Answer **all** the questions.

1. Citrate synthase catalyses the conversion of oxaloacetate into citric acid in the Krebs cycle. It exhibits product inhibition.

Which of the following is the correct description of citrate synthase?

	Type of respiration involved in	Location of enzyme	Inhibitor
A	anaerobic	cytoplasm	citric acid
B	aerobic	mitochondria	citric acid
C	aerobic	mitochondria	oxaloacetate
D	anaerobic	cytoplasm	oxaloacetate

Your answer ☐

[1]

2. Which of the following statements is / are true?

Statement 1: Microtubules are part of the '9 + 2' formation in bacterial flagella.
Statement 2: Microtubules can be prevented from functioning by a respiratory inhibitor.
Statement 3: Microtubules are involved in moving chromosomes from the equator to the poles of the cell during mitosis.

A 1, 2 and 3
B Only 1 and 2
C Only 2 and 3
D Only 1

Your answer ☐

[1]

3. 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**.

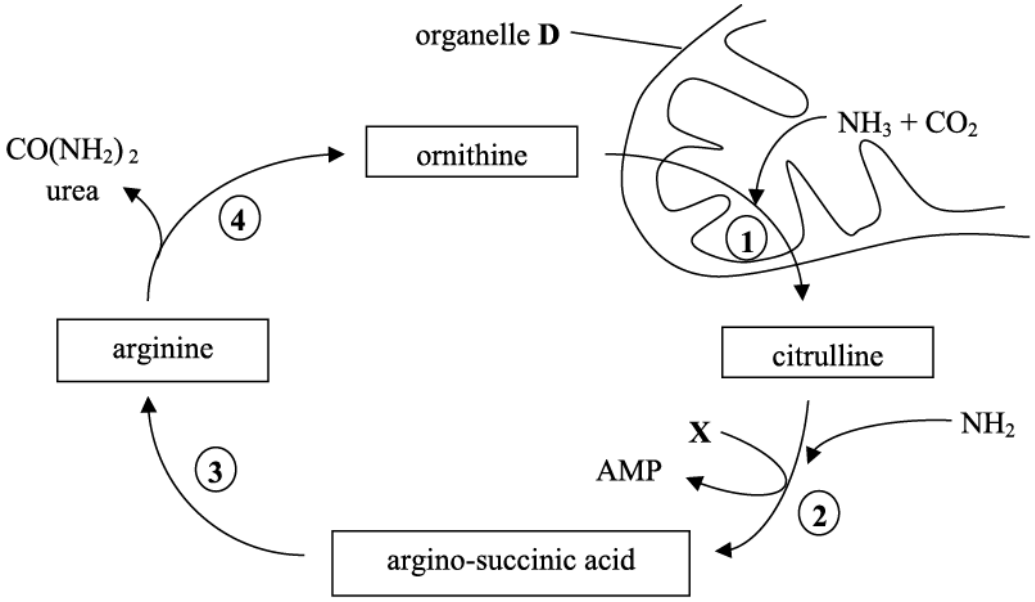


Fig. 17.2

(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]

4. Plants photosynthesise and respire. **Fig. 18.1** shows the rate of production of carbohydrate in photosynthesis and the rate of use of carbohydrate by respiration.

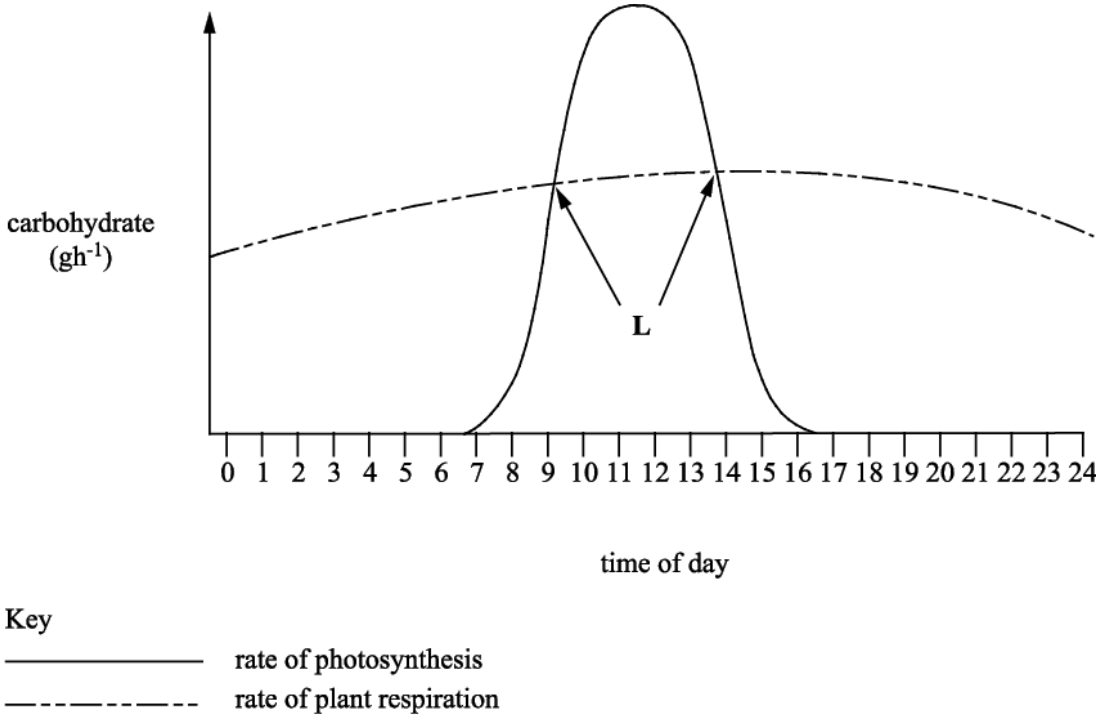


Fig. 18.1

(i) Explain the shape of the curve for the rate of photosynthesis in **Fig. 18.1**.

---**[2]**

(ii) Explain the shape of the curve for the rate of plant respiration in **Fig. 18.1**.

---**[2]**

(iii) What is happening at the points indicated by the letter **L**?

---

[1]

5(a). 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.

