OCR A-LEVEL BIOLOGY A · H420

BIOLOGY



EXAM QUESTION PACK

5.2.2 RESPIRATION

SCORE	PERCENTAGE
/189	%

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11. One of the main functions of the liver cells is the formation of urea by the ornithine cycle, an outline of which is shown in **Fig. 17.2**.

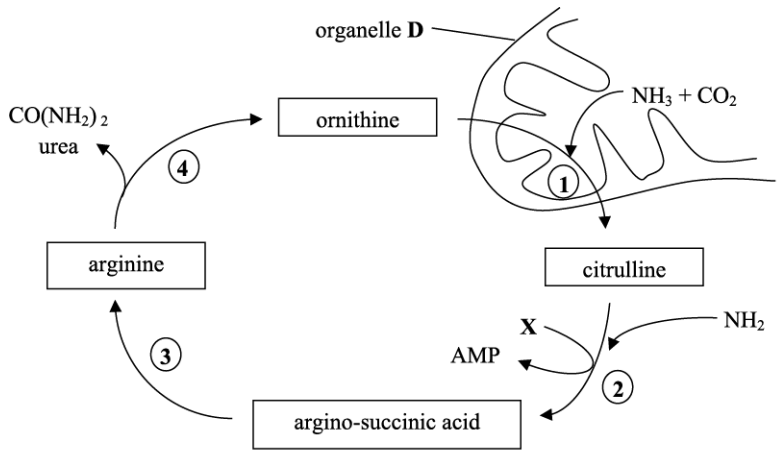


Fig. 17.2

i. Step **1** of the cycle takes place in the organelle represented by **D**.

Identify organelle **D**.

_____ **[1]**

ii. During the cycle ornithine moves into organelle **D** and citrulline moves out of the organelle.

Suggest the method by which these molecules move into and out of the organelle during the cycle. Give reasons for your choice.

_____

_____

_____

_____ **[2]**

iii. How has the ammonia that is used in step **1** been formed?

_____

_____ **[1]**

iv. Identify the compound labelled **X** in **Fig. 17.2**.

_____ **[1]**

12. A group of students set up a simple respirometer, as shown in **Fig. 1.1**, and used it to determine the rate of respiration in germinating mung beans.

- They placed a small muslin bag of soda lime into the syringe and then added five germinating mung beans, which were held in place with the syringe plunger.
- The students measured the movement of the red fluid in the capillary tube.
- After each set of readings the plunger was reset to return the fluid to its original position.

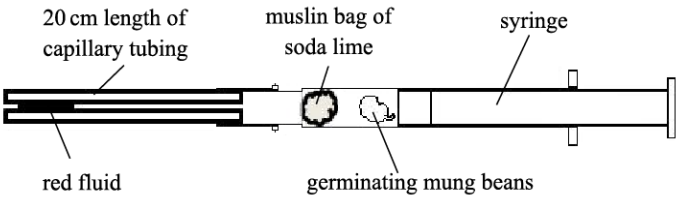


Fig. 1.1

The results are shown in **Table 1.1**.

Time (s)	Distance moved by the red fluid in capillary tube (mm)		
	1	2	3
0	0.0	0.0	0.0
30	11.5	12.0	12.5
60	22.5	21.5	17.5
90	31.0	32.0	32.5
120	41.5	42.0	42.5
150	53.0	54.0	53.5
180	63.0	63.0	64.0
210	72.5	71.0	71.5
240	78.5	79.5	79.0
270	87.5	88.5	87.0

Table 1.1

a. Give **one** limitation of using this method to investigate respiration rate.

_____

_____ **[1]**

b. Read the procedure carefully. Identify **one** variable that had not been controlled in this experiment **and** suggest an improvement to control that variable.

Variable _

Improvement_ _

_ _

[2]

c. Describe how you would add the red fluid to the capillary tube at the start of the experiment.

---

[1]

d. The data shows an anomalous result at 60 seconds.

Explain why the result is considered to be anomalous **and** describe one correct way of dealing with this type of result.

---

[2]

e. Using the data the student obtained, calculate the mean rate of respiration for germinating mung beans between 90 and 150 seconds.

Answer…… **[1]**

f. What additional information would be needed to calculate:

i. the volume of oxygen taken up by the seeds.

---

[1]

ii. the oxygen uptake for this batch of seeds to be comparable with data from another type of bean.

---

[1]

g. * The group of students wanted to find out if the rate of respiration of a small invertebrate animal was comparable to that of the mung beans.

Adapt the procedure used to investigate the respiration rate of a small invertebrate, such as a woodlouse or caterpillar, with that of mung beans.

Comment on the results you might expect from this experiment and the conclusions you might draw.

[6]

13(a). Termites are highly social insects. They are thought to have evolved from earlier forms of insect at least 150 million years ago, in the Jurassic geological period. They are related to cockroaches.

i. How might scientists a century ago have known that termites evolved in the Jurassic geological period?

[1]

ii. What new source of evidence might help today's scientists to find out how closely related termites are to cockroaches?

[1]

(b). Fig. 5.1 shows a termite mound, the nest of approximately one million individuals. The photograph was taken in Queensland Australia, about 3000 kilometres south of the equator.

i. **Fig. 5.1** shows that the interior of the termite mound is full of interconnecting chambers. At the top of the mound some of these chambers open to the air outside.



ii. Worker termites spend all their time working in brood chambers low in the mound, where eggs and larvae develop.

Explain how carbon dioxide produced in the respiring body cells of worker termites is removed to the air outside the termite mound.

_____

_____

_____

_____

_____

_____ **[4]**

iii. In Africa, closer to the equator, the mounds built by some species of termite are blade-shaped, with the long axis pointing North–South. **Fig. 5.2** shows an example of a termite mound in Africa.



Fig. 5.2

Suggest why the African termites need to build mounds in this shape and orientation.

_____

_____

_____ **[2]**

14. An investigation was carried out into the effect of adding different volumes of water on the survival of seedlings.

There were 60 seedlings in each group.

The results are shown in Table 18.

Volume of water added to soil (cm^3)	Day	Number of seedlings surviving
10	3	60
	6	59
	9	59
	12	58
	15	57
	18	57
20	3	60
	6	57
	9	54
	12	54
	15	54
	18	53
30	3	60
	6	58
	9	56
	12	50
	15	50
	18	48
40	3	60
	6	48
	9	40
	12	34
	15	26
	18	20
60	3	60
	6	41
	9	21
	12	6
	15	2
	18	2

Table 18

i. Summarise the conclusions that can be drawn from these data.

---

[3]

ii.  Water can fill air spaces in the soil surrounding the roots.

This prevents oxygen from reaching root hair cells.

Using your knowledge of aerobic and anaerobic respiration, explain why overwatering can kill plants.

---

[6]

15. The endosymbiosis theory suggests that mitochondria may have evolved from bacteria that were taken inside other cells.

These cells then evolved into eukaryotes.

i. Give **two** structural features of mitochondria that support this theory.

1 _____

_____

2 _____

_____

[2]

ii. Explain why early eukaryotes were able to grow more quickly than cells that did not possess mitochondria.

_____

_____

_____

_____

_____

_____

_____

_____ **[3]**

16. Fig. 16.1 shows the structure of ATP.

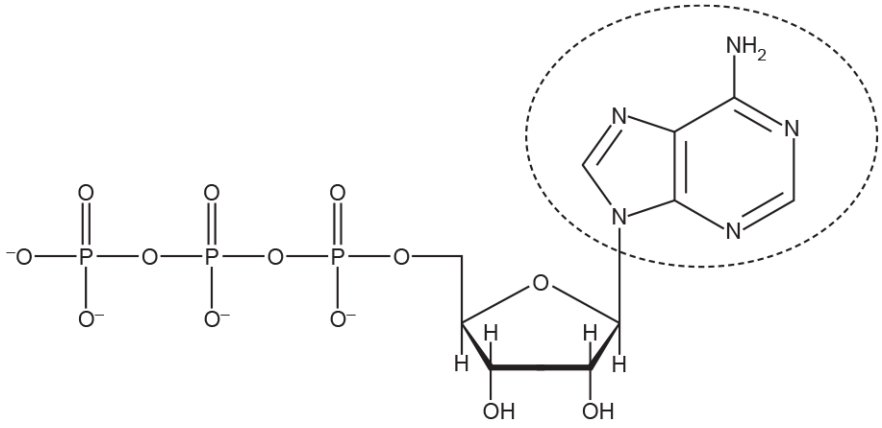


Fig. 16.1

i. Name the circled component in Fig. 16.1.

_____ **[1]**

ii. Name the type of reaction that occurs when ATP is converted to ADP.

_____ **[1]**

iii. A teacher told his students that the human body makes the equivalent of its own mass in ATP every day.

Explain why, at the end of the day, only a small proportion of the students' mass was ATP.

_____

_____

_____

_____ **[2]**

17(a). Describe **two** ways in which the structure of mitochondrial membranes is related to the function of a mitochondrion.

1 _____

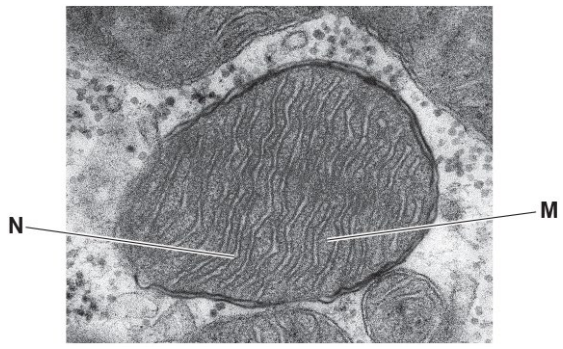
_____

2 _____

_____

[2]

(b). The image below is a photomicrograph of a mitochondrion.



i. State the type of microscope used to produce this image.

_____ **[1]**

ii. Identify the structures labelled **M** and **N** in the photomicrograph.

M .....

N .....

[2]

18. Brown fat is a type of tissue.

Brown fat has a higher need for oxygen because fat cells in this tissue carry out aerobic respiration at a higher rate than fat cells in other tissues.

Suggest which organelle is present in higher numbers in brown fat cells than in other fat cells.

_____ **[1]**

19. Fig. 19.2 is a transverse section of a sperm cell. The mitochondria of sperm cells form a spiral around the central flagellum.

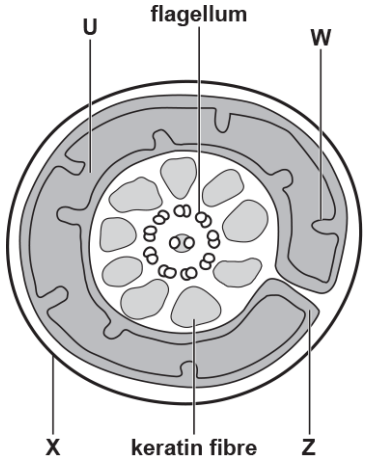


Fig. 19.2

i. Identify the structures labelled with the following letters:

U ----------

W ----------

Z ----------

[3]

ATP, $FADH_2$ and hexose 1,6-bisphosphate are three organic products of respiration in sperm cells.

Table 19 shows how the production of ATP, $FADH_2$ and hexose 1,6-bisphosphate in sperm cells is affected by three different substances.

Substance	Organic products of respiration per sperm cell		
	ATP (10^{-10} mol s^{-1})	$FADH_2$ (10^{-11} mol s^{-1})	Hexose 1,6-bisphosphate (10^{-11} mol s^{-1})
Cyanide	2.54	0.00	5.78
Fluoride	0.00	0.00	0.00
Sucrose	6.89	2.53	5.42

Table 19

ii. What can be concluded about the difference between the effects of **cyanide** and **fluoride** on respiration in sperm?

---

[1]

20. ATP can be produced in various ways. Each stage of respiration contributes to the production of ATP.

Describe the production of ATP by **substrate-level phosphorylation** in different stages of respiration with reference to the number of ATP molecules produced.

_____

_____

_____

_____

_____

_____

_____ **[4]**

21. Fig. 2.1 shows a naked mole rat, *Heterocephalus glaber*.



Fig. 2.1

The naked mole rat is a mammal. However, it has several features that are unusual for mammals.

Naked mole rats can survive without oxygen for up to 18 minutes. This is several times longer than other mammals of a similar size.

The following information might help to explain how naked mole rats can survive without oxygen for a long time:

- In normal glycolysis, the enzymes needed to convert glucose to triose phosphate may be inhibited by lactate.
- Naked mole rats can use fructose as a respiratory substrate.
- Fructose is converted to triose phosphate.
- Triose phosphate can then enter the glycolysis pathway.

i. Suggest why the use of fructose allows naked mole rats to survive without oxygen for a long time.

