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VCE Biology ¾

Cellular Respiration and Anaerobic Fermentation [2.2]

Test Solutions

42 Marks. 1 Minute Reading. 34 Minutes Writing.

Results:

Test Questions	_____ / 34
Extension	_____ / 8

Section A: Test Questions (34 Marks)

Question 1 (5 marks)

Tick whether the following statements are **True** or **False**.

	True	False
a. The main output of glycolysis is the production of 4 ATP molecules.		✓
Net gain is 2 ATP; 4 are produced, but 2 are used.		
b. The Krebs cycle occurs in the mitochondrial matrix.	✓	
c. Lactic acid fermentation in animals occurs in the mitochondria.		✓
It occurs in the cytoplasm.		
d. NADH and $FADH_2$ are electron carriers that donate electrons to the Electron Transport Chain.	✓	
e. Anaerobic fermentation produces more ATP than aerobic cellular respiration.		✓
Anaerobic produces 2 ATP; aerobic produces 36-38 ATP		
f. The cristae of the mitochondria increase the efficiency of ATP production by providing more surface area for the Electron Transport Chain.	✓	
g. In yeast, pyruvate is converted into ethanol and carbon dioxide during anaerobic fermentation.	✓	
h. Oxygen is the final electron acceptor in the Electron Transport Chain during aerobic respiration.	✓	
i. Biofuels are considered non-renewable because they are derived from fossil fuels.		✓
Biofuels are renewable as they come from organic biomass.		
j. Temperature has no impact on the rate of cellular respiration.		✓
Temperature affects enzyme activity, which influences respiration rates.		

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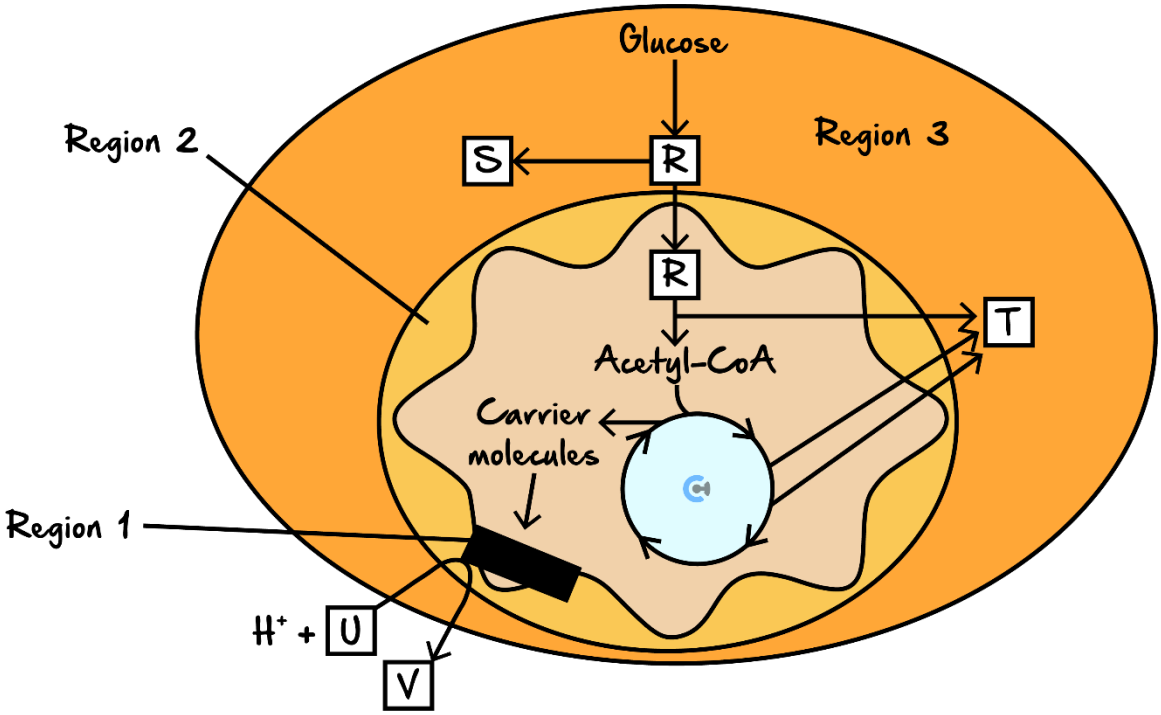
The following information applies to the four questions that follow

There are a number of ways in which an animal cell is able to use compounds such as glucose to produce the energy that it needs to be able to function. The diagram below outlines the general metabolic pathways for cellular respiration in an animal cell.