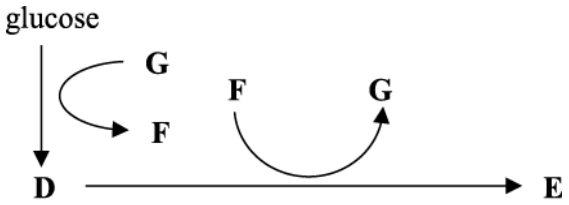


Fig. 20.2

(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]

(b). 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]

6. The respiratory quotients (RQs) of three respiratory substrates are shown below:

carbohydrates: 1.0
lipids: 0.7
proteins: 0.9

An experiment was carried out to investigate which molecules are used as respiratory substrates in different cell types. The results are shown in the table below.

Cell type	Oxygen consumed (mm^3 min^{-1})	Carbon dioxide produced (mm^3 min^{-1})
cancerous	12.78	12.82
normal	13.45	9.40

Which of the statements, **A** to **D**, supports these results?

A cancer cells respire mainly carbohydrates
B cancer cells respire mainly lipids
C normal cells respire mainly carbohydrates
D normal cells respire mainly proteins

Your answer ☐

[1]

7. Which of the following, **A** to **D**, is the correct summary of the net products of the Krebs cycle for **one** molecule of pyruvate?

A 3 reduced NAD, 1 reduced FAD, 2 CO_2, 1 ATP

B 2 reduced NAD, 2 CO_2, 2 ATP

C 4 reduced NAD, 2 reduced FAD, 3 CO_2, 2 ATP

D 2 reduced NAD, 1 reduced FAD, 3 ATP

Your answer ☐

[1]

8. LHON is an inherited mitochondrial condition that causes problems with aerobic respiration. It is the result of a mutation in mitochondrial DNA (mtDNA) and is passed from mother to child. LHON is presently incurable, but one theoretical treatment involves removing the mutation from the mother's mtDNA.

Which of the statements, **A** to **D**, correctly explains why this could be a viable treatment for LHON?

A enzymes involved in glycolysis are unaffected by mtDNA

B enzymes involved in the Krebs cycle, link reaction and electron transport chain are affected by mtDNA

C enzymes involved with oxidative phosphorylation are unaffected by mtDNA

D enzymes involved with photophosphorylation are affected by mtDNA

Your answer ☐

[1]

9. * 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]

10(a). 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]

(b). Fig. 19.1 is an outline of the Krebs cycle.

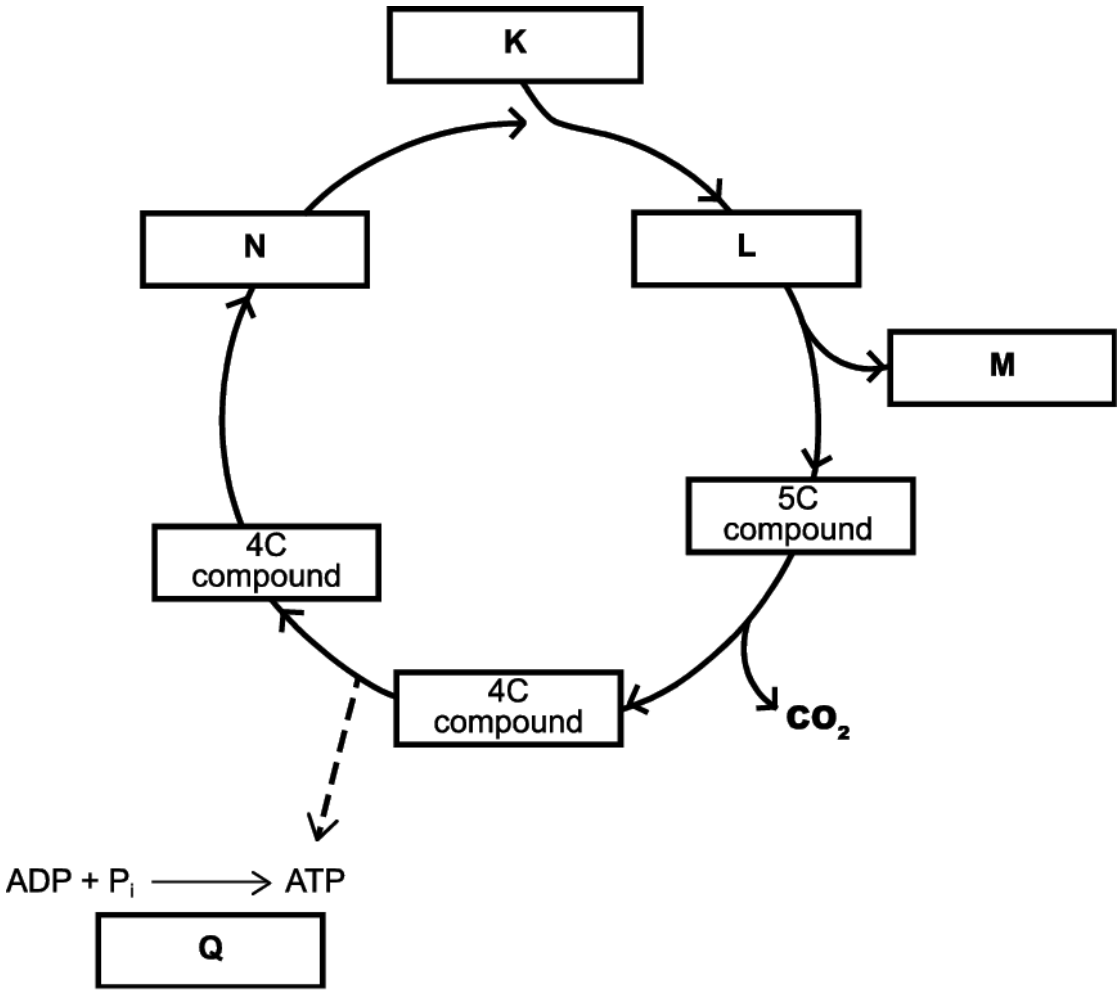


Fig. 19.1

(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]**

11. 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.

