Respiration

Model Answers 2

Level	A Level
Subject	Biology
Exam Board	OCR
Module	Communication, homeostasis and energy
Topic	Respiration
Booklet	Model Answers 2

Time allowed: **73 minutes**

Score: **/54**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>69%	56%	50%	42%	34%	26%

Question 1

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

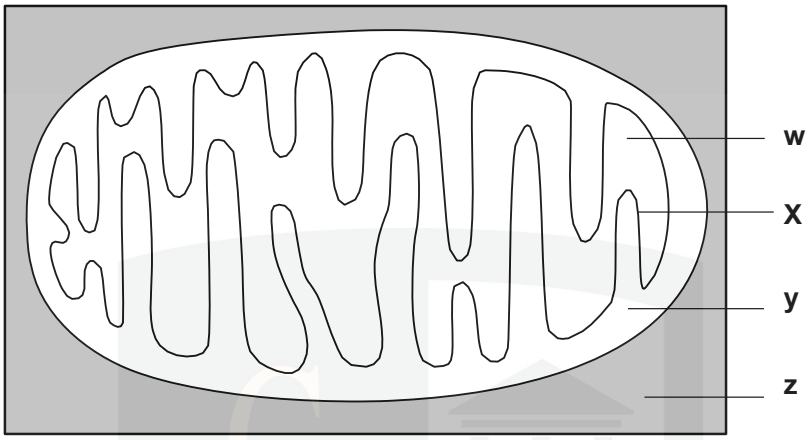


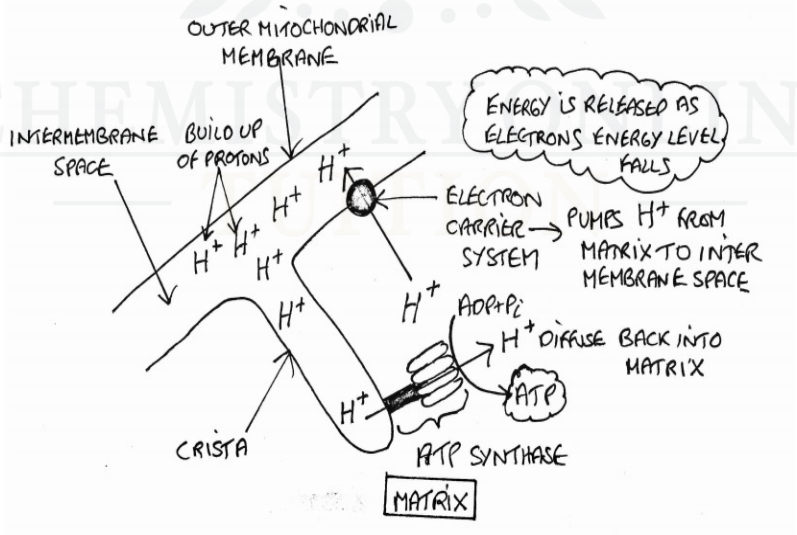
Fig. 3.1

(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	W	the matrix
glycolysis	Z	the cytoplasm
electron transport chain	X	the inner mitochondrial membrane/crista
Krebs cycle	W	the matrix

[4]



(ii) Why does aerobic respiration yield fewer molecules of ATP than the theoretical maximum? **[2]**

- Some of the ATP produced by aerobic respiration is used to transport to pyruvate into the mitochondrion
- Some of the energy released along the electron transport chain is released as heat and not used to transport hydrogen ions
- Not all the hydrogen ions diffuse back into the matrix through ATP synthase complexes

(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]**

- Anaerobic respiration only involves glycolysis, which is the conversion of glucose into pyruvate
- Only two molecules of ATP are made as a net result
- These ATPs are made by substrate level phosphorylation
- This is because oxygen is not available as the final electron acceptor
- Pyruvate must be reduced to lactate in animals, to regenerate NAD for glycolysis to continue
- During anaerobic respiration there is no electron transport chain or oxidative phosphorylation

The wording of this question seems rather vague, however you should know that only two molecules of ATP are made by anaerobic respiration and that It only involves glycolysis. You should also be aware why pyruvate or ethanal have to be reduced to lactic acid and ethanol. This question is basically asking you to write as much is you know about anaerobic respiration.

