycle and combines with a four-carbon molecule (oxaloacetate), but carbon dioxide enters the Calvin cycle and combines with the five-carbon RuBP.

15

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