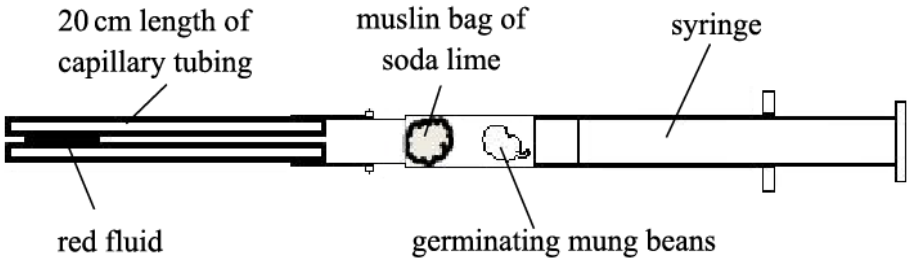


Fig. 1.1

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]

12. Herbicides work in a number of different ways.

(i) Some herbicides, known as phenoxy herbicides, mimic the action of the auxin, indoleacetic acid (IAA).

What is the normal action of IAA in plant cells?

[1]

(ii) The herbicide atrazine works by disabling plastoquinone, one of the proton pumps in photosystem II.

Explain how atrazine would kill a susceptible plant.

[5]

13(a). 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]

(b). A mouse assay, using 99 mice, was used to determine the median lethal dose of the the toxin.

(i) Suggest what is meant by the term *median lethal dose.*

---

[1]

(ii) The median lethal dose of the toxin is in the range of 5 – 50 ng kg^{-1} body mass, depending on the toxin type and the method of introduction into the body.

Calculate the probable lethal dose of the **least toxic** botulinum toxin for an individual with a body mass of 85 kg.

Show your working and give your answer in µg.

Answer_____ µg **[2]**

(iii) The toxin acts primarily at the cholinergic nerve terminals of stimulatory motor neurones. Part of the molecule binds irreversibly to specific receptors on the presynaptic membrane. The toxin–receptor complex is then taken into the cytoplasm of the neurone where the disulfide bond is broken, releasing the section of the molecule which acts to block the release of the neurotransmitter.

Explain why botulism can be fatal.

---

[2]

14(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.

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]

(ii) 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.

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

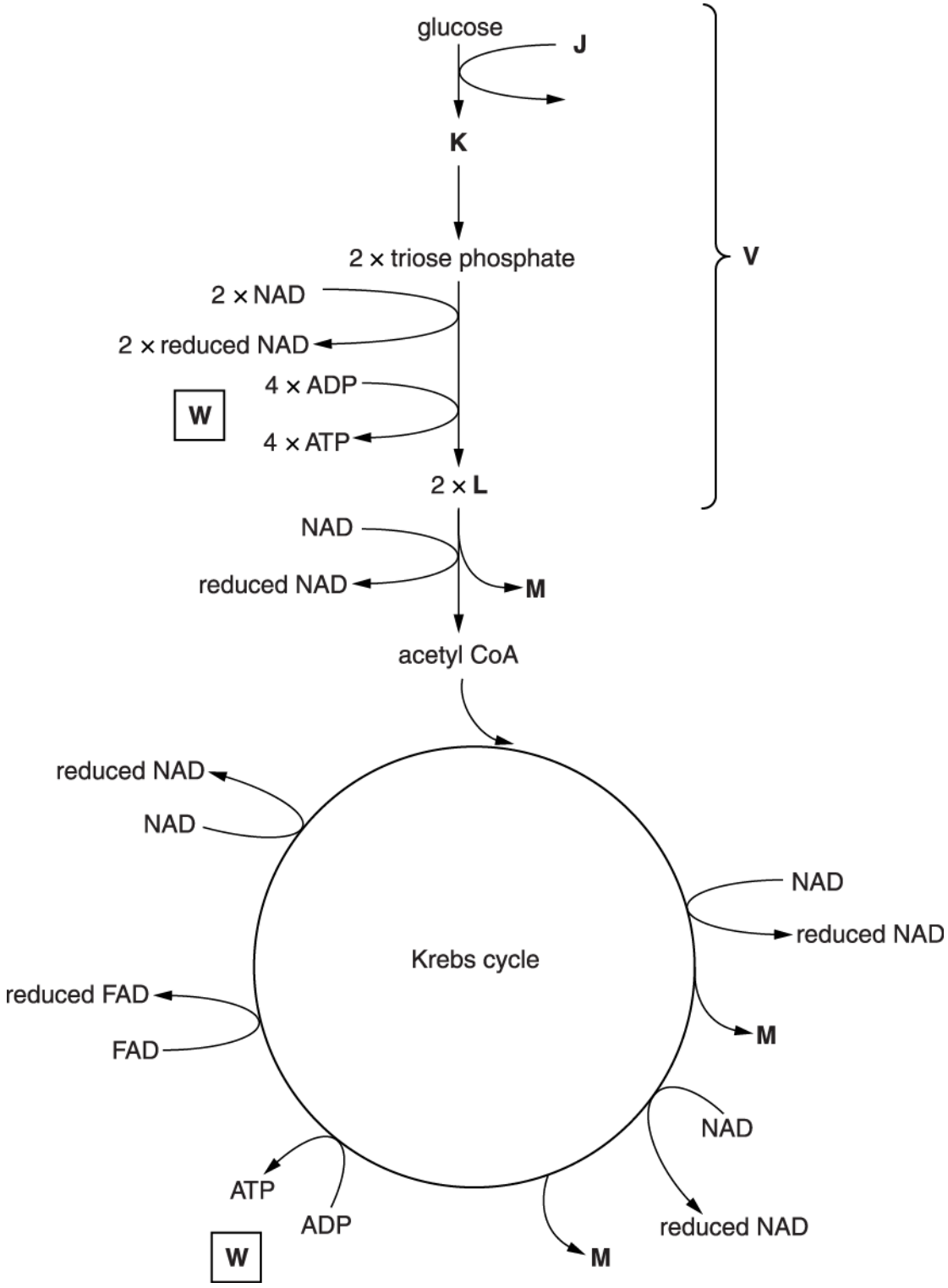
---

[2]

Fig. 5.1

Fig. 5.2

15. ATP is produced in cells by the process of respiration. Some of the reactions involved in the process of respiration are outlined in the figure.



(i) Compound **J** is required for the reaction pathway to start.

Identify compound **J**.

[1]

(ii) Identify compounds **K** to **M**.

K

L

M

[3]

(iii) Name the pathway labelled **V**.