[Total : 11]

Question 2

(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 vegetables stored 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]**

- As temperature increases, the respiration rate increases
- The respiration rate doubles for a 10°C rise in temperature
- As temperature increases from 5°C to 15°C the rate of respiration increases from 21mg to 44 mg of carbon dioxide

In the results the respiration rate at 0° C was 17, which clearly doubles to 34 at 10°C, from 5° to 15°C it increases from 21 to 44, which is approximately double. Clearly 34 is double that of 17, but 44 is not quite double that of 21. However, the examiner is expecting you to make this observation. You may also note that as the temperature increases from 10°C to 20°C, the rate rises from 34 to 69, again approximately double. This feature of enzyme catalysed reaction is known as a Q_{10}

(ii) Discuss what the data in Table 5.1 indicate about the best conditions for storage of fruits and vegetables. . **[2]**

- Lower temperatures are the best conditions because the respiration rate is low
- 0°C or freezing could be best
- Freezing might be too low though as cells could be damaged
- For some foods, such as onions, temperature does not seem to matter
- Some of the data, such as potatoes and parsnips, some of the data is missing, so conclusions can't be made for these

The missing data, which is denoted with an asterix, is deliberate. It's included so that hopefully you will use this in your answer. Exam technique is the key to this question.

(iii) Identify, with reasons, which fruit or vegetable listed in Table 5.1 is **least** likely to spoil during storage. **[3]**

- Least likely to spoil is the onion
- Onion has the lowest respiration rate across all temperatures
- Onion can still be stored at room temperature or 20°C

(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]**

- Asparagus is the most difficult to keep fresh during storage
- The respiration rate is highest of all the foods across all temperatures

(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]**

- The parasites rely on their host for oxygen
- They live in the blood but in the plasma which has little dissolved oxygen
- Oxygen is combined with haemoglobin in the red blood cells
- Haemoglobin has a higher affinity for oxygen than the parasite

The only topic you have studied regarding the transport of oxygen in the blood is haemoglobin and oxygen dissociation curves. Every answer you give must include an aspect of theory you have covered and not just be a piece of fiction. Try to relate the demands of this question to the specification, even if at first it might not seem that obvious.

(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]

- In animals pyruvate is reduced to lactic acid / lactate
- No other steps are involved and only one product is formed
- Lactate dehydrogenase can therefore catalyse the reverse reaction
- In plants there are two steps including the removal of carbon dioxide
- Carbon dioxide is lost from the plant so carboxylase cannot catalyse the reverse reaction

[Total: 14]

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Question 3

(a) Adenosine tri-phosphate (ATP) is an important product of respiration. The ATP molecule is made up of five sub-units, as shown in Fig. 5.1.

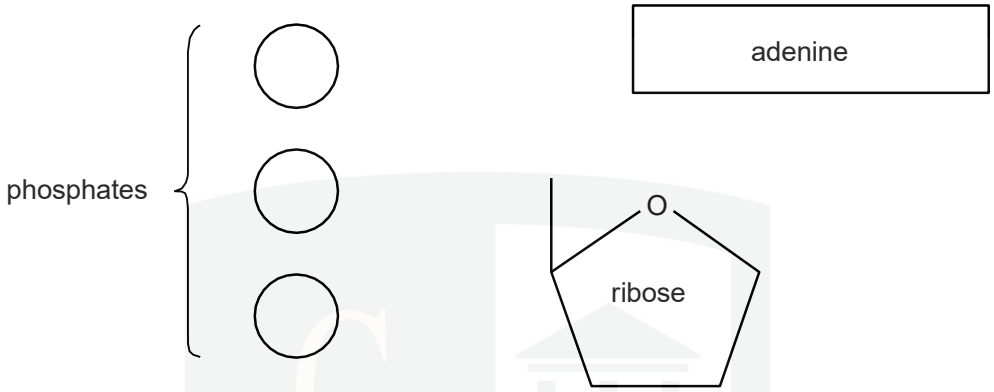
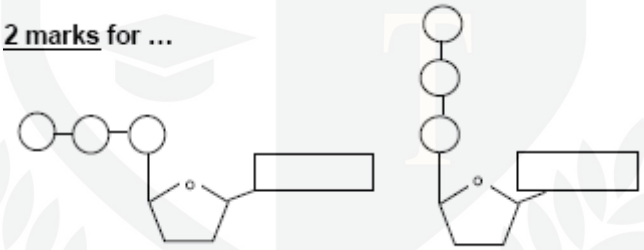


Fig. 5.1

(i) In the space below, indicate how these sub-units are joined in a molecule of ATP. **[2]**

2 marks for ...