Question 2 (1 mark)

Which process occurs in **Region 2** of the diagram?

A. Glycolysis

B. Krebs cycle

C. Electron Transport Chain

D. Alcoholic fermentation

Question 3 (1 mark)

What is the role of acetyl-CoA as shown in the diagram?

A. It acts as the final electron acceptor in the Electron Transport Chain.

B. It is an intermediate product that enters the Krebs cycle.

C. It is a byproduct of glycolysis in the cytoplasm.

D. It is a molecule that carries oxygen to the mitochondria.

Question 4 (1 mark)

What is represented by **Region 1** in the diagram?

A. Cytoplasm where glycolysis occurs.

B. Matrix of the mitochondria where the Krebs cycle takes place.

C. Cristae of the mitochondria where the Electron Transport Chain operates.

D. Nucleus of the cell where transcription happens.

Question 5 (1 mark)

Which of the following gives the correct names of compounds ***S***, ***T***, and ***U***, shown in the first diagram above?

	S	***T***	***U***
A.	Glucose	NADH	ATP
B.	Glucose	Carbon dioxide	Oxygen
C.	Pyruvate	NADH	Oxygen
D.	Pyruvate	Carbon dioxide	ATP

Question 6 (1 mark)

Fermentation of grapes is used in agriculture to produce wine. The bottles are tightly sealed and make a noticeable 'pop' when opened, with bubbles forming throughout the liquid. The bubbles are due to:

A. Oxygen being produced in the electron transport chain.

B. Carbon dioxide and lactic acid being produced.

C. Carbon dioxide being produc

D. The splitting of water in the li

Explanation:

Carbon dioxide is produced as well as ethanol in the anaerobic pathway in plants. This gas creates the bubbles and pop in wine.

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Question 7 (1 mark)

The action of ATP synthase decreases when the ATP concentration is high. One consequence in human cells is that the rate of anaerobic respiration increases.

Which one of the following consequences would be expected to occur due to the increase in the rate of anaerobic respiration?

A. Oxygen intake will increase.

B. Ethanol concentration in cells will increase.

C. Lactic acid concentration in cells will increase.

D. Carbon dioxide concentration in cells will increase.

Question 8 (1 mark)

E10 fuel, sold at most Victorian service stations, contains:

A. Alcohol from fermentation of sugar cane mixed with petroleum.

B. Synthetic petroleum produced by genetically modified *E coli* bacteria.

C. Transesterified lipids, made by reacting vegetable oils with ethanol.

D. Petrol which has been modified by an enzyme to reduce the toxicity of exhaust.

Question 9 (1 mark)

Glycolysis is part of aerobic respiration. Glycolysis:

A. Is the second stage of aerobic respiration.

B. Can only occur when mitochondria are present.

C. Results in the formation of pyruvate.

D. Releases three molecules of ATP for each glucose molecule used up.

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Question 10 (1 mark)

Cellular respiration can be summarised in one chemical equation but this is a shorthand way of representing many chemical reactions that occur in a series of stages.

Which statement concerning the stage of electron transport is correct?

A. For each glucose molecule that enters the Krebs cycle, five loaded acceptor molecules enter the electron transport reactions.

B. Electron transport occurs on the outer membrane of the mitochondria.

C. Electrons from the loaded acceptor molecules enable oxygen to combine with hydrogen to form water.

D. For each molecule of glucose consumed in glycolysis, 36 ATP molecules are produced in the electron transport reactions.

Question 11 (1 mark)

Fungal cells produce energy through anaerobic respiration. The products of anaerobic respiration, in this example, include:

A. Carbon dioxide, water and ATP.

B. Glucose, oxygen and water.

C. NADH, carbon dioxide and ATP.

D. Ethanol, carbon dioxide and ATP.

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Sub-Section: Short Answer Questions

Question 12 (8 marks)

2,4-dinitrophenol is a chemical that is toxic to mitochondria. When added to mitochondria this chemical allows electron transport to occur but prevents the phosphorylation of ADP to ATP. The chemical achieves this by breaking the essential link between electron transport and ATP synthesis. This toxin causes mitochondria to produce heat instead of ATP. The greater the amount of toxin added, the quicker its action.

a. If mitochondria are poisoned with 2,4-dinitrophenol by what process could a plant cell produce more ATP? (1 mark)

Question 4
This question required students to have an understanding of the various types of respiration, in particular the different stages of aerobic respiration. Students demonstrated a poor

Question 4a.