[1]

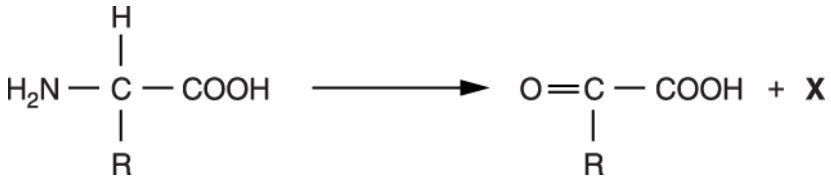
(iv) ATP is produced in two different ways during respiration.

- Some ATP is produced at the points labelled W.
- ATP is also produced using reduced NAD and reduced FAD on the inner mitochondrial membrane.

Outline the differences in the two ways by which ATP is produced in respiration.

[3]

16. L"if_notalone">liver cells also use amino acids for protein synthesis.



Suggest **one** other use of amino acids in liver cell metabolism.

[1]

17(a). Humans harvest a wide range of fruits and vegetables as food. Cellular respiration supplies energy and forms part of the natural ripening process in fruits and vegetables. This ripening process may continue after the fruits and vegetables are harvested, as the cells continue to respire.

The rate of cellular respiration after harvesting affects the shelf-life of fruits and vegetables as it can lead to changes in food quality. After harvesting, some fruits and vegetables enter a dormant (inactive) state while others remain active during storage.

Table 5.1 contains data that show the respiration rate of a selection of fruits and vegetablesstored at different temperatures after harvesting. The respiration rate is measured by the rate of carbon dioxide produced.

Fruits and vegetables	**Respiration rate (mg CO_2 kg^{-1} h^{-1})**				
	at 0 °C	**at 5 °C**	**at 10 °C**	**at 15 °C**	**at 20 °C**
Apple	3	6	9	15	20
Asparagus	60	105	215	235	270
Blackberry	19	36	62	75	115
Cauliflower	17	21	34	44	69
Onion	3	5	7	7	8
Orange	4	6	8	18	28
Parsnip	12	13	22	37	n/a*
Potato	n/a*	12	16	17	22
Turnip	8	10	16	23	25

* no data were collected at these temperatures

Table 5.1

(i) Describe the pattern of respiration shown by cauliflower at increasing storage temperatures of 0 °C to 20 °C.

---

[2]

(ii) Discuss what the data in Table 5.1 indicate about the best conditions for storage of fruits and vegetables.

---

[2]

(iii) Identify, with reasons, which fruit or vegetable listed in Table 5.1 is **least** likely to spoil during storage.

---

[3]

(iv) Which fruit or vegetable listed in Table 5.1 is likely to be the most difficult to keep fresh during storage? Give a reason for your answer.

---

[1]

(b). Respiration can be aerobic or anaerobic.

(i) Certain parasites live in the blood of mammals.

Suggest why, even though blood carries oxygen, these parasites are adapted to respire anaerobically.

---**[2]**

(ii) The anaerobic respiration pathway in animal cells can be reversed, but the anaerobic respiration pathway in yeast cells cannot be reversed.

Explain why, using your knowledge of the differences between the two pathways.

In your answer, you should use appropriate technical terms, spelled correctly.

---**[4]**

18. As mammalian muscle uses energy to contract, it needs an energy supply.

Complete the following passage by choosing the best term to fill each gap.

Most ATP for muscle contraction is generated by aerobic respiration in organelles

called _____. Most of this ATP is produced by the stage of aerobic

respiration called _____.

If the oxygen supply is insufficient, ATP can also be obtained from anaerobic respiration, in which pyruvate is

converted to the toxic product _____ .

A third source of ATP in muscle involves the transfer of a phosphate group to ADP from a

substance called _____.

During the contraction of skeletal muscle, energy from ATP is used to break

the _____ that hold the actin and _____ together.

[6]

19. A mixture of three sugars is added to batch fermenter at the beginning of the process:

- the monosaccharide glucose, which the yeast uses up first, during days 0 to 2
- the disaccharide maltose, which is used during days 1 to 5
- the trisaccharide maltotriose, which is used during days 4 to 6.

Suggest why the yeast uses the sugars in this order.

---

[3]

20(a). Fig. 3.1 is a diagram representing a mitochondrion located in the cytoplasm of an animal cell.

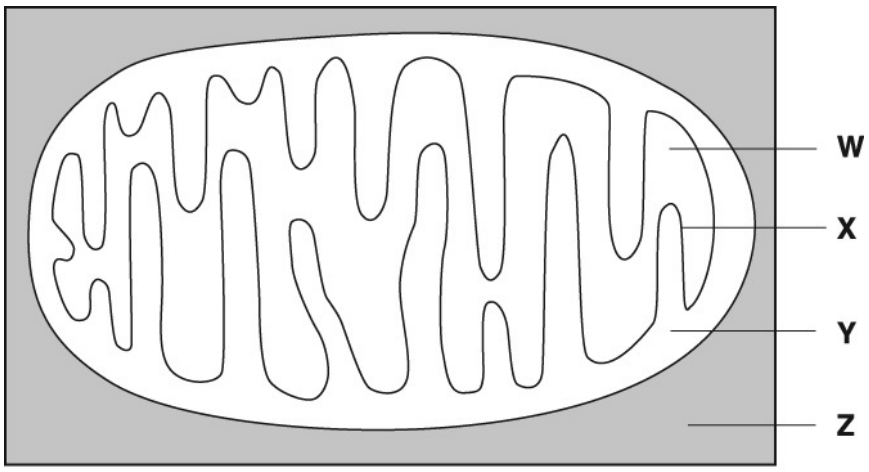


Fig. 3.1

(i) Use the letters **W** to **Z** to identify the region in Fig. 3.1 where each of the following occurs.

You may use each letter once, more than once or not at all.

link reaction _____

glycolysis _____

electron transport chain _____

Krebs cycle _____

[4]

(ii) Why does aerobic respiration yield fewer molecules of ATP than the theoretical maximum?

_____

_____

_____

_____

_____ **[2]**

(b). Explain why the incomplete breakdown of glucose in **anaerobic** respiration produces less ATP than aerobic respiration.

In your answer, you should use appropriate technical terms, spelled correctly.

[5]

21. The serial endosymbiotic theory suggests that some eukaryotic organelles came about as a result of close associations between early unicellular organisms.

The following statements describe oxidative phosphorylation in bacteria:

1 The enzymes involved in electron transport and oxidative phosphorylation are on the inner layer of the bacterial membrane.
2 The inner layer of the membrane is folded, increasing its surface area.
3 The membrane contains cytochromes and ATP-synthase complexes.