_____

_____

_____

_____ **[2]**

ii. Suggest **one** other aspect of the physiology of naked mole rats that explains how they are able to survive without oxygen for a long time.

---

[1]

22. Amino acids can be converted to other molecules and used in respiration.

Fig. 4.1 shows the formulae of five amino acids that can be used in respiration.

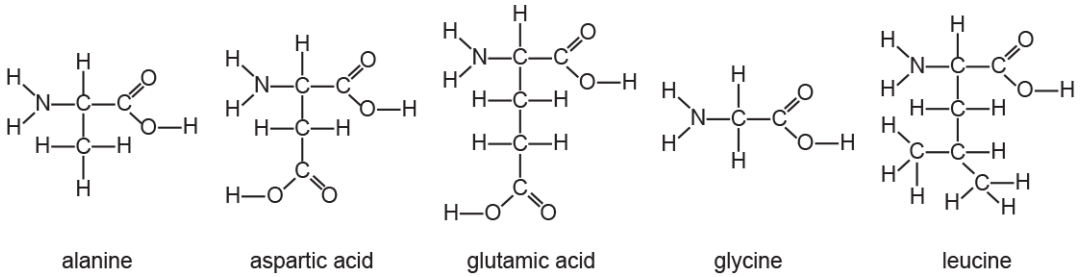


Fig. 4.1

Fig. 4.2 shows an outline of the link reaction and the Krebs cycle.

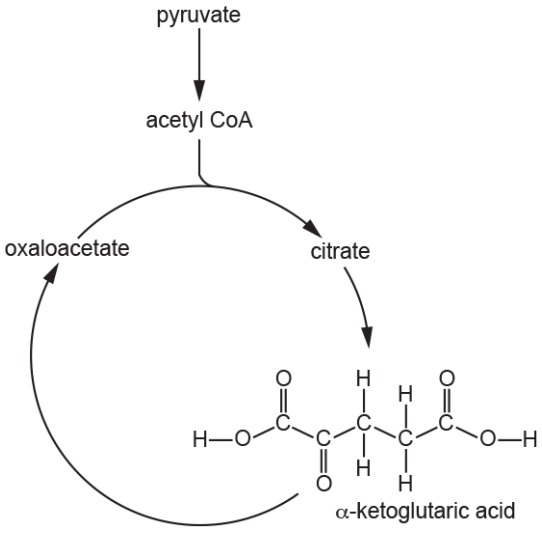


Fig. 4.2

i. The table below contains information about three amino acids.

Use **Fig. 4.1** and **Fig. 4.2** and your own knowledge to draw a conclusion about which amino acid is being described.

Write your conclusions and a justification for each conclusion in the table.

Information about amino acid	**Conclusions**	
	Name of amino acid	**Justification**
Converted to pyruvate with the fewest changes		....
Converted to α-ketoglutaric acid with the fewest changes		....
The amino acid with the highest RQ		....

[4]

ii. Outline the reactions that must occur to convert α-ketoglutaric acid to oxaloacetate in **Fig. 4.2**.

_____

_____

_____

_____

_____ **[2]**

23. NAD, FAD and Coenzyme A (CoA) are molecules that are involved in cellular respiration.

Which of the following statements about these molecules is / are correct?

1 NAD and FAD are examples of coenzymes.
2 NAD is reduced by accepting hydrogen atoms.
3 CoA delivers the three carbon atoms of pyruvate to the Krebs cycle in the form of an acetyl group.

A 1, 2 and 3 are correct
B only 1 and 2 are correct
C only 2 and 3 are correct
D only 1 is correct

Your answer ☐

[1]

24. Respiration is an important metabolic process that takes place in all living cells.

What is the **precise** location of the link reaction within cells?

_____ **[1]**

25. Cells can use fatty acids instead of carbohydrates as respiratory substrates. A process called beta oxidation is used to break down fatty acids to acetyl CoA for use in respiration.

Fig. 2 shows a simplified example of beta oxidation.

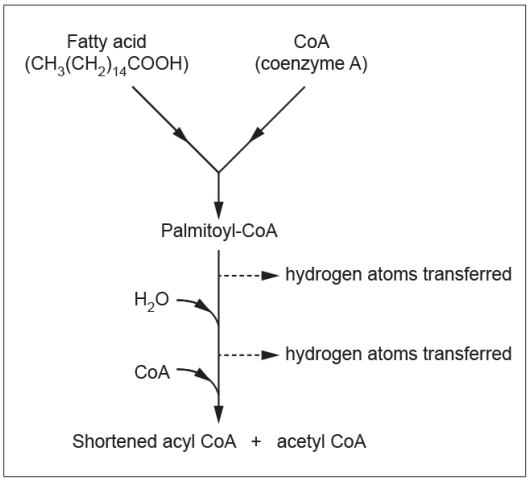


Fig. 2

i. Using the information in Fig. 2, calculate the percentage of carbon atoms in the fatty acid that are able to enter the Krebs cycle.

Answer = _____ %

[1]

ii. The percentage of carbon atoms that a reaction makes available for use in the Krebs cycle can be described as the efficiency of the reaction.

Calculate the efficiency of the **link reaction**. Using your answer to part (i), state whether the link reaction is **more, less** or **equally** efficient when compared to the reactions described in Fig. 2.

Show your working.

Answer = _____ %

Link reaction is _____ efficient

[1]

iii. Fig. 2 shows the role of coenzyme A in beta oxidation.

Suggest a role for coenzymes **other than coenzyme A** in beta oxidation.

_____

_____

[1]

26. Respiration is an important metabolic process that takes place in all living cells.

Fig. 19.1 is an outline of the Krebs cycle.

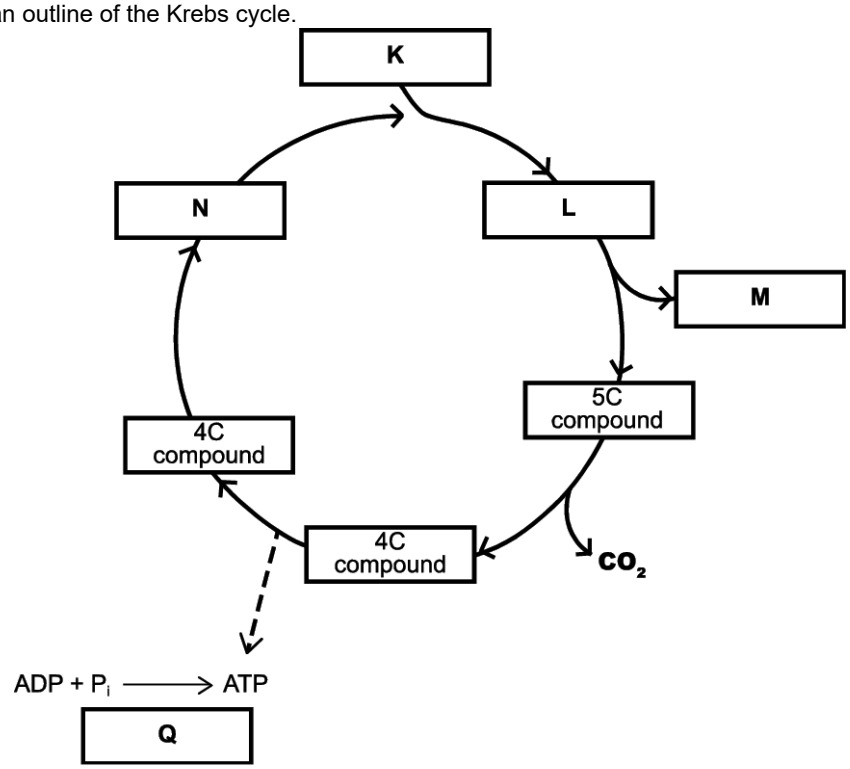


Fig. 19.1

i. For each of the letters below write the **molecule** that is missing from the diagram.

K _

L_ _

M_ _

N_ _

[4]

ii. Name the **process** represented by the letter **Q**.

_____ **[1]**

27. * The light-independent stage requires coenzymes. For example, NADPH reduces molecules by adding electrons, and ATP phosphorylates molecules by adding phosphate groups.

Coenzymes are involved in other cellular processes, including respiration.

Summarise the importance of coenzymes in **respiration**. You should include details of the molecules and processes involved.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____ **[6]**

28(a). *Some individuals can eat large quantities of fatty and carbohydrate-rich food without putting on weight. One possible hypothesis that could explain this is related to the mitochondrial inner membrane.

Scientists have suggested that some individuals may have a larger number of proton pores in their inner mitochondrial membrane than normal.

Explain how having a larger number of proton pores in the inner mitochondrial membrane would result in a person being less likely to gain weight.

[6]

(b). Oxidative phosphorylation is a stage in aerobic respiration, which occurs in mitochondria.

Fig. 18 is a diagram of part of a mitochondrion, showing components, regions and processes involved in oxidative phosphorylation.

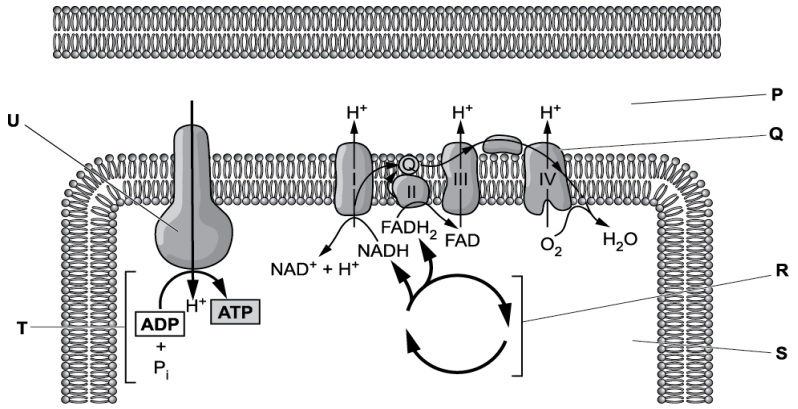


Fig. 18

i. Name the **components** labelled **U** and **Q**.

U _____

Q _____

[2]

ii. Name the two **regions** labelled **P** and **S**.

P _____

S _____

[2]

iii. Name the two **processes** labelled **R** and **T**.

R _____

T _____

[2]

(c).

i. What properties of the mitochondrial inner membrane allow chemiosmosis to occur?

_____

_____

_____

_____

_____ **[2]**

ii. Describe **two** quantitative changes in region **P** which occur as a result of oxidative phosphorylation.

_____

_____ **[1]**

29. * Insects use glucose to generate ATP.

Outline the processes involved in the generation of ATP through **chemiosmosis**.

[6]

30. Most ATP is produced in mitochondria by chemiosmosis.

Outline how ATP is produced in mitochondria by chemiosmosis.

[3]

31(a). A student carried out an investigation into the production of CO_2 in five different species of yeast.

The yeast cells were placed in different environments and the CO_2 production was measured.

Table 20 shows the results of the experiment. The mean values for these data are also represented as a graph in Fig. 20.

		Carbon dioxide produced (bubbles min^{-1})				
Conditions		**Species**				
		S. cerevisiae	*C. krusei*	*C. albidus*	*C. albicans*	*A. pullulans*
	Trial					
	1	23	18	34	12	22
	2	18	17	20	15	21
	3	23	19	32	26	24
	4	24	23	26	13	22
	5	25	19	28	14	26
	6	15	17	29	12	22
	7	16	19	20	15	25
Aerobic	8	17	23	36	13	27
	9	23	19	20	10	27
	10	25	17	19	13	25
	11	25	16	34	11	25
	12	23	16	20	11	25
Standard deviation		4	2	7	4	2
	Trial					
	1	12	6	22	8	34
	2	10	9	29	22	36
	3	12	10	19	6	29
	4	13	12	34	12	32
	5	15	7	25	19	28
	6	9	8	19	10	26
	7	10	9	23	14	27
Anaerobic	8	15	10	27	9	29
	9	15	5	35	6	35
	10	14	7	26	7	20
	11	15	8	19	21	30
	12	11	9	25	13	34
Standard deviation		2	2	5	6	……

Table 20

Using the information in Table 20, calculate the standard deviation for the number of CO_2 bubbles produced by *A. pullulans* in anaerobic conditions.

Write the answer into the space provided in Table 20. Give your answer to **one** significant figure. Show your working.

[Answer on Table 20] **[3]**

(b). Fig. 20 is a graph showing the mean values of the data from Table 20.