(ii) Suggest the type of reaction that removes a phosphate group from an ATP molecule.

[1]

Hydrolysis

(b) The formation of ATP is now widely accepted as being achieved by the process of **chemiosmosis**.

Various pieces of evidence have been documented to support this theory. Three of these are described below.

1	In isolated mitochondria that have had their outer membranes removed, electron transfer takes place but the mitochondria are unable to produce ATP.
2	The pH of the inter-membrane space is lower than the pH inside the rest of the mitochondrion.
3	The outer mitochondrial membrane is permeable to protons. If isolated mitochondria are supplied with ADP and inorganic phosphate and placed in a solution of pH 8, no ATP is produced. If, however, these mitochondria are placed in an acidic solution, ATP is produced.

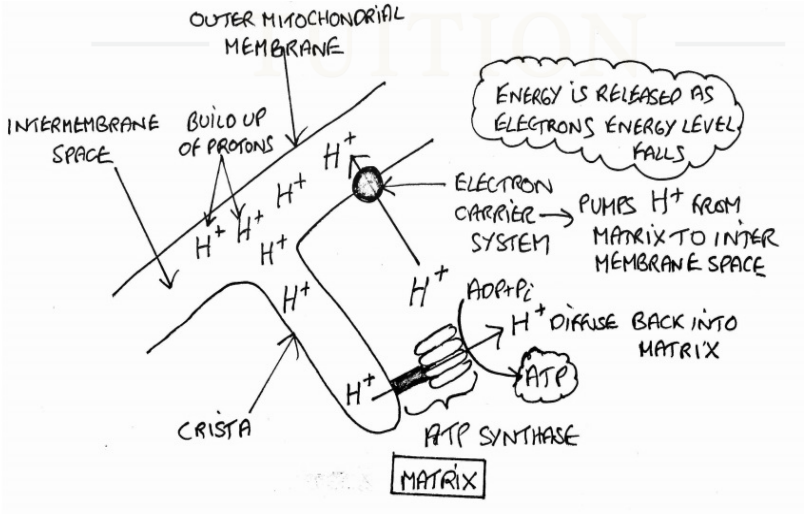
Identify the pieces of evidence above, **1**, **2** or **3**, that supports each of the following statements about the theory of chemiosmosis.

Write '**none**' if a statement is not supported by any of the pieces of evidence above.

(i) Electron transfer occurs on the inner membrane of the mitochondrion. 1 **[1]**

(ii) Protons are actively pumped across the inner mitochondrial membrane into the inter-membrane space. None **[1]**

(iii) Protons accumulate in the inter-membrane space. 2/3 **[1]**



[Total: 6]

Question 4

The compound 2,3,5-triphenyl-tetrazolium chloride (TTC) is an electron acceptor. TTC will diffuse into actively respiring cells and accept electrons from the electron transport chain.

When TTC accepts electrons and becomes reduced, it changes from colourless to pink. The tissues in which this reaction takes place will be stained a pink colour.

(a) State the **precise** location of the electron transport chain in the cell. **[1]**

The electron transport chain is in the inner mitochondrial membrane or cristae of the mitochondria

(b) A student carried out an investigation into the respiratory activity of plant tissue. She used three groups of germinating broad bean seeds. These were first treated as shown in Table 3.1.

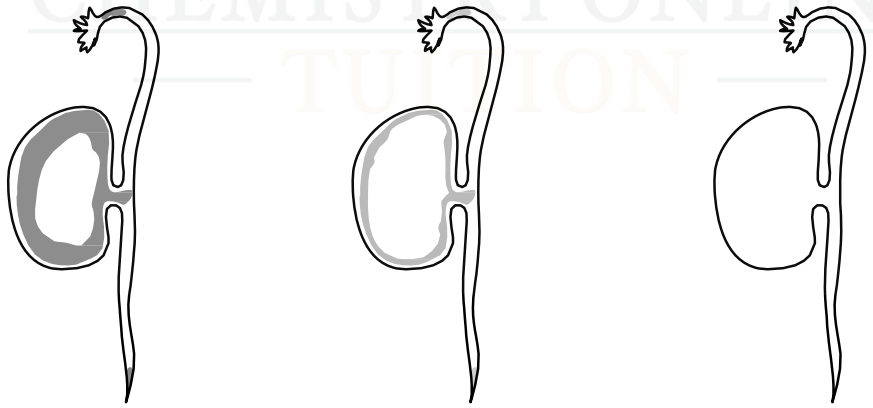
Table 3.1

seed	treatment
group **A**	kept at 22 °C for 24 hours before the investigation
group **B**	kept at 6 °C for 24 hours before the investigation
group **C**	kept at 22 °C for 24 hours and then placed in water at 90 °C for 5 minutes before the investigation

The groups of seeds were then sliced longitudinally and placed, cut surface down, in a shallow dish containing a small volume of TTC solution. The cut surfaces remained in contact with the solution for 10 minutes.