Which of the statements above demonstrates a link between bacterial cells and the mitochondria of eukaryotes?

A 1, 2 and 3
B Only 1 and 2
C Only 2 and 3
D Only 1

Your answer

[1]

22(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]**

23(a). 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.

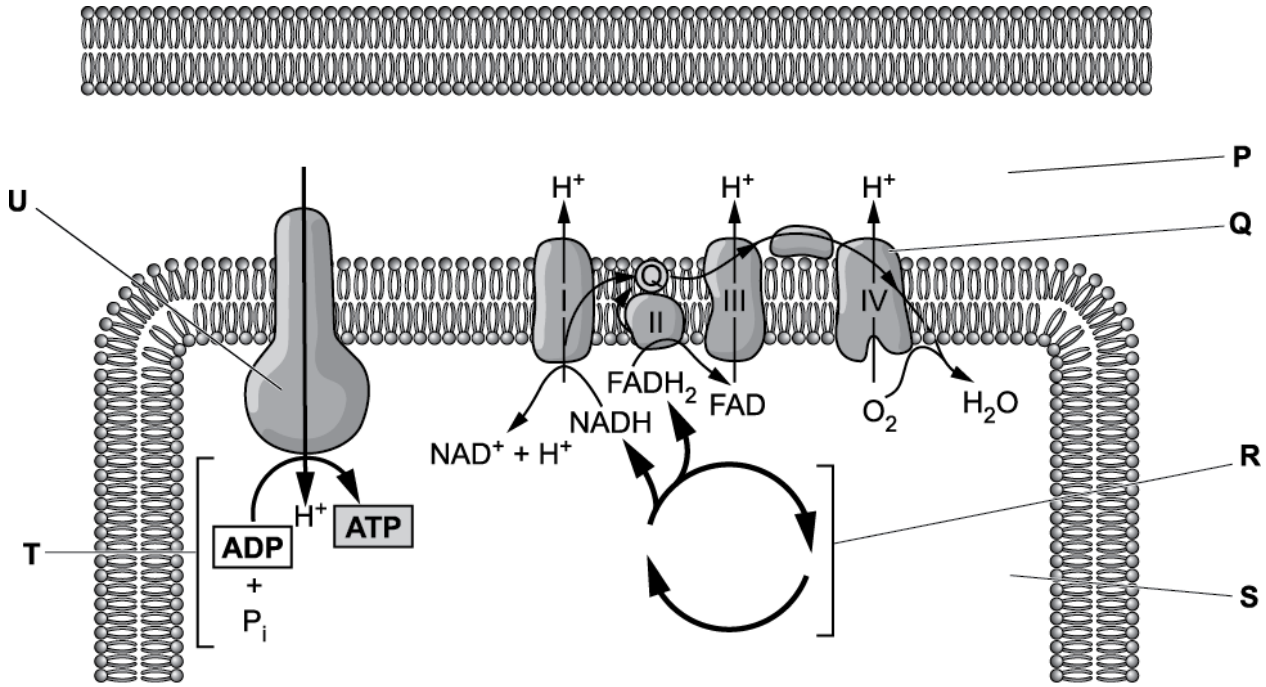


Fig. 18

(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]

(b).

(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]

(c). *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]

24(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]

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			B	1	
			Total	**1**	
2			C	1	
			Total	**1**	
3		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**	
4		i	increased photosynthetic activity during daylight (1) as light intensity increases there is increased activity of the light dependent reaction (1)	2	No marks available for describing the shape of the curve.
		ii	daytime temperatures generally higher than night time (1) rate of respiration increases with increased temperature as its enzymes are temperature-dependent (1)	2	No marks available for describing the shape of the curve.
		iii	compensation point(s) / carbohydrate produced by photosynthesis equal to carbohydrate used in respiration (1)	1	
			Total	**5**	
5	a	i	**D** pyruvate (1) **E** lactate (1)	2	

Question			Answer/Indicative content	Marks	Guidance
		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.
	b		*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	
			Total	**8**	
6			A	1	
			Total	**1**	
7			A	1	
			Total	**1**	
8			B	1	
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
9			* 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.** • **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.*	6	**Indicative scientific points may include…** • Coenzyme A: ◦ transfers acetyl / acetate / 2C from link reaction to Krebs cycle • ADP/ATP: ◦ phosphorylation of / addition of phosphate group to, glucose to form hexose-1, 6-bisphosphate in glycolysis ◦ dephosphorylation of / removal of phosphate group from, TP in glycolysis ◦ dephosphorylation of / removal of phosphate group from, intermediate in Krebs cycle ◦ formation from substrate level phosphorylation ◦ formation from oxidative phosphorylation, harnessing chemical energy from chemiosmosis / proton motive force • 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

Question			Answer/Indicative content	Marks	Guidance
			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** No response or no response worthy of credit.		
			Total	**6**	
10	a		matrix of mitochondrion	1	**ALLOW** mitochondria
	b	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	**6**	

Question			Answer/Indicative content	Marks	Guidance
11	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** difficult to read the meniscus (may be subjective) (1)	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'.

Question			Answer/Indicative content	Marks	Guidance
	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.

Question			Answer/Indicative content	Marks	Guidance
	d		*Explanation* it is more than 10% from the mean **or** it is different from the other data at 60 seconds **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)	2	**ALLOW** 'it is out of line' **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	

Question			Answer/Indicative content	Marks	Guidance
	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. *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.	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.
			Total	**15**	

Question			Answer/Indicative content	Marks	Guidance
12		i	(stimulates) cell, elongation / division	1	**IGNORE** ref to action outside the cell, or to unqualified "growth" etc.
		ii	*three from* **1** reduced / no, proton pumping / proton motive force / chemiosmosis (1) **2** photophosphorylation stops (1) **3** less / no, ATP produced (1) **4** less / no, reduced NADP produced (1) **5** no, Calvin cycle / carbon fixation / light independent stage (1) *plus* **6** no, TP / (hexose) sugars, made (1) **7** no respiratory substrate / respiration ceases (1)	5	**3 ALLOW** cessation of vital process that needs ATP **IF** ATP mentioned but **IGNORE** respiration (as credited in mp 7).
			Total	**6**	
13	a	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	
	b	i	amount that is required to kill the 50^{th} mouse when they are arranged in order of lethal dose	1	
		ii	4.25 (μg) (1)(1)	2	**ALLOW** 1 mark for correct working using, least lethal dose is 50 ng kg^{-1} 50 × 85 = 4250 ng /1000 = 4.25 μg
		iii	*two from* intercostal muscles are / diaphragm muscle is, weakened / paralysed (1) *idea that* ventilation and oxygenation of blood is, reduced / compromised (1) cells / (named) organ(s), cannot, obtain oxygen for respiration / carry out aerobic respiration (1)	2	
			Total	**7**	