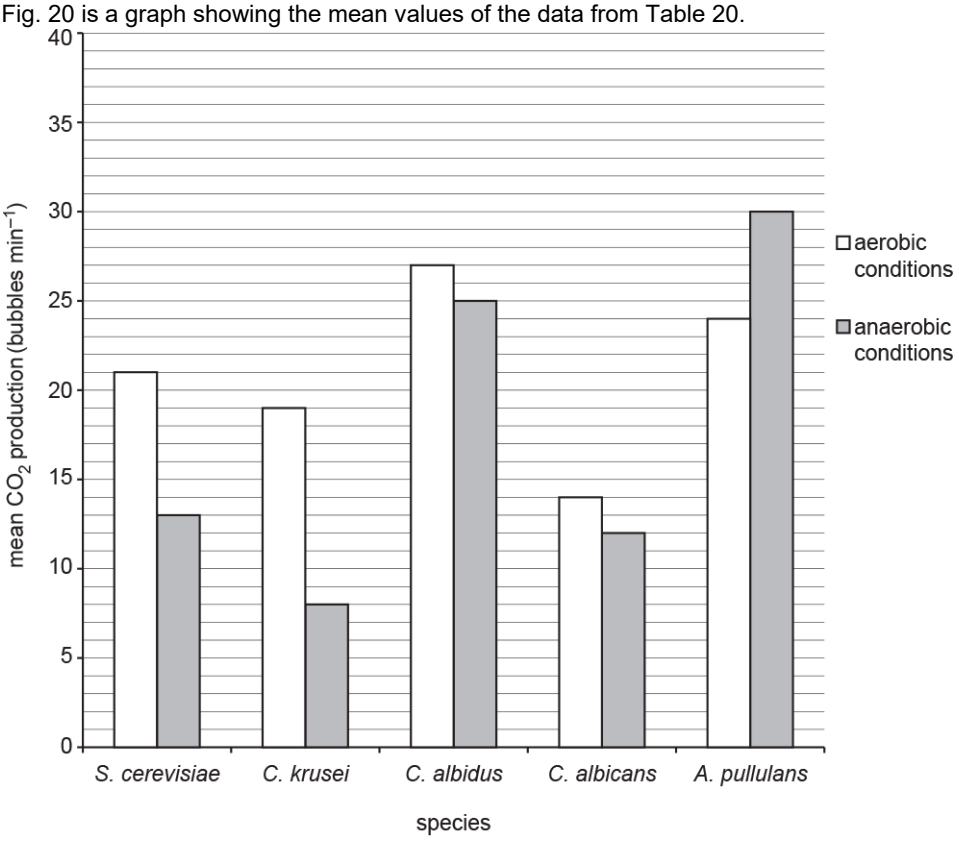


Fig. 20

Plot the standard deviations for all data on Fig. 20.

[Answer on Fig. 20] **[2]**

(c). Calculate the mean percentage change in CO_2 production for *S. cerevisiae* when moving from anaerobic to aerobic respiration. Give your answer to **four** significant figures.

Show your working.

Answer = …… **[3]**

(d).

i. The student drew the following conclusions:

1	All the yeast I investigated produced more CO_2 during aerobic respiration than anaerobic respiration.
2	There is a significant difference between the CO_2 production in aerobic and anaerobic conditions in *C. albidus*.

For each conclusion, state and explain whether the student is correct.
1

_____

_____

_____

2

_____

_____

_____ **[2]**

ii. The student found the following definitions of errors in a text book:

Random errors:

mistakes during measurements caused by low-resolution equipment

Systematic errors:

repeated inaccurate measurements in the same direction caused by problems with equipment

Which type of error is suggested by the student's data? Justify your answer.

_____

_____

_____ **[1]**

(e). Anaerobic respiration in yeast cells requires enzymes.

Which organelle is responsible for synthesising these enzymes?

_____ **[1]**

32. Bread contains a mixture of polypeptides known as gluten.

Gluten consists of two types of polypeptide: gliadins and glutenins.

Gluten helps to trap carbon dioxide within bread dough. This enables bread to rise when it is baked.

The carbon dioxide is produced by baker's yeast, *Saccharomyces cerevisiae*. This species of yeast is able to convert ethanol to acetyl CoA at low glucose concentrations.

Fig. 2 shows the oxygen consumption and carbon dioxide production of a population of *S. cerevisiae* grown in batch culture. The population was provided with glucose as their only initial source of carbon.

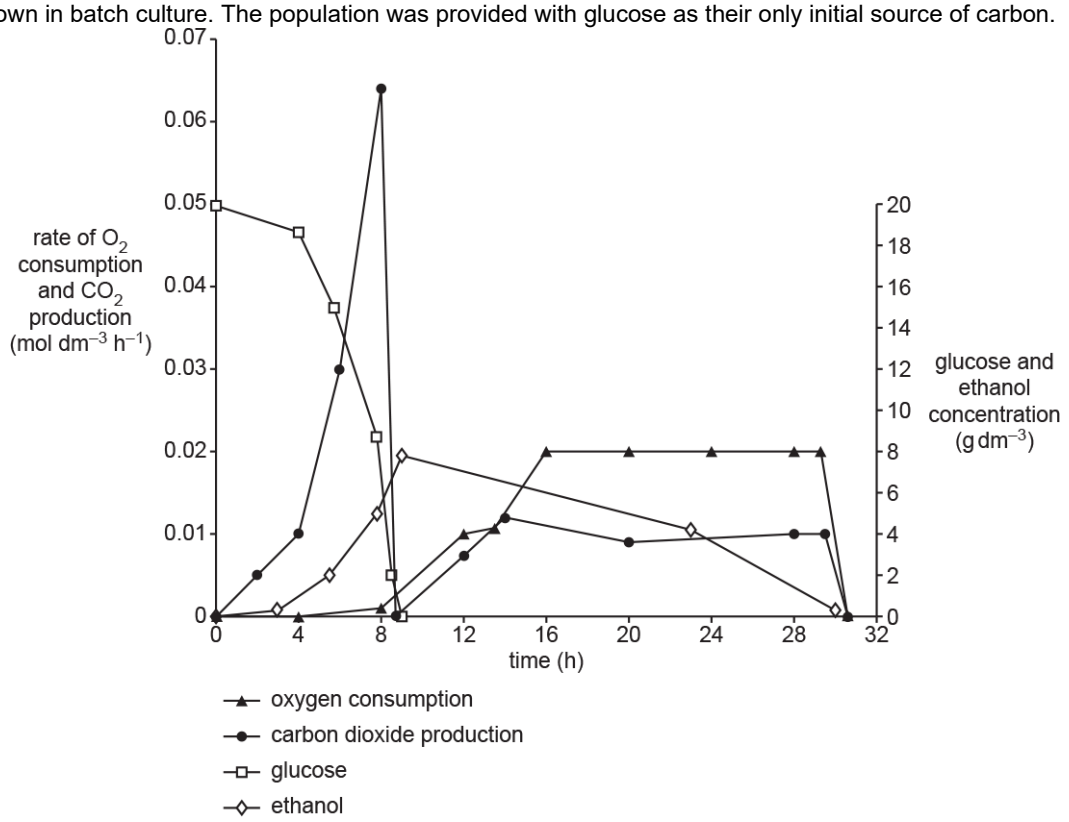


Fig. 2

i. Suggest and explain what conclusions can be drawn from Fig. 2 about the factors that affected the rate and type of respiration carried out by *S. cerevisiae* in this batch culture.

_____

_____

_____

_____

_____

_____

_____

_____ **[3]**

ii. Describe **two** practical considerations to ensure the *S. cerevisiae* population grows successfully when the initial culture is established.

_____

_____

_____

_____

_____ **[2]**

iii. Scientists wanted to estimate the number of yeast cells in a 25 cm^3 solution of *S. cerevisiae*. They carried out the following two dilutions:

- 1 cm^3 of the original solution was mixed with 9 cm^3 of nutrient solution to make solution 2.
- 1 cm^3 of solution 2 was mixed with 9 cm^3 of nutrient solution to make solution 3.

The scientists transferred 0.1 cm^3 of solution 3 onto an agar plate. 15 separate colonies grew on the plate.

Calculate the number of yeast cells in the original 25 cm^3 solution.

Express your answer in standard form to **three** significant figures. Show your working.

Answer: …… **[2]**

33. Botulism is a condition resulting from the action of botulinum toxin. The main symptom of botulism is skeletal muscle weakness, which can be fatal.

i. Botulinum toxin is produced by the anaerobic bacterium *Clostridium botulinum.*
What information does the word 'anaerobic' suggest about the bacterium?

_____

_____ **[1]**

ii. The toxin is initially produced as a large single polypeptide that has low potency.
After the toxin has been acted upon by a protease, two chains are produced which remain connected by a disulfide bond. In this form it is far more toxic.

Describe the action of the protease when it acts on the toxin.

_____

_____ **[1]**

34(a). Athletic sprinters require large amounts of energy in short periods of time. Many elite sprinters can run 100 metre races in under 10 seconds.

Under normal conditions, exercise requires an increased rate of breathing. It has been observed that some of the best sprinters only take one breath at the start of the race and do not inhale again until the end of the race.

Suggest how these sprinters can expend so much energy without needing to carry out aerobic respiration.

_____

_____

_____

_____ **[2]**

(b). Part of the body's response 'fight or flight' is to run away from the threat. Prolonged vigorous exercise puts high demands on the body's metabolism.

The muscle cells require an adequate supply of oxygen for respiration. If insufficient oxygen is available, the cells must respire anaerobically.

Fig. 20.2 outlines the process of anaerobic respiration in muscle cells.

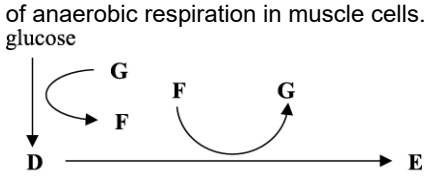


Fig. 20.2

i. Identify the compounds labelled **D** and **E** in **Fig. 20.2**.

D _____

E _____

[2]

ii. What is the role of compound **D** in anaerobic respiration?

_____

_____ **[1]**

iii. Why is it important that compound **G** is formed during the reaction in which compound **D** is converted into compound **E** in anaerobic respiration?

_____

_____

_____ **[2]**

iv. Compound **E** is toxic and is removed from the muscle cell. It is transported to an organ in the body.
Which organ is compound **E** transported to **and** how does it reach this organ?

_____

_____ **[1]**

35(a). The following passage describes the use of alternative substrates in respiration. Complete the passage by writing in the missing words.

Glucose is not the only substrate that can be used for respiration in cells. Fats are hydrolysed to fatty acids and glycerol during digestion. Glycerol is converted to ……, which can then be decarboxylated to produce an acetyl group which is combined with coenzyme A and can then enter the …… cycle. Fatty acids are also converted to acetyl coenzyme A. Proteins need to be converted into amino acids which must then be deaminated in the …… . The resulting molecule can then be converted to pyruvate which enters the …… reaction. Because energy is required for these processes, the respiration of protein gives a lower yield of …… than the respiration of carbohydrates.

[5]

(b).

i. Different foods contain different respiratory substrates, so have different energy content. Food labels often give the energy content of foods in kcal.

Table 17 describes the typical energy content of different foods.

Food	Energy content per 100 g (kcal)
Chocolate	478
Pasta	567
Fish	145
Apple	68
Cheese	831

Table 17

How much energy per unit mass does the highest energy food in Table 17 contain compared to the lowest energy food in Table 17?

Express the answer as a percentage to **three** significant figures.

Answer = …… % **[2]**

ii. The following facts relate to energy release from foods during respiration:

- The energy required for the synthesis of one mole of ATP is 30.5 kJ
- 1 kcal is equal to 4.18 kJ
- 1 mole is equal to 6.02×10^{23} molecules.

Calculate the theoretical yield of ATP molecules from the respiration of a 35 g chocolate bar. Show your working. Give your answer in standard form to **three** significant figures.

Answer = ... **[3]**

iii. Suggest and explain why cheese has the highest energy content of the foods in Table 17.

---**[2]**

36(a). Some companies offer snack foods that contain a higher protein content than usual. 'Protein cookies' are an example of this kind of food. Some protein cookies contain up to 37 g of protein per cookie.

A student examined these foods by measuring the respiratory quotient (RQ) of maggots that were fed different types of cookie.

The student measured the oxygen consumption and carbon dioxide production of maggots when they were fed protein cookies and normal cookies.

The cookies were powdered and treated to remove all fat before being fed to the maggots.

Table 21 is a summary of the results.

Cookie	Carbon dioxide produced (cm^3 min^{-1})	Oxygen absorbed (cm^3 min^{-1})
1	13.29	13.56
2	13.04	13.87

Table 21

Use the information in Table 21 to deduce which of the two cookies is the protein cookie. Explain your choice.

---**[3]**

(b). The student then changed the experiment to investigate whether respiration of the cookies by yeast was different from respiration of the cookies by maggots.