The seeds were then removed from the dish. The excess TTC solution was wiped off and the cut surfaces of the seeds in each group were observed.

The appearance of the seeds in each group is shown in Fig. 3.1. The shaded areas are the regions where the tissues have stained a pink colour.



seeds in group A **seeds in group B** **seeds in group C**

Fig. 3.1

(i) Describe the differences observed in the seeds in groups **A**, **B** and **C**. **[1]**

A has more stain B and C has none

(ii) Suggest reasons for the results observed in the seeds in group **A**. **[2]**

- The shaded areas in A are respiring
- 22° C is suitable temperature for respiration
- Reduced NAD is produced in glycolysis, the Link reaction and Krebs cycle
- At 22°C there are more electrons are transferred to TTC hence the pink colour in the tissues of group A

The compound in this investigation (TTC) accepts electrons at the end of the electron transport chain, so it indicates how much aerobic respiration is taking place. The electrons originate from the reduced NAD.

(iii) Suggest reasons for the difference in the amount of staining observed in the seeds in groups **B** and **C** when compared to those in group **A**. **[2]**

- Enzymes are involved in the stages of glycolysis, Link reaction and Krebs cycle
- Seeds B have less kinetic energy so they collide less frequently and from fewer enzyme/substrate complexes
- Enzymes in group C have been denatured by boiling

Remember that the examiner is on the look for 'enzyme/substrate complexes'! As soon as you see different temperatures being used you should be thinking about enzymes, don't forget about the biochemistry in this question.

(c) If oxygen is not present or is in short supply, respiration can take an anaerobic pathway **after glycolysis**. In plant cells, this pathway is the same as the one used in yeast cells.

(i) Name the hydrogen acceptor in this pathway. **[1]**

The hydrogen acceptor in plants during anaerobic respiration is ethanal.

(ii) Name the intermediate compound in this pathway. . **[1]**

- The intermediate compound in this pathway is also ethanal.

Stay with your convictions and don't be put off, even though you've just used ethanal in the last answer. And make sure you are clear in your answer that the 'a' in ethanal doesn't look like an'o'!

(iii) Name the products of this pathway. **[1]**

The products of the pathway are carbon dioxide and ethanol

(iv) Explain why this pathway is important for the plant cell. **[2]**

- The process releases NAD so it can be reduced again in glycolysis
- Same ATP is available for metabolic processes such active transport

Pyruvate from glycolysis is decarboxylated by the removal of carbon dioxide to ethanal, which is then reduced to ethanol. This recycles the NAD so it can continue to be involved in glycolysis where it accepts 2 hydrogen atoms, without this NAD glycolysis cannot take place so no ATP will be made.

[Total: 11]

Question 5

One way of calculating the rate of respiration is to measure the volume of oxygen taken up over a period of time.

A student carried out an experiment to investigate the effect of temperature on the rate of respiration in soaked (germinating) pea seeds and dry (dormant) pea seeds.

A simple piece of apparatus called a respirometer was used, as shown in Fig. 4.1.