Question			Answer/Indicative content	Marks	Guidance
14	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**	

Question			Answer/Indicative content	Marks	Guidance
15		i	(2 molecules of) ATP / adenosine triphosphate;	1	**Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**
		ii	**K** hexose (1,6) (bis)phosphate; **L** pyruvate; **M** carbon dioxide / CO_2;	3	**Mark the first answer on each prompt line.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** K **CREDIT** glucose (6) phosphate / fructose (1) phosphate / fructose (1,6) diphosphate / hexose diphosphate **DO NOT CREDIT** glucose (1,6) bisphosphate L **ACCEPT** pyruvic acid M if used, formula must be correct
		iii	glycolysis / glycolytic;	1	**Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **Examiner's Comments** Parts (i), (ii) and (iii) were well answered, indicating the candidates' good knowledge of respiration.

Question			Answer/Indicative content	Marks	Guidance
		iv	by substrate level phosphorylation; detail; by, chemiosmosis/ oxidative phosphorylation; detail;	3 max	e.g. • by removing phosphate from a compound (in the reaction pathway) e.g. • hydrogen lost from, redNAD / redFAD • electrons pass down, ETC / electron transport chain • ref to proton gradient / electrochemical gradient • ref to ATP synth(et)ase **Examiner's Comments** Detail of oxidative phosphorylation was good, although there was some confusion as to where the protons were pumped and whether they moved down or up a gradient. The detail on substrate level phosphorylation was lacking. Candidates were expected to indicate that the phosphate to phosphorylate ADP came directly from a compound in glycolysis or Krebs cycle. The only information offered by most candidates was that ADP added a phosphate to become ATP.
			Total	**8**	

Question			Answer/Indicative content	Marks	Guidance
16			1 in respiration / in Krebs cycle / as a respiratory substrate; 2 gluconeogenesis; 3 conversion to, lipid / fatty acid; 4 transamination;	1 max	**IGNORE** ref to protein synthesis (as in Q) used in the regeneration / repair of liver cells 1 **DO NOT CREDIT** for anaerobic respiration / glycolysis 2 **CREDIT** conversion to glucose 3 **ACCEPT** conversion to, steroid / bile salts **IGNORE** glycerol **Examiner's Comments** Most candidates supplied a suitable suggestion. It was clear that some either did not read the question properly or did not realise that enzymes are protein as they suggested protein synthesis or enzyme synthesis. Others suggested a function of the liver which was unrelated to amino acids.
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
17	a	i	**1** (as the temperature increases) the respiration <u>rate</u> increases; **2** respiration <u>rate</u> doubles with a 10°C temperature increase; **3 comparative** figures with **correct units** (units once for respiration and once for temperature) in the context of either mp;	2 max	**Only credit answers that refer to an increase in temperature – no ora** **1 Clear statement required – cannot be inferred from figures quoted.** **ACCEPT** positive correlation between temperature and respiration rate **IGNORE** ref to directly proportional **2 Clear statement required – cannot be inferred from figures quoted**. **CREDIT** $Q_{10} = 2$ **3** e.g. • between 0 and 20°C the respiration goes from 17 to 69 mg CO_2 kg^{-1} h^{-1} • between 5 and 10°C the rate changes by 13 mg CO_2 kg^{-1} h^{-1} e.g. • between 0 and 10°C the rate goes from 17 to 34 mg CO_2 kg^{-1} h^{-1} • between 10 and 20°C the respiration goes from 34 to 69 mg CO_2 kg^{-1} h^{-1} | 0 °C | 5 °C | 10 °C | 15 °C | 20 °C | | 17 | 21 | 34 | 44 | 69 | **Note**: 'between 0 and 20°C the respiration rate increased from 17 to 69 mg CO_2 kg^{-1} h^{-1}' = **2 marks** (mps 1 & 3) **But** 'at 0°C the respiration is 17 mg CO_2 kg^{-1} h^{-1}' and at 20°C it is 69' = **1 mark** (mp 3) **Examiner's Comments** Most candidates achieved both marks here, demonstrating evidence of sound preparation for this type of question, with good references to data being seen. Most candidates gave a clear general statement

Question			Answer/Indicative content	Marks	Guidance
					to gain mark point 1, although a good number only gave lengthy lists of figures. A few failed to refer to 'rate' of respiration. Very few picked up on the idea of Q_{10}. When quoting data, candidates are expected to use units as stated in the source material.

Question			Answer/Indicative content	Marks	Guidance
		ii	**1** *best conditions are* low(er) temperatures because respiration rate low; **2** 0°C / freezing, could be / is, best; **3** *idea that* 0°C might be too low as (the food cells) might be damaged at 0°C; **4** *idea that* for some (named) food(s) (storage) temperature doesn't seem to matter; **5** *idea that* data is incomplete for, potato / parsnip, so, only limited / no, conclusions can be made; **6** *idea that* if product needs to ripen during storage then a higher temperature (not above 20°C) will be ideal;	2 max	1 5°C or below **IGNORE** statements that simply describe a trend **3 ACCEPT** ref to freezing instead of 0°C **4 NOT** asparagus, blackberry or cauliflower **6 IGNORE** ref to ethene **Note**: '0°C is best as the respiration rate is low' = **2 marks** (mps 1 & 2) **Examiner's Comments** The discursive nature of this question made it a little more challenging. Most candidates, nevertheless, seemed able to access the idea of lower temperatures being better for storage, although, as in part (i), some failed to gain the first mark due to omitting the reference to 'rate'. When using source material such as a table or graph, candidates are expected to quote the precise parameter. Not all made the link to 0°C being best and only a few answers clearly discussed the idea of higher temperatures being desirable if ripening was required. Some candidates did mention that data was incomplete for potato / parsnip but did not describe this as a limitation for drawing conclusions. Others thought these vegetables were not respiring at all. Weak answers described the trend (higher respiration rate at higher temperatures) and just quoted data from the table.