The student planned to allow yeast cells and maggots to respire the cookie powder in anaerobic conditions and measure the RQ over 2 minutes.

State and explain **one** problem with the student's method.

---**[3]**

37. Honeypot ants belong to several different genera. Some specialised individuals are used as food storage vessels. These individuals have swollen abdomens that store various foods, which can be given to members of the colony when required.

One such individual is shown in Fig. 19.1.



Fig. 19.1

An investigation was carried out into the respiratory substrate of three different genera of honeypot ant, by measuring oxygen uptake and carbon dioxide production.

The data are shown in Table 19.1.

Genus	**CO_2 produced ($mm^3\ s^{-1}$)**	**O_2 produced ($mm^3\ s^{-1}$)**
Camponotus	0.89	0.88
Melophorus	0.59	0.66
Cataglyphis	1.01	1.47

Table 19.1

Use the data in Table 19.1 to suggest the likely diet of each genus of honeypot ant.

Justify your answer.

Genus	**Diet**	**Justification**
Camponotus	mainly carbohydrate	....
Melophorus	....	....
Cataglyphis	....	....

[3]

38. A person's RQ changes when they exercise.

Fig. 4.3 shows how RQ changes with the power a person exerts during exercise. Power, measured in watts (W), increases as the intensity of physical exercise increases.

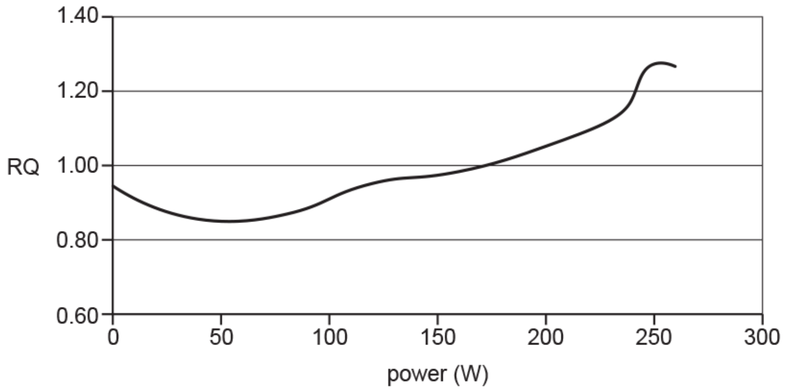


Fig. 4.3

What can you conclude about respiration at 0, 50 and 250 W based on the RQ values?

0 W____

____

50 W____

____

250 W____

____

[3]

39. A student investigated the effect of different sugars on the respiration rate in yeast.

The student wanted to study the effect of the different sugars on the rate of growth of a yeast population.

They used a colorimeter to measure the absorbance of a culture of yeast cells.

The absorbance of the yeast culture is proportional to the concentration of yeast cells.

As the yeast multiplied, it was necessary to dilute the sample to obtain a reading on the colorimeter.

i. Describe how the student could use 1 cm^3 pipettes and 10 cm^3 measuring cylinders to dilute the sample so that it was 10 000 times less concentrated.

_____

_____

_____

_____

_____

_____

_____

_____ **[3]**

ii. A light microscope can be used to observe yeast cells.

State the equipment that would be needed, in addition to a microscope, to measure the average diameter of yeast cells.

_____

_____ **[2]**

iii. The student prepared a starter culture using 2.5×10^{-3} g yeast cells in 1 dm^3 nutrient broth.

The average mass of a yeast cell is 2.0×10^{-11} g.

Calculate the number of cells in the starter culture.

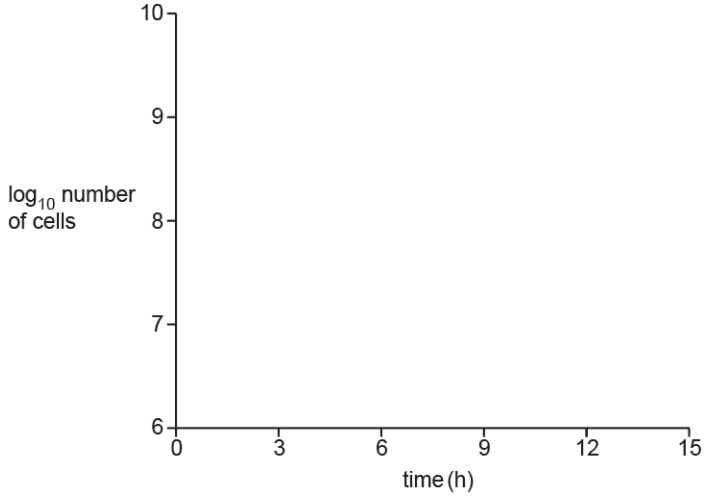
Give your answer in standard form.

number of cells = ... **[2]**

iv. The population of this yeast doubles every 90 minutes when growing under ideal conditions.

A different starter culture was prepared containing 1×10^7 cells.

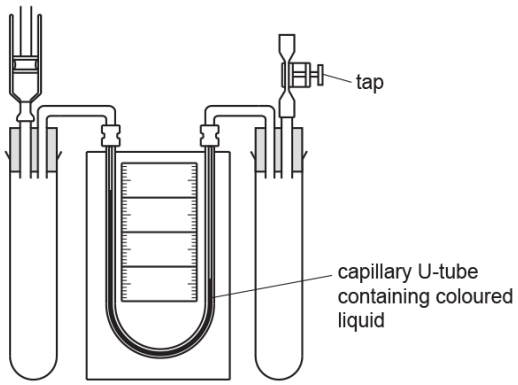
Use the axes below to sketch the growth curve you would expect for the yeast culture over the first 15 h.



[3]

40. A respirometer, shown below, can be used to investigate respiration.

A student placed 5 cm^3 of potassium hydroxide solution in the left-hand tube of the respirometer. The student suspended a basket above the liquid and placed 10 g of respiring seeds in the basket.



Which of the following statements about this investigation is **not** correct?

A The level of the liquid in the left-hand arm of the capillary tube would decrease (move downwards) with time.

B The potassium hydroxide solution absorbs carbon dioxide.

C The rate of movement of the liquid in the capillary tube is a measure of the rate of respiration.

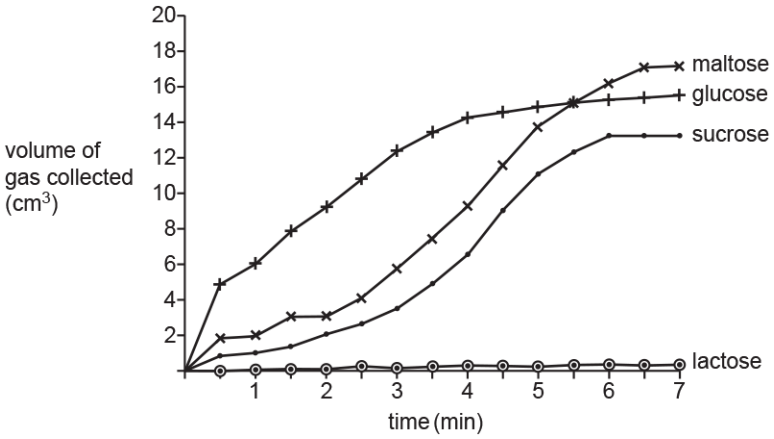
D The tap can be opened to equalise the pressure in each tube.

Your answer ☐

[1]

41(a). A student investigated the effect of different sugars on the respiration rate in yeast.

The student calculated mean values for each sugar and plotted the results on a graph. The graph is shown below.



i. Describe how the student could use the graph to calculate the rate of respiration for each type of sugar.

---

[3]

ii. * The student concluded the following from the graph:

- The rates of respiration with glucose, maltose and sucrose were very similar.
- The yeast could not hydrolyse disaccharides.

Evaluate the student's conclusions.

_____

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[6]

(b). The following procedure was used:

- Prepare a stock solution of yeast containing 10 g of dried yeast in 250 cm^3 of pH5 buffer.
- Prepare solutions of each sugar containing 5 g of sugar in 250 cm^3 of distilled water.
- Keep the yeast and sugar solutions in a water bath at 35 °C until required.
- Set up the apparatus with a 250 cm^3 conical flask connected by a rubber tube to a 100 cm^3 gas syringe.
- Add 25 cm^3 of yeast solution and 25 cm^3 of sugar solution to the flask, immediately connect the flask to the gas syringe and start the clock.
- Record the volume of gas produced after 30 s and then every 30 s for 7 min.
- Repeat the experiment 5 times for each different sugar.
- Prepare a fresh yeast solution for each set of sugars.

i. Describe **two** precautions the student should take between each experiment to ensure repeatable results.

1_ _

_ _

_ _

2_ _

_ _

_ _

[2]

ii. The student's procedure did not include a negative control.

Describe **one** negative control that the student could have used.

_____

_____**[1]**

Mark scheme - Respiration

11		i	mitochondrion	1	**ALLOW** mitochondria.
		ii	*either* facilitated diffusion (1) conversion of ornithine into citrulline creates concentration gradients **or** (molecules are not lipid soluble so) require protein channels to cross membrane (1) ***or*** active transport (1) ornithine and citrulline need to be moved into and out of **D** more quickly than would be met by diffusion (1)	2	
		iii	deamination / removal of NH_2 group from amino acid (1)	1	
		iv	ATP (1)	1	
			Total	**5**	
12	a		*idea that* the oxygen will leak from the connectors so reduce the gas movement (1) **or** oxygen uptake may not be a good representation of respiration rate in germinating seedlings (1) **or** a small volume of gas is being measured in the capillary (1) **or** measurements only taken every 30 seconds (1) **or**	1	**ALLOW** seal not air tight so will not prevent gas escaping during the experiment **or** *the idea* that gas leakage is a problem and needs to be prevented. **ALLOW** the respiratory substrate stored in the seed will affect the oxygen needed **or** the idea that if photosynthesis has begun oxygen uptake will be disrupted. **ALLOW** need to record the maximum volume of gas taken up during the experiment. **ALLOW** alternative wording e.g. 'more frequent readings are needed'.

			difficult to read the meniscus (may be subjective) (1)		
	b		*Variable* the mass of the seeds is not given (1) *Improvement* take the mass of the seedlings at the start (1) *Variable* the volume / mass of soda lime is not specified (1) *Improvement* use a known mass of soda lime each time (1) *Variable* the size of the syringe is not given (1) *Improvement* use a 2 cm^3 syringe (1) *Variable* the capillary tube internal diameter is not given (1) *Improvement* use a capillary tube of length 20 cm and a 1 mm internal diameter (1) *Variable* temperature not controlled (1) *Improvement* allowing apparatus to, stabilise / equilibrate to temperature, before taking readings (1) *AVP* (1)	2	The control method must be suitable, and be directly linked to the variable. **ALLOW** suggested mass values. **ALLOW** suggested mass values. **ALLOW** alternative size if suitable for the activity. **ALLOW** *idea that* only a linear measurement is obtained not a volume. **ALLOW** alternative size if suitable for the activity. **ALLOW** use of a water bath and thermometer to stabilise the temperature. Must be explicit to provide valid data e.g. no scale on the capillary tube, no timing, no details of how to take the readings. Details must be workable and suitable to provide valid results e.g. scale on the capillary tube, use of timing devices, description of how to take readings from the scale etc.
	c		dipped into a small beaker and allowed to run	1	**ALLOW** suitable details of how the red fluid is added.
	d		*Explanation* it is more than 10% from the mean **or** it is different from the other data at 60 seconds	2	**ALLOW** 'it is out of line'

			or it does not follow trend for the times for replicate 3 (1) *Action* anomaly should be identified and excluded from processing **or** anomaly must be identified but could be included in calculations **or** repetition to obtain another reading (1)		**ALLOW** 'it is out of line'
	e		0.36 mm s^{-1} (1)	1	Rate and units required for the mark.
	f	i	the internal diameter of the capillary tube (1)	1	
		ii	the mass of the bean seeds (1)	1	
	g		* **Level 3 (5–6 marks)** Describes a clear and detailed experiment that has been effectively adapted for use with chosen invertebrate to allow for the comparison of the rate of respiration with that of mung beans. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Describes an experiment to compare the rate of respiration of chosen invertebrate with mung beans but there is insufficient detail of the procedure to allow a valid comparison. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** An attempt to describe an experiment to investigate the respiratory rate of an invertebrate but little comparison with mung beans. If results or conclusion suggested, likely to be muddled or inaccurate.	6	**Relevant points include:** **experiment** • mass of invertebrate and mass of beans the same • safe and ethical use of invertebrates e.g. add screen so that animal(s) cannot touch the muslin bag • bigger syringe needed (5–10 cm^3) • keep temperature constant / same for both assays • keep light constant / same for both assays • use same mass of soda lime in both assays • measuring distance moved by coloured, red liquid at regular time intervals • repeat experiments. **results and conclusions** • invertebrates rate of respiration is expected to be higher than the rate of respiration of the beans *because* • invertebrates are moving around • metabolic processes require energy / generate heat.