Marks	0	1	Average
%	61	39	0.4

Acceptable answers were anaerobic respiration, glycolysis or fermentation.

The most common incorrect answers given were photosynthesis and aerobic respiration.

b. Where in the mitochondria does electron transport

Question 4b.

Marks	0	1	Average
%	55	45	0.5

Cristae, inner membranes or membrane folds needed to be specified; simply stating 'membranes' was not sufficient.

A common incorrect response was grana.

A researcher wanted to study cellular respiration in insect cells. She cultured some muscle cells from the common field cricket, Teleogryllus oceanicus, and then studied the effects of adding 2,4-dinitrophenol to these cells. An agricultural company may want to fund this research.

c. Give one reason why an agricultural company might want to fund research on the effects of this toxin on field crickets. (1 mark)

Question 4c.

Marks	0	1	Average
%	25	75	0.8

Any of the following answers were accepted:

- field crickets eat crops
- the compound may be effective as a pesticide/insecticide against crickets
- the chemical may be used to get rid of crickets.

The Experiment is summarised in the table below. Temperature observations in each trial were made at equal time intervals.

Observations made at equal time intervals	**Temperature** ℃		
	Control (no 2,4-dinitrophenol)	Trial 1 (2,4-dinitrophenol added)	Trial 2
1 (start)	28	28	28
2	27	28	29
3	28	29	
4	29	31	
5	28	36	
6	28	23	
7	27	21	

d. In terms of energy production, why did the temperature go up in trial 1 and not in the control? (1 mark)

Question 4d.

Marks	0	1	Average
%	67	33	**0.4**

The presence of 2,4-dinitrophenol caused trial 1 to produce heat (instead of ATP). There was no chemical in the control group, therefore ATP was produced, not heat.

The two situations had to be compared in order to gain the mark.

e. Explain why the temperature went down after the fifth observation in trial 1. (1 mark)

Question 4e.

Marks	0	1	Average
%	78	22	**0.2**

The enzyme denatured, or an increase in heat killed/damaged the cells.

Students who gave poor expressions such as 'enzymes dying' or 'chemical is used up' received no credit.

f. Trial 2 had twice the concentration of 2,4-dinitrophenol added. Compare the table by writing in temperatures in the spaces provided to predict the trend. (2 marks)

Question 4f.

Marks	0	1	2	Average
%	11	59	30	**1.2**

Students needed to indicate an initial rise in the temperature occurring faster than in trial 1 and a decline that commenced no later than time interval 5. Two examples of appropriate sequences for trial 2 (from the commencement) include 28, 29 30, 36, 23, 21, 19 and 28, 29, 36, 30, 28, 24, 19.

This part of the question was generally well answered.

Another researcher suggested adding pyruvate to the cells to cancel out the effects of this toxin.

g. Explain what effect adding pyruvate would have on cancelling out the effect of this toxin. (1 mark)

Question 4g.

Marks	0	1	Average
%	84	16	**0.2**

Various answers to this question were possible, depending on when the pyruvate was to be added.

- If it was added at the beginning of the experiment, there would be no effect because pyruvate is used before the electron transport process.
- If the pyruvate was added after the experiment, there would be no effect because the toxin has already destroyed the enzymes or cricket cells (many students wrote crickets in error).
- If the answer referred to Krebs Cycle, there may have some ATP as replacement by the addition of pyruvate.

Stating that some ATP would be produced independent of electron transport was also acceptable.

Question 13 (3 marks)

a. Write the word or chemical equation for aerobic cellular respiration. (1 mark)

Question 7a.

Marks	0	1	Average
%	44	56	**0.6**

Either of:

- glucose + oxygen→carbon dioxide + water
- $C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2$

Energy/ATP was not required to gain the mark. Some students did not have the correct products and reactants.

b. Cyanide inactivates metabolic reactions at the cristae of mitochondria. Cyanide poisoning often results in death. Explain why. (2 marks)

Question 7b.

Marks	0	1	2	Average
%	44	25	31	**0.9**

Both of:

- the electron transport chain would be unable to provide larger amounts of ATP
- there would be insufficient energy available to maintain life.

An answer such as 'There would be no energy available to the cell' was incorrect as glycolysis, anaerobic respiration and the Kreb's cycle would produce some ATP. Writing 'this would result in death of the cell' was simply repeating the stem of the question.