Question			Answer/Indicative content	Marks	Guidance
		iii	**1** onion; **2** has low(est) respiration <u>rate</u>; **3** across all temperatures (in the investigation / up to 20°C) **or** temperature has, the least / little, effect on respiration <u>rate</u>; **4** can be, stored / kept, at, higher temperatures / room temperature / at 20°C;	3	**1 DO NOT CREDIT** if an additional suggestion is made **3 DO NOT CREDIT** 'temperature has **no** effect on respiration rate' **4 CREDIT** *idea that* no need to store in fridge **Examiner's Comments** This was a relatively straightforward application of data question and one which was attempted successfully by most. Many good answers were awarded the first three mark points in one sentence. A few missed the point completely, selecting asparagus, and some mentioned multiple fruits / vegetables. A significant number of candidates appeared to misread or misunderstand the question and answered in terms of the "highest respiration rate", linking this to having plenty of energy to stay fresh.

Question			Answer/Indicative content	Marks	Guidance
		iv	asparagus **and** has a high respiration rate across all temperatures / has the highest respiration rate (of the foods);	1	**Both parts of the mark point required for the mark to be awarded** **DO NOT CREDIT** 'asparagus' without a supporting reason **ACCEPT** 'has a high respiration rate even at low temperature(s)' **Examiner's Comments** Most recognised that asparagus was the correct answer. Those candidates who failed to gain the mark did so either because they named onion (having already mistakenly given asparagus in answer to part (iii)) or because they omitted the reference to 'rate' of respiration. Reasons were expected to refer to the range of possible storage temperatures.
	b	i	**1** *idea that* parasites have little access to oxygen; **2** (inaccessible because) little oxygen dissolved in plasma / oxygen not very soluble (in plasma); **3** (inaccessible because) *idea that* oxygen is, combined with haemoglobin / contained in red blood cells; **4** *idea that* haemoglobin has greater affinity for oxygen than parasite (pigment);	2 max	**1 DO NOT CREDIT** '**no** oxygen accessible' clearly stated **DO NOT CREDIT** in the context of, the mammal respiring anaerobically / deoxygenated blood / temporary lack of oxygen **3 ACCEPT** in context of saturation **Note**: 'because the oxygen is bound to haemoglobin, the parasite is unable to use it' = **2 marks** (mps 3 & 1) **Examiner's Comments** This question proved an effective discriminator with only good answers achieving marks. These gained two marks for managing to describe how inaccessibility of oxygen was due to its carriage in erythrocytes. Few candidates

Question			Answer/Indicative content	Marks	Guidance
					seemed to understand that the plasma is also involved, but with very little oxygen dissolved. A significant number of answers failed to gain marks as candidates related the parasitic adaptation to survival either in deoxygenated blood (because they were in a vein or the host was exercising) or after death of the host. Some thought that the parasite simply lacked appropriate enzymes / mitochondria and failed to actually address the question as to why the adaptations had occurred in the first place. Many candidates were concerned that the parasite should not take oxygen from its host as this would damage the host's health or result in its death. The idea of the host having a higher affinity was seen but not always linked to the idea of haemoglobin and a pigment in the parasite. Generally, it was stated that the entire parasitic organism had a lower affinity for oxygen.
		ii	*in animals* **A1 pyruvate** is, converted / reduced, to, **lactate** / lactic acid; **A2** can be reversed as no, atoms lost / other product formed; **A3 lactate dehydrogenase** available to reverse the reaction; *in yeast* **Y1** pyruvate converted to **ethanol** (in 2 steps) **and carbon dioxide** / CO_2; **Y2** cannot be reversed as, carbon dioxide is / atoms are, lost; **Y3** (de)**carboxylase** enzyme cannot reverse the reaction;	3 max	**Only award 3 content marks if A mark(s) plus Y mark(s)** **awarded** **A1 Cannot be inferred** from awarding of **A2** or **A3** **A2** e.g. pyruvate and lactate are both 3C compounds so reaction can be reversed **Y1 CREDIT** pyruvate decarboxylated to ethanol **Y2** e.g. pyruvate is 3C and, ethanol / ethanal, is 2C so reaction cannot be reversed
		ii	**QWC** – technical terms used appropriately and spelled correctly;	1	Use of **three** terms from:

Question	Answer/Indicative content	Marks	Guidance
			pyruvate, lactate, lactate dehydrogenase carbon dioxide, ethanol (de)carboxylase / (de)carboxylation (or derived term) **Please insert a QWC symbol next to the pencil icon, followed by a tick (□) if QWC has been awarded or a cross (×) if QWC has not been awarded You should use the green dot to identify the QWC terms that you are crediting.** **Examiner's Comments** This question allowed for real discrimination and differentiation. Many candidates accessed the A1 and Y1 marks (together with the QWC mark). Fewer candidates were awarded a fourth mark. There was a lot of confused chemistry. Common misconceptions were that CO_2 was released in the lactate pathway and ethanol was confused with ethanal or with ethanoic acid. Candidates described the importance of re-oxidising reduced NAD but did not focus on the possible 'reverse reactions'. A number thought that ethanol could not be converted back into pyruvate as it was so toxic that it had to be removed from the cell immediately it was produced. Candidates who focused on why the pathways cannot be reversed and ignored the instruction to use their knowledge (and hence give detail) of the difference between the pathways neglected to include enough description of the pathways to be awarded A1 or Y1. There was difficulty in clearly explaining that atoms were either lost or were not and describing the consequence for reversal. Candidates often mentioned lactate dehydrogenase but not in its role of reversing the pyruvate to lactate reaction. Some candidates mentioned pyruvate decarboxylase but hardly any suggested that a carboxylase enzyme would be required to reverse the pyruvate to ethanol reaction.