			The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear. **0 marks** No response or no response worthy of credit.		
			Total	**15**	
13	a	i	fossils in, known-age / Jurassic, strata / rocks	1	
		ii	DNA / cytochrome c	1	
	b	i	carbon dioxide diffuses down concentration gradient out of the respiring cell (1) carried through body from cell (to tracheoles) by blood passing out via tracheoles / trachea / spiracles (1) respiration generates heat (1) hot gases expand and are less dense so rise up by convection through the mound to vents at mound-top (1)	4	
		ii	*shape,* large or increased surface area to volume ratio (1) smallest area exposed to greatest heat (1)	2	Response **must** be linked to context of avoiding overheating / needing to get rid of heat.
			Total	**8**	
14		i	increased volume of water added (to seedlings), leads to lower survival (of seedlings) ✓ larger decrease in survival for added water, above / from, 30 (cm^3) ✓ volume of water has no effect on number (of seedlings) surviving up to the first 3 days / AW ✓ quote data points / calculation(s) used, to support any point ✓	3 max	**ALLOW** the more water the faster they die **ALLOW** ora e.g. less / little, decrease in survival for 30(cm^3) and below **DO NOT ALLOW** at 30cm^3 minimum one pair of readings quoted for two water volumes (no units needed)

					Examiner's Comments In **Q18(b)(i)** most candidates stated the correct trend or correlation and this was often supported with relevant comparisons of two or more data points. Few went on to expand their response and, consequently, a large percentage of candidates failed to achieve maximum marks here.
		ii	Read through the whole answer from start to finish, concentrating on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance. Using a 'best-fit' approach based on the science content of the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme. Once the level is located, award the higher or lower mark. **The higher mark** should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met. **The lower mark** should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing. **In summary:** • **The science content determines the level.**	**6**	**Indicative scientific points may include…** **Aerobic respiration (A)** *Statement* **(S)** *The scientific statement can be implied by giving good scientific detail* • (No oxygen so) no aerobic respiration occurs *Further detail* **(D)** • No, link reaction / Kreb's cycle / ETC / oxidative phosphorylation

			• **The communication statement determines the mark within a level.** **Level 3 (5–6 marks)** A detailed scientific statement about aerobic respiration **AND a** detailed scientific statement about anaerobic respiration **AND** more than one scientific consequence for the plant of overwatering *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** A detailed scientific statement about either aerobic or anaerobic respiration **AND** a scientific consequence for the plant of overwatering *There is a line of reasoning presented with some structure.* *The information presented in the most part relevant and supported by some evidence.* **Level 1 (1–2 marks)** A statement about either aerobic or anaerobic respiration **AND** a scientific consequence for the plant of overwatering *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant and correct.* **0 marks** No response or no response worthy of credit.		• No oxygen to act as the final, electron / hydrogen acceptor **Anaerobic respiration (An)** *Statement* **(S)** *The scientific statement can be implied by giving good scientific detail* • (Plant has to) switch to anaerobic respiration / only anaerobic respiration can occur *Further detail* **(D)** • Only glycolysis occurs • Alcoholic fermentation occurs • NAD regenerated (for glycolysis) • Pyruvate to ethanal to ethanol • Named enzyme e.g. pyruvate decarboxylase • (Only) 2 ATP **Scientific consequences for the plant(C)** • ethanol is toxic • (alcoholic fermentation) is irreversible • Less ATP produced / only 2 ATP from glycolysis • Less / no, active transport • (root hair cells) cannot take up mineral ions (by active transport) • so (plant) cannot make, proteins / amino acids / DNA / chlorophyll etc • cannot generate water potential gradient (into roots) / water potential (in root hair cells) is too high • water cannot be absorbed (so cells cannot remain turgid) • less / no, photosynthesis

					Examiner's Comments **Q18(b)(ii) Level of Response** Examiners reported that there were some excellent responses to this question. In such responses, candidates demonstrated the ability to discuss the consequences of lack of oxygen on both aerobic and anaerobic respiration. Details included a relevant discussion of the different 8 stages of aerobic respiration i.e. link reaction, Krebs cycle or oxidative phosphorylation, with some candidates starting their explanation with the statement *'there would be no oxygen to act as the final electron acceptor'*. Although stronger candidates also gave good detail about anaerobic respiration, generally this was not quite as well expressed. Candidates who referred to the lactate pathway were still able to gain the top level as some plants do use this mechanism. Candidates were often able to state that only glycolysis would be able to occur to produce small quantities of ATP and that NAD would be regenerated but detail about the pyruvate to ethanol pathway was seen less often. To obtain a Level 3 answer, candidates needed to talk about two consequences of the lack of oxygen to the plant and this proved problematic for candidates, as it required them to bring together a variety of different ideas from the A Level course. Many did know that ethanol is toxic, and that less ATP would be produced overall. The best answers included references to a reduction in active transport and the consequences of this on mineral uptake. Candidates who achieved Level 2 were often able to give a great deal of detail about aerobic respiration but were not able to provide the same level of detail about anaerobic respiration and were only able to give one consequence to the plant. Level 1 candidates gave a simple statement such as, *'with no oxygen the plant cannot carry out aerobic respiration'*. Candidates who did not also give a consequence did not pick up any marks. In general, candidates presented good lines of reasoning with structure, so many were able to achieve the higher mark within each level.
			Total	**9**	

15		i	length / size , similar to that of a bacterium ✓ contain (circular) DNA ✓ contain (70S / small / 20nm) ribosomes ✓ (may) have plasmids ✓ have double membrane ✓	max 2 (AO3.2) (AO2.1)	**If more than two responses given:** mark **first** response on each prompt line. If responses on first prompt line and nothing on second line then mark first **two** on first prompt line
		ii	*cells with mitochondria / early eukaryotes* **1** would be able to respire aerobically ✓ **2** (this) produces more ATP ✓ **3** ATP needed for , active transport / cell division / protein synthesis / DNA replication ✓ **4** more ATP allows faster metabolic , processes / reactions ✓	3 (AO2.1)	**Assume for cells with mitochondria** **Only need to mention ATP once** **ALLOW ORA** for cells without mitochondria for **MPs 1, 2, 4** **ALLOW** releases more energy **DO NOT ALLOW** 'produces' energy **IGNORE** growth **ALLOW** more ATP so can meet higher metabolic demand
			Total	**5**	
16		i	adenine ✓	1 (AO2.1)	**DO NOT ALLOW** adenosine **IGNORE** nitrogenous base / purine
		ii	hydrolysis ✓	1 (AO2.1)	**IGNORE** dephosphorylation
		iii	because ATP is , broken down / hydrolysed (to ADP) ✓ ATP is constantly recycled ✓ ATP used to provide energy for , (named) metabolic reactions / processes ✓ ATP is , not stored long term / used immediately ✓	max 2 (AO2.1)	**ALLOW** ATP is unstable **ALLOW** constant interconversion of ATP and ADP (+Pi) **ALLOW** ATP produced is coupled to metabolic reactions **IGNORE** used for respiration unqualified **ALLOW** ATP is used as fast as it is produced
			Total	**4**	
17	a		contain / location of , (named) electron carriers / ETC / ATP synth(et)ase / proton pumps ✓ (provide , site / location / surface) for , chemiosmosis / ATP synthesis / oxidative phosphorylation ✓ allow , formation / maintenance , of , H+ / proton / hydrogen ion , gradient ✓	max 2 (AO1.1)	**Mark as continuous prose**

			outer membrane is highly permeable to allow movement of (named) molecules ✓		
	b	i	transmission electron (microscope) ✓	1 (AO2.1)	**ALLOW** TEM, 'microscopy' for 'microscope'
		ii	**M** = matrix ✓ **N** = crista(e) ✓	2 (AO1.1)	**ALLOW** inner membrane for **N**
			Total	**5**	
18			mitochondria / mitochondrion	1 (AO2.5)	
			Total	**1**	
19		i	**U** matrix ✓ **W** crista(e) / <u>inner</u> (mitochondrial) membrane ✓ **Z** <u>inter</u>-membrane space ✓	**3**	**IGNORE** ETC / ATP synthase / cytochromes **ALLOW** <u>inter</u>-membranal space **Examiner's Comments** **Q19(c)(i)** was generally well-answered although some candidates failed to interpret the diagram correctly and gave totally irrelevant structures as their answers. The most common mistake was failing to identify the inter-membrane space or referring to it as the inner-membrane space.
		ii	cyanide, prevents / AW, aerobic respiration **AND** fluoride, prevents / AW, anaerobic respiration (which also prevents aerobic respiration) ✓	**1**	*BOTH statements required for one mark* **IGNORE** 'affects' throughout **ALLOW** link reaction / Krebs cycle / ETC / oxidative phosphorylation instead of aerobic respiration **ALLOW** cyanide allows, glycolysis / anaerobic respiration **ALLOW** prevents, all respiration / both stages of respiration **IGNORE** lactate fermentation **Examiner's CommentsQ19(c)(ii)** saw some strong responses with candidates using data to support their answer even though it was not required. Weaker candidates gave vague answers about how fluoride and cyanide 'affected' respiration or repeated the

					information in the table without attempting a conclusion.
			Total	**4**	
20			2 (ATP molecules per glucose) from, glycolysis / (breakdown of) triose (bis)phosphate ✓ (when) triose (bis)phosphate / TP, converted / broken down, to pyruvate ✓ *ref to* net yield of 2 (ATP) / 4 (ATP) made but 2 used up (in glycolysis) ✓ 1 ATP (produced) per, (turn of the) Krebs cycle / acetyl (coA) ✓ when 5-carbon compound is converted to, 4-carbon compound / oxaloacetate ✓	**4 max**	**ALLOW** '4 ATP made from 2 TP's' 'net yield of 2 ATP's in glycolysis' = mp1 and 3 for 2 marks **ALLOW** 2ATP, per glucose in Krebs cycle / from every 2 acetyl (coA) **ALLOW** 'when citrate converted to oxaloacetate' **ALLOW** 'when succinyl CoA converted into succinate' **ALLOW** 'between (intermediate) 4C compounds' **Examiner's Comments** The production of ATP by substrate level phosphorylation was well understood by many. Candidates began their answer by stating that there would be a net production of 2ATP in glycolysis, or that 4 ATP would be produced but 2 were used up at the start. While many referred to triose phosphate being the source of phosphate, few then added that TP would be converted to pyruvate. Many candidates were unclear as to how many ATP would be generated in Krebs' cycle although higher ability ones commented that one ATP would be made per turn of the cycle, or two per molecule of glucose. Some correctly described where in the cycle ATP would be made while others thought it would be between citrate and the 5C compound, or at multiple points in the cycle. Some candidates believed that ATP would be produced in the link reaction and many

<table>
<tr><td></td><td></td><td></td><td></td><td></td><td>went on to describe oxidative phosphorylation , which gained no credit.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>4</td><td></td></tr>
<tr><td>21</td><td></td><td>i</td><td>glycolysis / anaerobic respiration, can continue / AW✓

because, conversion of glucose to TP is not needed / lactate inhibition is irrelevant / AW ✓

ATP is produced when TP is converted to pyruvate ✓</td><td>2 max
(AO2.6)</td><td>IGNORE lactate pathway
ALLOW description of glycolysis

e.g. 'enzymes needed to convert fructose to triose phosphate are not inhibited by lactate'

<u>Examiner’s Comments</u>

Candidates often referred to glycolysis being able to continue, though only a few explained that the alternative pathway would be inhibited by lactate, or that the conversion of TP to pyruvate would yield ATP.</td></tr>
<tr><td></td><td></td><td>ii</td><td>low body temperature / slow metabolic rate ✓

less energy is spent on thermoregulation ✓</td><td>1 max
(AO2.1)</td><td>ALLOW low metabolic rate / fewer metabolic reactions

ALLOW other plausible physiological adaptations e.g. more <u>creatine</u> phosphate stores / more able to buffer H^+ ions / more myoglobin / Hb has higher affinity for oxygen / dissociation curve shifted to left / bradycardia / more erythrocytes

<u>Examiner’s Comments</u>

This question was not well answered by the majority of candidates with many relating this to SA:V ratios or the idea of size. Most correct responses identified the slow metabolic rate of the mole rat, with few using the information gained at the start of the question to state that mole rats spend less energy on thermoregulation.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>3</td><td></td></tr>
<tr><td>22</td><td></td><td>i</td><td><table><tr><td>Description of amino acid amino acid</td><td>Name of Justification</td><td></td></tr><tr><td>Converted to pyruvate with the</td><td>Alanine</td><td>(Both have) 3 carbon</td></tr></table></td><td>4
(AO3.1)</td><td>ALLOW (both have) 3C atoms
DO NOT ALLOW ‘same number of C and, H / O, atoms’</td></tr>
</table>