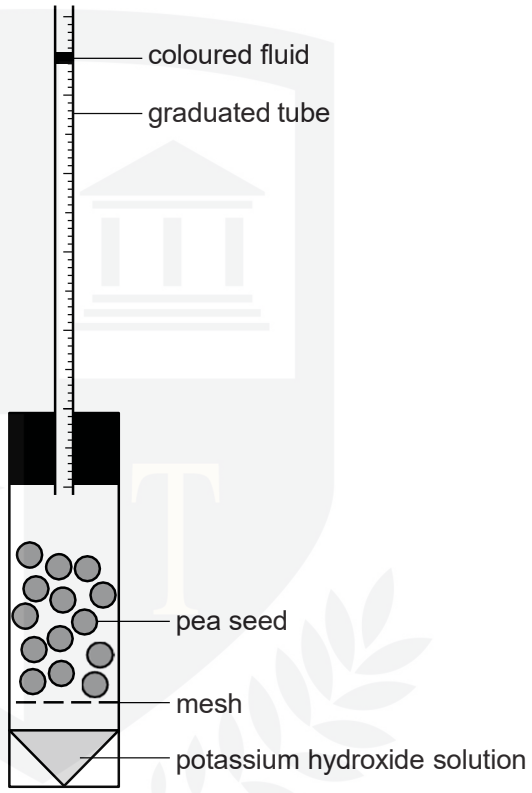


Fig. 4.1

The potassium hydroxide solution in this apparatus absorbs carbon dioxide. If the apparatus is kept at a constant temperature, any changes in the volume of air in the respirometer will be due to oxygen uptake.

(a) State the stage or stages of aerobic respiration during which:

(i) carbon dioxide is produced **[1]**

Link reaction and Krebs cycle

(ii) oxygen is used. **[1]**

Oxidative phosphorylation

(b) The student set up three respirometers, **A**, **B** and **C**, in water baths at two different temperatures. The respirometers were left for 10 minutes in order to equilibrate.

The contents of each respirometer are shown in Table 4.1.

Table 4.1

temperature (°C)	respirometer	contents
15	**A**	30 soaked pea seeds
	B	glass beads + 30 dry pea seeds
	C	glass beads
25	**A**	30 soaked pea seeds
	B	glass beads + 30 dry pea seeds
	C	glass beads

At each temperature, respirometer **C,** which contained only glass beads, was a control.

Respirometer **B**, at each temperature, also contained some glass beads.

(i) Suggest why, at each temperature, respirometer **B** contained **some** glass beads. **[2]**

- The glass beads are included to make the volume of the contents the same as that in the other respirometers
- The volume of the peas in A is greater than the volume of peas in B as they have been soaked in water
- Without the glass beads that would be a greater volume of air in B than in A

(ii) Suggest how the student determined the quantity of glass beads to place in respirometer **B** at each temperature.

[2]

- The student could determine the quantity of glass beads by finding the difference in volume between the soaked peas and dry peas
- The difference between the two represents the volume of glass bead required
- By calculating the volume of one bead you could determine the number of beads equivalent to the volume required

Another way to find the number needed would be to place the soaked peas in the test tube and add some water. Then set up another identical tube with the soaked peas and the same volume of water. Then to the tube containing the dried peas add glass beads until the volume is the same in both tubes

(c) After the student had left each respirometer to equilibrate, a small volume of coloured fluid was introduced into each graduated tube.

The respirometers were then left in the appropriate water baths for 20 minutes and maintained at the correct temperature. During this time, the coloured fluid in the graduated tube moved.

The level of the coloured fluid in each respirometer was recorded at the start of the experiment and after 20 minutes.

The results are summarised in Table 4.2.

Table 4.2

temperature (°C)	respirometer	reading at start (cm^3)	reading after 20 minutes (cm^3)	difference (cm^3)	corrected difference (cm^3)	rate of oxygen uptake ($cm^3 min^{-1}$)
15	**A**	0.93	0.74	0.19	0.16	0.008
	B	0.93	0.86	0.07	0.04	0.002
	C	0.91	0.88	0.03		
25	**A**	0.94	0.63	0.31	0.27	0.014
	B	0.93	0.84	0.09	0.05	0.003
	C	0.95	0.91	0.04		

(i) Table 4.2 is incomplete.

Calculate the missing value for the rate of oxygen uptake for soaked pea seeds (**A**) at **25 °C**.

Show your working. **[2]**

- 0.014

If you're not sure how to calculate this then look how they have calculated the other values, once you've worked this out then do the question the same way

(ii) Explain why there is an increased rate of respiration in soaked seeds at 25 °C compared with soaked seeds at 15 °C.

[2]

- At a higher temperature molecules have more kinetic energy
- Enzymes involved in respiration would then be more active and increase the rate of respiration

Remember any reference to the effect of a change in temperature is sure to involve enzymes at some point

(iii) Suggest a reason for the difference in the rate of respiration between soaked and dry pea seeds.

[2]

- All reactions in the cell take place dissolved in solution
- In solution enzymes and substrates can move and collide
- Soaked peas need more ATP
- Soaked peas are making more proteins and cell division is also taking place at an increased rate

This question is referring to 2 separate answers. The role of water in cells and why the rate of respiration of a soaked pea should be greater

[Total: 12]