Question			Answer/Indicative content	Marks	Guidance
			Total	**14**	
18				6	**Mark the first answer on each prompt line.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**
			mitochondria;		**ACCEPT** mitochondrion **DO NOT CREDIT** mitochondrial matrix
			oxidative phosphorylation;		**IGNORE** electron transport chain (as not a stage)
			lactate;		**ACCEPT** lactic acid
			creatine phosphate / phosphocreatine;		**DO NOT CREDIT** creatinine
			(cross-)bridge / (cross-)link; myosin (head);		**DO NOT CREDIT** bond **ACCEPT** phonetic spelling
					Examiner's Comments This question proved to be a good discriminator, with less able candidates scoring 2 or 3 marks and stronger candidates scoring 5 or 6 marks. Almost all candidates correctly got the mark for mitochondria, and most also got the mark for myosin. The most common mark missing from this question was for creatine phosphate.
			Total	**6**	

Question			Answer/Indicative content	Marks	Guidance
19			**1** glucose can, be used / enters glycolysis, directly / without being broken down (first); **2** maltose, must, be hydrolysed / have glycosidic bonds broken; **3** enzyme / maltase, only made when, needed / maltose present / glucose running out; **4** enzyme induced / gene(s) switched on; **5** transcription and translation / protein synthesis, takes time; **6** maltotriose requires, more (2) hydrolysis (reactions) / breaking of more (2) glycosidic bonds **or** enzyme to break down maltotriose made last;	3 max	**ACCEPT** 'monosaccharide' for glucose and 'disaccharide' for maltose and 'trisaccharide' for maltotriose throughout **1 IGNORE** ref to glucose being used first / at start / immediately (as stated in Q) **Examiner's Comments** This was a challenging question, which few candidates grasped, often simply reciting the information given in the stem of the question. Many thought that glucose needed to be broken down before it could be used. There was a lot of reference to breaking the disaccharide or trisaccharide down before use, but many answers were vague and did not mention hydrolysis or glycosidic bonds, gaining no credit. Only a few candidates realised that enzymes would need to be produced to carry out the hydrolysis and that this would involve enzyme induction and protein synthesis.
			Total	**3**	

Question			Answer/Indicative content	Marks	Guidance
20	a	i	W; Z; X; W;	4	**Mark the first answer on each prompt line.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks** **Examiner's Comments** Most candidates were awarded 4 or 3 marks. Some provided multiple answers, which were not credited.
		ii	1 some ATP used to (actively) transport pyruvate (into the mitochondrion); 2 some ATP used to (actively) transport $H^{(+)}$ from (reduced) NAD, formed in glycolysis / into the mitochondrion; 3 some energy released in ETC, is not used to transport H^+ (across inner membrane) / is released as heat; 4 not all the H^+ movement (back across membrane), is used to generate ATP / is through ATP synth(et)ase; 5 not all the, reduced NAD / red NAD / NADH, is used to feed into the ETC;	2 max	**IGNORE** ref to phosphorylation of glucose as this is taken into account in estimate. 2 **DO NOT CREDIT** transport of (reduced) NAD 3 **ACCEPT** in context of oxidative phosphorylation 4 **ACCEPT** ref to H^+ leaking (back into matrix or out into cytoplasm) resulting in less ATP generated 5 **CREDIT** use of (some of) the red NAD for other purpose **Examiner's Comments** Most answers included reference to the transport of pyruvate into the mitochondrion. Remaining mark points were either inadequately expressed, such as referring to the leakage on hydrogen ions but not mentioning the fact that they would not, therefore, pass through the ATP synthase molecule or generate ATP.

Question			Answer/Indicative content	Marks	Guidance
	b		*in anaerobic respiration*	4 max	
			1 **glycolysis** / conversion of glucose into **pyruvate**, occurs;		
			2 produces 2 molecules of ATP (net);		2 **IGNORE** little / less / not much
			3 (only) substrate level phosphorylation (occurs);		
			4 **oxygen** not available as final **electron acceptor**;		4 **CREDIT** oxygen is available as the final electron acceptor in aerobic **IGNORE** ref to hydrogen acceptor
			5 pyruvate / ethanal, used to regenerate NAD for glycolysis (to continue);		5 pyruvate refers to lactate pathway, ethanal refers to fermentation
			6 (Krebs cycle and) electron transport chain / **chemiosmosis / oxidative phosphorylation,** do not occur;		6 ETC (etc.) ***only*** occur(s) in aerobic

Question			Answer/Indicative content	Marks	Guidance
			QWC;	1	Award if **3** of the following terms have been used in a correct context with correct spelling: **glycolysis pyruvate substrate level phosphorylation oxygen electron acceptor chemiosmosis / chemiosmotic oxidative phosphorylation** ***Please insert a QWC symbol next to the pencil icon, followed by a tick (?) if QWC has been awarded or a cross (?) if QWC has not been awarded.*** ***You should use the green dot to identify the QWC terms that you are crediting.*** **Examiner's Comments** Many candidates answered this question well. Mark points 1 and 2 were normally awarded. Low scoring answers concentrated on an account of aerobic respiration rather than a comparison with anaerobic or the reasons for the lack of ATP production in anaerobic respiration. Some incorrect descriptions of the lactate and ethanol pathways were given. Few candidates referred to substrate level phosphorylation in glycolysis. The QWC mark was normally awarded.
			Total	**11**	
21			A □	1	
			Total	**1**	

Question			Answer/Indicative content	Marks	Guidance
22	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}

Question			Answer/Indicative content	Marks	Guidance
		iii	(cheese is high in) fat which has, the highest / 831, kcal per 100g □ fatty acids have many H atoms □ can be oxidised many times in Krebs cycle □ (so) reduce many NAD / produce many NADH (in Krebs cycle) □	2 max	**ALLOW** many turns of Krebs cycle
			Total	**12**	

Question			Answer/Indicative content	Marks	Guidance
23	a	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
	b	i	(mostly) impermeable to H^+ ions / protons ☐ large surface area ☐ presence of, ATP synthase / stalked particles ☐	2 max	**DO NOT ALLOW** H / hydrogen **IGNORE** ETC / cytochromes
		ii	pH decreases **AND** becomes more positive(ly charged) ☐	1	

Question			Answer/Indicative content	Marks	Guidance
	c		***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.***		

Question			Answer/Indicative content	Marks	Guidance
			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 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.	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 • 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
			Total	**15**	

Question			Answer/Indicative content	Marks	Guidance
24	a		cookie 2 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 ☐	3 max	**ALLOW** ORA
	b		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 ☐	3	**IGNORE** "maggots will die“ because experiment is only for 2 minutes
			Total	**6**	