<table>
<tr>
<td></td><td></td><td></td>
<td>
<table>
<tr><td>fewest changes</td><td></td><td>atoms / Same number of carbon atoms</td></tr>
<tr><td>Converted to alpha-ketoglutarate with the fewest changes</td><td>Glutamic acid</td><td>(Both have) 5 carbon atoms / Same number of carbon atoms</td></tr>
<tr><td>The amino acid with the highest respiratory quotient (RQ)</td><td>Aspartic acid</td><td>Highest proportion of oxygen atoms (in its structure) / lowest proportion of C-H bonds (relative to other bonds)</td></tr>
</table>
First row correct ✓
Second row correct ✓
Aspartic acid ✓
Aspartic acid explanation ✓
</td>
<td></td>
<td>IGNORE ‘both have 2 carboxyl groups’

ALLOW (both have) 5C atoms
DO NOT ALLOW ‘same number of C and, H / O, atoms’</td>
</tr>
<tr>
<td></td><td></td><td>ii</td>
<td>decarboxylation / carbon dioxide produced ✓
dehydrogenation / hydrogen removal / reduced NAD produced / reduced FAD produced✓
ATP produced ✓
succinyl co-A / succinate / fumarate / malate / 4 C intermediate, produced ✓</td>
<td>2 max
(AO1.2)
(AO2.5)</td>
<td>ALLOW mp’s from correct equations</td>
</tr>
<tr>
<td></td><td></td><td></td><td>Total</td><td>6</td><td></td>
</tr>
<tr>
<td>23</td><td></td><td></td><td>B</td><td>1
(AO1.1)</td><td></td>
</tr>
<tr>
<td></td><td></td><td></td><td>Total</td><td>1</td><td></td>
</tr>
</table>

24			matrix of mitochondrion	1	**ALLOW** mitochondria
			Total	**1**	
25		i	12.5 /13 (%) ✓	**1**	• 16 carbon atoms in the fatty acid • 2 carbon atoms in acetyl CoA (which enters the Krebs cycle) • 2/16 x 100 = 12.5% **Examiner's Comments** The percentage of carbon atoms of palmitoyl CoA entering the Krebs cycle was frequently incorrectly calculated, with many candidates failing to read the question and thus stating 100% for complete oxidation. Few appreciated that in Figure 2, only two of the 16 carbon atoms would enter the Krebs cycle, giving a percentage of 12.5. Many divided a seemly arbitrary number by 16.
		ii	67(%) **AND** (the link reaction is) more efficient✓ **Examiner's Comments** The calculation of the efficiency of the link reaction was also often incorrect, with candidates giving an array of different answers. Higher ability candidates provided the correct answer of 67% and then stated that the link reaction would be more efficient than beta oxidation.	**1**	**ALLOW** 66.6· / 66.667 / 66.67 / 66.7 (%) **DO NOT ALLOW** 66.6 (incorrect rounding) • acetyl CoA (2 carbon atoms) is produced from pyruvate (3 carbon atoms) in the link reaction • 2/3 x 100 = 67 % **ALLOW** ECF if the answer to (i) is greater than 66.7% and 'less efficient' has been written ***OR*** if the answer to (i) is 66.7% and 'equally efficient' has been written if NR or no answer given in (i) then 1 mark for correct efficiency calculation and **IGNORE** efficiency statement **Examiner's Comments** The role of co-enzymes in beta oxidation was well understood by many candidates, with comments such as NAD/FAD would act as hydrogen acceptors or transfer hydrogen atoms. Some also stated that the carriers

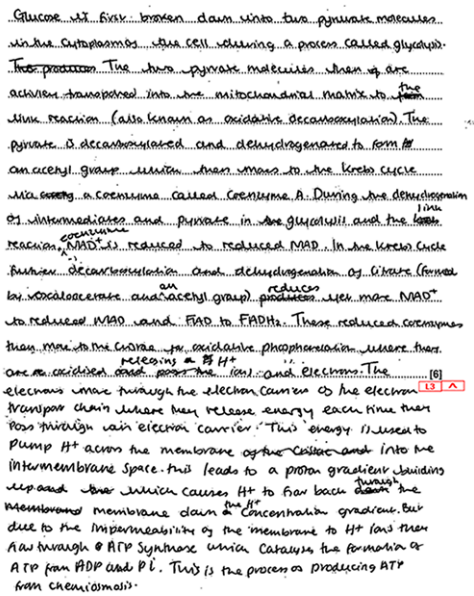
					would become reduced. Common errors included the co-enzymes simply removing hydrogen atoms, rather than accepting or transporting them, or an incorrect reference to hydrogen ions or molecules.
		iii	(FAD/NAD) accepts / is reduced by/ transfers / AW, hydrogen (atoms) ✓	**1**	**DO NOT ALLOW** hydrogen, ions / molecules **ALLOW** 'carries / transports / picks up, hydrogens' **IGNORE** 'removes, hydrogens'
			Total	**3**	
26		i	**K** acetyl group (of CoA) (1) **L** citrate (1) **M** carbon dioxide / CO_2 (1) **N** oxaloacetate (1)	4	**ALLOW** acetate
		ii	**Q** substrate level phosphorylation (1)	1	
			Total	**5**	
27			* Read through the whole answer from start to finish, concentrating on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance. Using a 'best-fit' approach based on the science content of the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme. Once the level is located, award the higher or lower mark. **The higher mark** should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met.	6	**Indicative scientific points may include…** • Coenzyme A: o transfers acetyl / acetate / 2C from link reaction to Krebs cycle • ADP/ATP: o phosphorylation of / addition of phosphate group to, glucose to form hexose-1, 6-bisphosphate in glycolysis o dephosphorylation of / removal of phosphate group from, TP in glycolysis o dephosphorylation of / removal of phosphate group from, intermediate in Krebs cycle o formation from substrate level phosphorylation o formation from oxidative phosphorylation, harnessing chemical energy from chemiosmosis / proton motive force

			The lower mark should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.
			
			In summary:
			
			• **The science content determines the level.**
			• **The communication statement determines the mark within a level.**
			
			Level 3 (5–6 marks)
			A full and detailed summary of the role of the different coenzymes in respiration, including their importance in processes that link together the component stages.
			
			There is a well-developed line of reasoning which is clear and logically structured. The processes are detailed and clearly explained.
			
			Level 2 (3–4 marks)
			A clear summary of the role of coenzymes in respiration is present, including some discussion of their involvement with various processes in the component stages.
			
			There is a line of reasoning presented with some structure. The processes have some detail and are explained generally well.
			
			Level 1 (1–2 marks)
			A limited summary of the role of some of the coenzymes in respiration is present, including some discussion of their involvement with process(es) in the component stages.
			
			There is a logical structure to the answer. The explanation, though basic, is clear.
			
			0 marks
					• NAD:
					  ○ oxidation of / removal of H / removal of electrons from, triose (bis)phosphate in glycolysis
					  ○ oxidation of / removal of H / removal of electrons from, pyruvate in link reaction
					  ○ oxidation of / removal of H / removal of electrons from, intermediates in Krebs cycle
					  ○ reduction of / addition of electrons to, electron transport chain / cytochrome in oxidative phosphorylation
					  ○ reduction of / addition of electrons to, pyruvate in lactate fermentation
					  ○ reduction of / addition of electrons to, ethanal in alcoholic fermentation
					• FAD:
					  ○ oxidation of / removal of H / removal of electrons from, intermediates in Krebs cycle

			No response or no response worthy of credit.		
			Total	**6**	
28	a		***Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.*** *Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.)* *Using a 'best-fit ' approach based on the science content of the answer, first decide which of the level descriptors,* ***Level 1****,* ***Level 2*** *or* ***Level 3****, best describes the overall quality of the answer.* *Then, award the higher or lower mark within the level, according to the* ***Communication Statement*** *(shown in italics):* • *award the higher mark where the Communication Statement has been met.* • *award the lower mark where aspects of the Communication Statement have been missed.* ***In summary:*** • ***The science content determines the level.*** • ***The Communication Statement determines the mark within a level.*** **Level 3 (5–6 marks)** Full and detailed explanation of how increased proton channels in inner mitochondrial membranes results in less likelihood of fat deposition in the body. Learner demonstrates a detailed understanding of the different processes involved and explains their implications. *There is a well-developed line of*	• 6	**Indicative scientific points may include…** • larger number of protons pores results in protons leaking back into matrix • reduces yield of ATP from chemiosmotic gradients • less ATP is made from oxidative phosphorylation • more energy wasted as heat

			reasoning supported by clear scientific detail. The information presented is relevant and clearly explained. **Level 2 (3–4 marks)** Generally clear explanation of how increased proton channels in inner mitochondrial membranes results in less likelihood of fat deposition in the body. Learner demonstrates a reasonable understanding of the different processes involved and explains their implications. *There is an attempt at a line of reasoning supported by some scientific detail. The information presented is largely relevant and clearly explained.* **Level 1 (1–2 marks)** Limited explanation of how increased proton channels in inner mitochondrial membranes results in less likelihood of fat deposition in the body. Learner demonstrates a limited understanding of the different processes involved and explains their implications. *There is little attempt at a line of reasoning supported by basic scientific detail. The information presented may be unclear and lack organisation.* **0 marks** No response or no response worthy of credit.		• energy from chemiosmosis decoupled from ATP synthesis • energy yield from aerobic respiration reduced per molecule of glucose • food not converted to ATP as efficiently • less excess energy intake in diet • less deposition of fat • fat stores may be respired for energy
	b	i	**U** ATP synthase ✓ **Q** electron carrier ✓	2	**ALLOW** ATP synthetase / F1 complex **ALLOW** cytochrome / proton pump
		ii	**P** inter-membrane space ✓ **S** matrix ✓	2	
		iii	**R** Krebs cycle ✓ **T** ATP synthesis ✓	2	**ALLOW** citric acid / tricarboxylic acid / TCA
	c	i	(mostly) impermeable to H^+ ions / protons ✓ large surface area ✓	2 max	**DO NOT ALLOW** H / hydrogen

			presence of, ATP synthase / stalked particles ✓		**IGNORE** ETC / cytochromes
		ii	pH decreases **AND** becomes more positive(ly charged) ✓	1	
			Total	**15**	
29			***In summary:*** *Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.)* *Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors,* ***Level 1****,* ***Level 2*** *or* ***Level 3****, best describes the overall quality of the answer.* *Then, award the higher or lower mark within the level, according to the* ***Communication Statement*** *(shown in italics):* ◦ award the higher mark where the Communication Statement has been met. ◦ award the lower mark where aspects of the Communication Statement have been missed. • **The science content determines the level.** • **The Communication Statement determines the mark within a level.** **Level 3 (5–6 marks)** Full and detailed description of the processes involved in chemiosmosis. Learner demonstrates a detailed understanding of where it occurs, the stages, reactants and products, describing a range of the processes involved. *There is a well-developed line of reasoning with accurate descriptions of the processes. The information presented is relevant and clearly outlined.*	6	**Indicative scientific points may include…** These are not mark points **See appendix** • occurs in mitochondria / on membrane • involves inner membrane and matrix • involves movement of hydrogen across membrane • use of enzyme / channel protein / ATP synthase • Hydrogen ions / H^+ ions pumped out of matrix across membrane into intermembrane space • Proton / H^+ gradient created • proton-motive force • H^+ ions pass through hydrophilic transmembrane protein • cristae / stalked particles involved • ATP synthase produces ATP from ADP + Pi • H^+ ions move from area of high concentration to low concentration • Some H^+ ions leak back into matrix / process is not completely efficient **<u>Examiner's Comments</u>** This Level of Response question assessed AO1 in the context of chemiosmosis. There were some excellent responses with candidates across the ability range demonstrating their ability to recall the process of chemiosmosis, the molecules involved and where in the cell it takes place. Many candidates followed the prompt in the question stem and referred only to

			Level 2 (3–4 marks) Detailed description of the processes involved in chemiosmosis. Learner demonstrates understanding of the where it occurs, stages, reactants and products, describing some of the processes involved. *There is a line of reasoning with accurate descriptions of the processes. The information presented is in the most-part relevant and supported by some detail.* **Level 1 (1–2 marks)** A description of the processes involved in chemiosmosis is attempted, with some understanding of the different stages, reactants and products. *The information is basic and communicated in an unstructured way. The information is supported by limited detail which may be unclear.* **0 marks** No response or no response worthy of credit. **NR** No response		chemiosmosis. Some candidates wrote extended responses including all stages of aerobic respiration which was not required and so were credited the lower mark within the level for their communication statement. There were some common errors seen in lower attaining responses which included mixing up the structures of mitochondria and chloroplasts and confusion about whether it was electrons or protons moving through the electron transport chain or ATP synthase. **Exemplar 4**  Glucose is first broken down into two pyruvate molecules in the cytoplasm of the cell releasing a process called glycolysis. The two pyruvate molecules then are actively transported into the mitochondrial matrix to the link reaction (also known as oxidative decarboxylation). The pyruvate is decarboxylated and dehydrogenated to form an acetyl group which then moves to the krebs cycle via coenzyme a coenzyme called Coenzyme A. During the dehydrogenation of intermediates and pyruvate in the glycolysis and the link reaction, coenzyme NAD^+ (s) reduced to reduced NAD. In the krebs cycle further decarboxylation and dehydrogenation of citrate (formed by oxaloacetate and acetyl group) produces an reduces more NAD^+ to reduced NAD and FAD to $FADH_2$. These reduced coenzymes then move to the cristae for oxidative phosphorylation where they are oxidised releasing a H^+ ion and electrons. The [6] electrons move through the electron carriers of the electron transport chain where they release energy each time they pass through an electron carrier. This energy is used to pump H^+ across the membrane of the cristae and into the intermembrane space. this leads to a proton gradient (building up) that which causes H^+ to flow back down through the membrane down a concentration gradient. but due to the impermeability of the membrane to H^+ ions they flow through ATP synthase which catalyses the formation of ATP from ADP and Pi. This is the process producing ATP from chemiosmosis. This exemplar shows an excellent Level 3 response for science content. The candidate has been credited with the lower mark within the level as over half of the response contains irrelevant detail about other stages in aerobic respiration which was not required.
			Total	**6**	
30			*idea of* establishment of H+ ion gradient ✓ H^+ ions, flow down a concentration gradient / AW ✓ from intermembrane space to matrix ✓ through ATP synthase ✓	3 max (AO1.1)	e.g. ' pumping protons into intermembranal space' **DO NOT ALLOW** 'H^+ ions pumped (from intermembrane space / through ATP synthase) **DO NOT ALLOW** 'energy produced to join ADP and Pi'

			energy, provided / AW, to join ADP and Pi (to form ATP) ✓		
			Total	**3**	
31	a		5 ✓✓✓	**3**	*If no definitive answer given in Table 20, look in space above for working and / or answer.* **ALLOW** 3, 4, 5 **OR** 6 to correct SF for **3 marks** **ALLOW 3**, 4, 5 **OR** 6 to incorrect SF for **2 marks** **ALLOW** 2 **OR** 7 to correct SF for **2 marks** **ALLOW** 2 **OR** 7 to incorrect SF for **1 mark** **ALLOW** any other figure to correct SF for **1 mark** any other figure to incorrect SF = **0 marks** If no marks awarded from above, look for the following evidence of working for **1 mark** mean / $\bar{x}$ = 30 **OR** Σ = 228 **OR** $s = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$ $\sqrt{\frac{\sum(X - \bar{X})^2}{N}}$ **OR** **Examiner's Comments** In **Q20(a)** it was pleasing to see some candidates remembering the formula for standard deviation (SD), despite this not being a requirement of the specification, and completing the calculation correctly. A few candidates appear to have estimated the SD by looking at the SD calculated for the other sets of data, or using the SD function on their calculators to elicit an answer. Overall many candidates were awarded maximum marks by either calculating the correct answer **5**, or estimating it would be somewhere between **3** and **6**. Bearing in mind that candidates were told to give their response to one significant figure, Examiners noted that some candidates gave responses

					to two or more significant figures. A proportion of candidates who had not given a final answer were credited with one mark for calculating the mean. However, there were quite a few candidates who understandably did not attempt the question in the absence of the formula, which should have been included.
	b		SD bars plotted correctly for the first four yeast species above and below the mean. ✓✓	**2**	*A correctly plotted SD bar is an accurately drawn vertical line. If the top and bottom of the line are capped, accept only the following symbols* —, X, ⊙ **IGNORE** *A. pullulans* (both columns) **ALLOW** one complete SD bar incorrect **For one mark** Four, five or six complete correct SD bars **Examiner's Comments** Candidates did not require an answer to Q20(a) in order to achieve full marks for **Q20(b)**, however those that did were in the minority. When the bars were plotted they were usually correct, though some candidates plotted the bars thinking the standard deviation was the total length of the bar rather than the length each side of the mean, resulting in the bars being half the required length. Some candidates appeared to have little knowledge of what an error bar should look like and plotted the SD as a number and even sometimes drew a line between points at the base of the graph or drew them as an extra bar. It is worth noting that a number of candidates who drew more conventional error bars would have lost marks had there been a requirement to use a ruler as there were some very poor freehand lines. Some candidates were unsure how to cap the line but the crosses and circles added rarely interfered with the accuracy of the plot.
	c		61.54 (%)	**3**	**IGNORE** + or - signs **ALLOW for two marks** *correctly calculated answer not to 4 SF* e.g. 61.538 / 61.5

			OR 70.20 (%) *(calculated from Table 20)* ✓✓✓		e.g. 70.198 / 70.2 **ALLOW for one mark** *evidence of a correct calculation* e.g. $\frac{21-13}{13} \times 100$ **OR** $\frac{21.417-12.583}{12.583} \times 100$ **Examiner's Comments** As the question stem for **Q20(c)** did not guide candidates to use Fig. 20 to access the means some picked a different route and used the figures from Table 20 in their calculations. Both routes could access three marks with 61.54% the most commonly seen correct response. Some candidates lost marks for errors of arithmetic or rounding whilst others that gave the correct number of significant figures in other questions occasionally failed to do so here. Percentage change for the wrong yeast species was seen and, unfortunately, many candidates incorrectly calculated from aerobic to anaerobic giving the incorrect response of 38.10%. A number of candidates also made the mistake of dividing the actual value of the anaerobic CO_2 production rather than the difference between the two values.
	d	i	**1** *incorrect because* *A. pullulans* / one yeast (species), produced more CO_2 in anaerobic conditions ✓ **2** *incorrect because* error bars / standard deviations, overlap ✓	**2**	**ALLOW** no *t*-test carried out **DO NOT ALLOW** range bars **Examiner's Comments** In **20(d)(i)** the majority of candidates identified the first statement as incorrect and went on to give the correct reason that *A. pullulans* produced more CO_2 in anaerobic conditions. Most candidates did identify the second statement as incorrect but only stronger candidates stated that it was incorrect because of the standard deviation overlap or that a statistical test was not carried out. Only stronger candidates grasped the fact that for error to be random the SDs must be wide-ranging thereby gaining credit in

					Q20(d)(ii). Most candidates cited some aspect of the methodology as being inaccurate as evidence for their answer or limitations of equipment rather than reflecting on the results.
		ii	random error (because) some (experiments / yeast species / columns on chart with) large SDs / error bars ✓	**1**	**DO NOT ALLOW** standard error **DO NOT ALLOW** range bars **Examiner's Comments** In **20(d)(i)** the majority of candidates identified the first statement as incorrect and went on to give the correct reason that *A. pullulans* produced more CO_2 in anaerobic conditions. Most candidates did identify the second statement as incorrect but only stronger candidates stated that it was incorrect because of the standard deviation overlap or that a statistical test was not carried out. Only stronger candidates grasped the fact that for error to be random the SDs must be wide-ranging thereby gaining credit in **Q20(d)(ii)**. Most candidates cited some aspect of the methodology as being inaccurate as evidence for their answer or limitations of equipment rather than reflecting on the results.
	e		ribosome(s) ✓	**1**	**ALLOW** <u>rough</u> endoplasmic reticulum / RER **Examiner's Comments** **Q20(e)** was generally well-answered with only a few incorrect responses seen, the most common being Golgi apparatus or nucleus.
			Total	**12**	
32		i	1. (at start) respiration is <u>anaerobic</u> / glucose converted into ethanol✓ 2. respiration, decreases rapidly / stops , once glucose used up ✓ 3. ethanol used (as a carbon source) once glucose has been consumed ✓ 4. aerobic respiration (of ethanol) ✓	**3 max**	**ACCEPT** oxygen is needed for the

			5. (because) acetyl Co A used in Krebs cycle ✓ 6. respiration stops when, ethanol / respiratory substrate, has been used up ✓		metabolism of ethanol **Examiner's Comments** This question proved to be a good discriminator. This was a difficult graph to interpret and some candidates were confused in their answers. There were numerous responses based entirely on recall of aerobic respiration followed by anaerobic respiration when yeast is used to produce ethanol. Candidates seemed quite happy to ignore or misrepresent the evidence of the graph to fit with their preconceptions. Good candidates just looked at the evidence and drew the correct if unfamiliar conclusion, which was that anaerobic respiration was followed by aerobic respiration. Weaker candidates did not get to grips with the idea that glucose was used as a respiratory substrate at first, and then ethanol. Neither did they link that with the type of respiration. Weaker candidates often gave a detailed description of the graph, quoting data in great detail, but did not mention the type of respiration occurring rather taking the approach of manipulating data, which gained no credit.
		ii	(use) aseptic techniques / avoid contamination ✓ provide (sources of) nutrients / respiratory substrates ✓ (incubate at) suitable temperature ✓ use (pH) buffer ✓ agitation / stirring / shaking ✓	**2 max**	**Mark first two suggestions given** **ACCEPT** a description of an aseptic technique **ACCEPT** sterile techniques **ACCEPT** a specific example of a nutrient **ACCEPT** optimum temperature / right temperature /a specific, appropriate temperature (15 – 35°C) **IGNORE** keep temperature constant / low temperature/ monitor temperature / control temperature **ACCEPT** maintain optimum pH / right pH /a specific, appropriate pH (4–7) **IGNORE** keep pH constant / monitor pH / control pH **ACCEPT** mixing

					IGNORE ref to aeration / oxygen supply / sparging **Examiner's Comments** This was well answered on the whole, and many candidates scored two marks. The majority of candidates got two marks for mentioning the use of aseptic techniques and mark point 3 or 4 for the use of optimum temperature or optimum pH. Some candidates stated control temperature and pH rather than the idea that these factors needed to be suitable for the yeast, and it was disappointing to see that some candidates suggested that the 'culture' should be sterilised, which gained no credit.
		iii	3.75 ✓ x 10^5 ✓	**2**	**One mark** awarded for a correct calculation with the wrong number of significant figures or not in standard form (e.g. 375000 , 375 x 10^3 ,3.8 x10^5) **Examiner's Comments** Many candidates had trouble with this calculation. It was clear which candidates had been taught how to calculate population numbers in relation to dilutions. However, a large proportion of the candidates then failed to give their answer in standard form or to three significant figures, and so only gained one mark. It is important that centres make sure that candidates know how to calculate serial dilutions and are able to put their answer into standard form and the correct number of significant figures. Some candidates were able to work out that there were 150 bacteria in 1 ml of 10^{-2} dilution, but then got confused and were unable to convert this to 15000 in 1 ml of original culture and hence then calculate 15000 x 25 = 375000 (3.75 x 10^5) in 25 cm^3 of the original culture.
		iv	*Yes because…* a suitable, range / intervals, of temperatures have been chosen ✓	**3 max**	**Max 2 for statements supporting only one view** **IGNORE** large / wide, range of temperatures

			volume controlled ✓ temperature , controlled / maintained ✓ repeats, to identify anomalies / outliers ✓ same yeast suspension used ✓ *No because…* availability of, oxygen/ nutrients / yeast concentration, not controlled ✓ pH is not be controlled at start of experiment ✓ *idea of* pH change would not be an accurate measure of respiration rate ✓ no time reference (to calculate rate) ✓ no control (sample) ✓		**IGNORE** repeats exclude anomalies **ACCEPT** 'better to collect (volume of) carbon dioxide produced' / 'It is better to use a respirometer' (implies pH change not accurate) 'because some CO_2 would diffuse into the air' **Examiner's Comments** Many candidates scored well on this question and it was good to see how many realised that using a pH probe is not an accurate way to measure respiration rate. However, some candidates used very vague language, such as 'a range of temperatures' without qualification, and a sizeable proportion gave only 'yes, because…' or 'no, because…' answers, obviously not understanding the significance of term 'evaluate'. Candidates need to be taught that when asked to evaluate they need to put arguments for and against. Weaker candidates suggested that pH needed controlling which showed a lack of understanding of the question. A number also did not get mp 4 under the Yes section because they did not mention that by doing repeats one can help to identify the anomaly. Instead they went one step further and were mentioning removing the anomaly or discarding it in order to calculate the mean.
		v	difference (between the means), is not significant / can be explained by chance (at p = 0.05) ✓	**1**	**ACCEPT** null hypothesis / H_o, can be accepted **DO NOT ACCEPT** null hypothesis / H_o can be rejected **ACCEPT** the results are not significantly different (p = 0.05) **Examiner's Comments** This was well answered, showing that many

					candidates seem to understand how to interpret statistical calculated values. It was clear that many candidates had been taught this basic statistical test and what it showed. However a significant number of students still gave confusing answers and failed to understand that if the *t* value is less than the critical value at p = 0.05, the null hypothesis should be accepted and there is no significant difference. They often confused results not being significantly different with the null hypothesis being rejected so they ended up getting no marks. Very weak candidates just stated that the results were not different. The words significant or different were missing from the responses.
			Total	**11**	
33		i	it (only) respires in the absence of oxygen	1	Must imply that the absence of oxygen is the preferred / essential condition. e.g. 'can respire in the absence of oxygen' does not really imply this, as this statement also applies to aerobic organisms.
		ii	it hydrolyses a peptide bond between two amino acids (residues) which are joined by a disulfide bond	1	
			Total	**2**	
34	a		*two from* cells are able to tolerate, high levels of lactate / acidity / low pH (1) have high phosphocreatine stores (1) use of stored ATP (1)	2	
	b	i	**D** pyruvate (1) **E** lactate (1)	2	
		ii	is a hydrogen acceptor / removed hydrogen from reduced NAD	1	
		iii	*two from* for glycolysis to take place, NAD / **G**, is needed (1) there is a limited amount of NAD in the cell (1) formation of, NAD / **G**, allows, glycolysis to continue / some ATP to be formed (1)	2	
		iv	liver **and** in the blood	1	Both required for 1 mark.

			Total	**8**	
35	a		pyruvate ✓ Krebs ✓ liver ✓ link ✓ ATP ✓	5	**ALLOW** citric acid / tricarboxylic acid / TCA
	b	i	1122.06 ✓✓	2	**1 mark max** if answer is not to 6 s.f. **1 mark max** for rounding error If incorrect, **ALLOW** 1 mark for evidence of: $\frac{831 - 68}{68} \times 100$ **ALLOW** 1 mark for 91.8171
		ii	1.38 × 10^{25} ✓✓✓	3	**2 marks max** if answer is not to 3 s.f. If incorrect, **ALLOW** 1 mark for evidence of any of the following, up to a maximum of 2: ○ conversion of 100g to 35g, e.g. $478 \times \frac{35}{100} = 167.3\ \text{kCal}$ ○ conversion of kcal to kJ, e.g. 167.3 × 4.18 = 699.31 kJ • conversion of moles to molecules × 6.02 × 10^{23}
		iii	(cheese is high in) fat which has, the highest / 831, kcal per 100g ✓ fatty acids have many H atoms ✓	2 max	

<table>
<tr><td></td><td></td><td></td><td>can be oxidised many times in Krebs cycle ✓

(so) reduce many NAD / produce many NADH (in Krebs cycle) ✓</td><td></td><td>ALLOW many turns of Krebs cycle</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>12</td><td></td></tr>
<tr><td>36</td><td>a</td><td></td><td>cookie <u>2</u> is protein cookie ✓

RQ of cookie 2 is 0.94 AND RQ of cookie 1 is 0.98 ✓

lower RQ means (cookie 2) must have more protein ✓

RQ closer to 1.0 means more carbohydrate ✓</td><td>3 max</td><td>ALLOW ORA</td></tr>
<tr><td></td><td>b</td><td></td><td>maggots will not produce CO_2, during lactate fermentation ✓

yeast will produce CO_2, during alcoholic fermentation ✓

measuring RQ requires CO_2 production / RQ value (for maggots) will be lower than normal ✓

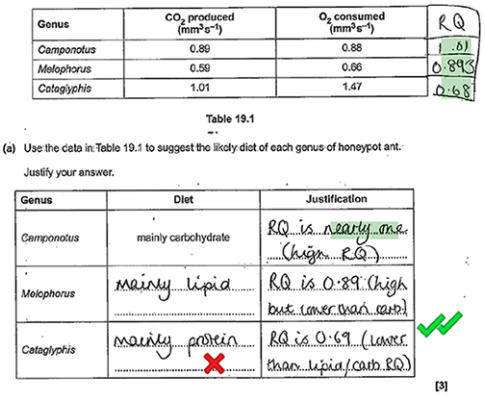
OR

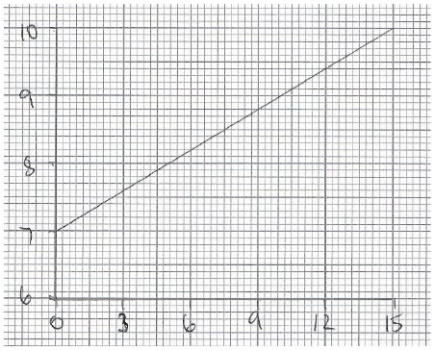
2 minutes not long enough for, yeast / maggots, to, break down / respire, cookie ✓

CO_2 produced (by yeast) is not from respiration of cookie ✓

RQ (comparison) will be invalid ✓</td><td>3</td><td>IGNORE “maggots will die” because experiment is only for 2 minutes</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>6</td><td></td></tr>
<tr><td>37</td><td></td><td></td><td><table><tr><th>Genus</th><th>Diet</th><th>Justification</th></tr><tr><td>Camponotus</td><td>mainly carbohydrate</td><td>(RQ is) 1.0</td></tr><tr><td>Melophorus</td><td>protein
OR
lipid <u>and</u>
carbohydrate</td><td>(RQ is) 0.9</td></tr></table></td><td>3</td><td>DO NOT ALLOW all three substrates for Melophorus
ALLOW amino acids for protein for Melophorus
ALLOW fat / oil / triglyceride / fatty acid for lipid for Cataglyphis</td></tr>
</table>

			Cataglyphis	lipid	(RQ is) 0.7 ✓✓✓		**ALLOW THREE** marks for correctly completed table **ALLOW RQs** to greater number of sig.figs. e.g. 1.01 / 0.89 / 0.687 If **Rf** or **RV** is stated instead of RQ allow **max 1** for **justification** column **ALLOW TWO** marks for all correctly calculated RQ values in **justification** column / on Fig.19.1 **OR** **ALLOW TWO** marks for: correct two responses in **diet** column **AND** for correct three **justifications** written in words i.e. *Camponotus* – CO_2 produced is , similar / equal to O_2 consumed *Melophorus* - CO_2 produced is 0.07 less than O_2 consumed *Cataglyphis* - CO_2 produced is 0.46 less than O_2 consumed **If RQ values have not been calculated or are incorrect** **ALLOW ONE** mark for correct **diet** column **OR** correct **justification** column written in words **OR** two correct RQ values **Examiner's Comments** There were some excellent responses from candidates who were able to correctly calculate RQ values and then suggest the correct diet, although some candidates confused protein and lipids. Some candidates described the justifications in words but did not include numerical data or calculations and whilst not credited for this, they could still be credited for a correct diet column. **Exemplar 3**

					 Genus / CO_2 produced (mm^3s^{-1}) / O_2 consumed (mm^3s^{-1}) / RQ *Camponotus* 0.89 0.88 1.01 *Melophorus* 0.59 0.66 0.893 *Cataglyphis* 1.01 1.47 0.68 Table 19.1 (a) Use the data in Table 19.1 to suggest the likely diet of each genus of honeypot ant. Justify your answer. Genus / Diet / Justification *Camponotus* — mainly carbohydrate — RQ is nearly one. (high RQ) *Melophorus* — mainly lipid — RQ is 0·89 (high but lower than carb) *Cataglyphis* — mainly protein ✗ — RQ is 0·69 (lower than lipid/carb RQ) ✓ [3] This exemplar shows correct justification with clear calculations of the RQ values. Although they have confused the two respiratory substrates in the diet column.
			Total	**3**	
38			*0 watts*: (mainly) carbohydrates respired / AW ✓ *50 watts:* (more) fats / lipids / amino acids / proteins, respired / AW ✓ *250 watts:* (more) anaerobic respiration / AW ✓	3 (AO3.1)	**ALLOW** (mainly) glucose respired **DO NOT ALLOW** 'only, fats / amino acids / proteins, respired'
			Total	**3**	
39		i	**1** correct description of 1:10 dilution ✓ **2** need to make , a total of four 1:10 dilutions / hree further 1:10 dilutions ✓ **3** correct values of dilutions given between stages e.g.1:10 to 1:100 ✓ **4** (ensure) mixing of yeast (suspension) at each stage ✓	3 max (AO2.4) (AO3.3)	**e.g.** take 1 cm^3 of culture and make up to 10 cm^3 **ALLOW** diagram showing serial dilution steps **DO NOT ALLOW** $1cm^3$ + $10cm^3$ **DO NOT ALLOW** add 0.1 cm^3 into $9.9cm^3$ for **MP1** (due to measuring cylinders provided) but then ECF for **MPs 2 and 3** **ALLOW** values in standard form e.g. 1: 102 **ALLOW** e.g. stir thoroughly and repeat
		ii	eyepiece graticule ✓ stage micrometer ✓	2 (AO2.3)	**IGNORE** haemocytometer
		iii	1.25×10^8 ✓✓	2 (AO2.4)	**FIRST CHECK ON THE ANSWER LINE if answer = 1.25×10^8, award 2 marks If answer incorrect:** **ALLOW** 1 mark for

					answer not in standard form **OR** incorrect standard form e.g. 125 x 10^6 **OR** use of equation with correct figures $number\ of\ cells = \frac{2.5 \times 10^{-3}}{2.0 \times 10^{-11}}$
		iv	straight line ✓ starting at 0,7 ✓ ending at 15,10 ✓	3 (AO2.4)	
			Total	**10**	
40			A	1 (AO2.7)	
			Total	**1**	
41	a	i	**1** rate of respiration is proportional to rate of gas production ✓ **2** use a tangent (on non linear part of curve) ✓ **3** measure / calculate , slope / gradient (of each line) ✓ **4** volume of gas (collected) divided by time ✓ **5** compare the same , time / period (between sugars) ✓	max 3 (AO2.3) (AO3.3)	**ALLOW MPs 2, 3 and 5** from annotation of graph **ALLOW** seen as units e.g. $cm^3\ min^{-1}$ **ALLOW** within prose / calculations
		ii	***Summary of instructions to markers:*** *See instruction 10 on page 5 of this mark scheme.* **Level 3 (5–6 marks)** An evaluation of **both** conclusions to include for **and** against statements *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated* **Level 2 (3–4 marks)** An evaluation of **one** conclusion to	6 (AO3.2)	**Indicative scientific points may include:** *Conclusion that rate of respiration of glucose, maltose and sucrose is similar* ***Supporting statements (correct because)*** • the slope of each curve is similar • values for overall / mean rates are similar • calculated values e.g. sucrose ~$1.9cm^3\ min^{-1}$, glucose ~$2.1cm^3min^{-1}$, maltose ~$2.4cm^3min^{-1}$ ***Against statements (incorrect because)***

			include for **and** against statements. **OR** for **or** against statements for **both** conclusions. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence* **Level 1 (1–2 marks)** Incomplete evaluation e.g. for **or** against statements for **one** conclusion. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** *No response or no response worthy of credit.*		• glucose respiration begins sooner than maltose / sucrose • glucose has more rapid increase at beginning • lag before respiration of maltose / sucrose begins • sucrose / maltose rate continues to increase as glucose is slowing down • maltose / sucrose may need to be hydrolysed before used in respiration *Conclusion that yeast could not hydrolyse disaccharides* ***Supporting statements (correct because)*** • little / no lactose respiration • lactose is disaccharide • lactose was not hydrolysed • yeast do not have the enzyme to hydrolyse lactose ***Against statements (incorrect because)*** • maltose / sucrose are disaccharides • maltose / sucrose are respired • may be that lactose could be hydrolysed but cannot be absorbed ***Either conclusion (against)*** • need statistical analysis to determine significance • e.g. t-test / standard deviation • measuring volume of gas over time only estimate of rate of respiration
	b	i	rinse / change , flask / equipment ✓ stir yeast , (stock) solution / suspension ✓ (yeast stock solution made from) same type of yeast ✓ ensure connection to gas syringe is tight ✓	max 2 (AO3.3)	**ALLOW** e.g. use different stirrer each time **ALLOW** ensure no leaks in gas syringe

			check temperature of , water bath / yeast (stock) solution , is 35 ºC ✓		
		ii	boiled (and cooled) yeast / use buffer instead of yeast ✓	1 (AO3.3)	
			Total	**12**	