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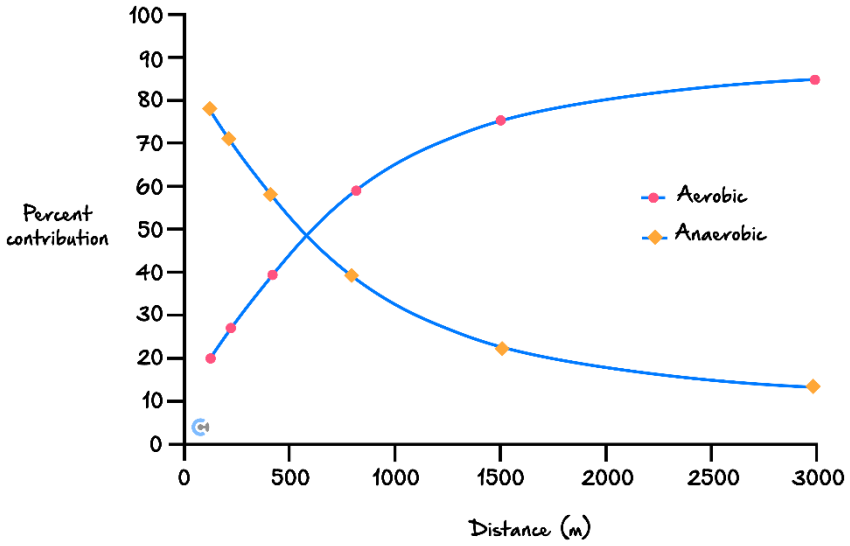
Question 14 (8 marks)

Elite runners use both anaerobic and aerobic systems to complete their running events. A series of measurements of the anaerobic and aerobic contributions over distances ranging from 100 m to 3000 m of elite male runners were made. The runners exercised as intensely as possible and the data gained is illustrated in the graph below.



a.

i. What is the balanced chemical equation for aerobic respiration? Include any energy conversions that are part of the reaction. (2 marks)

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ 1 mark

$36/38ADP + 36/38Pi \rightarrow 36/38ATP$ 1 mark

ii. Describe one difference between anaerobic and aerobic respiration. (1 mark)

Any one of:

- aerobic produces 38 ATP compared to anaerobic which produces 2 ATP
- aerobic occurs slower than anaerobic
- aerobic produces CO_2 and H_2O and anaerobic produces lactic acid
- aerobic is longer lasting than anaerobic

1 mark

iii. How far would an athlete need to run if he was depending equally on the contribution of aerobic and anaerobic respiration? (1 mark)

550 m (give or take about 25 m)

b. Explain which system elite athletes rely on when completing a 3000 m race. (2 marks)

b. Athletes have about a 90% reliance on aerobic and 10% reliance on anaerobic respiration. 1 mark
This is most efficient at providing maximum amount of ATP (38 ATP per glucose) (with maximum sustainable effort for that distance. 1 mark

Elite runners are always looking for new training strategies to improve their performance in particular running events. Coaches help to develop training schedules that provide an opportunity for better results.

c. Describe a training schedule that could be offered to an elite 100 m athlete to improve their performance. Use the data gained from the graph to support your answer. (2 marks)

Reliance is mainly on anaerobic respiration (about 80%), so a strength-based training schedule would be best, 1 mark
such as building up muscle using weights
OR
repetitive maximum effort short sprints. 1 mark

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Section B: Extension (8 Marks)

Question 15 (8 marks)

Wine is traditionally produced in glass bottles sealed with a cork. When a bottle of wine is opened, the cork is often sniffed to detect whether the wine has 'gone off'. This is usually caused by the cork not sealing the bottle correctly and air getting in. Wine that has 'gone off' will have an unpleasant smell, and will also have little or no alcoholic content.

a. Name the process that would normally occur within the wine to produce the alcohol. (1 mark)

Fermentation

b. Explain what occurs when the wine has access to air due to the presence of a poor-quality cork. (2 marks)

Oxygen enters the wine **(1 mark)** and the yeast present carries out aerobic cellular respiration as a consequence **(1 mark)**.

c. Write a word equation for the process identified in **part b.** (1 mark)

glucose and oxygen → carbon dioxide and water **(1 mark)**.

d. Suggest a reason why the normal process of alcohol production is less likely to occur once air has entered the wine bottle. (3 marks)

Yeasts are facultative anaerobes and use fermentation when oxygen is absent and aerobic cellular respiration when oxygen is available **(1 mark)**. Aerobic cellular respiration produces 36-38 ATPs per molecule of glucose compared to 2 ATPs produced per molecule of glucose by fermentation **(1 mark)**. Since aerobic cellular respiration is more productive in terms of ATP production, the yeast will use this option rather than fermentation when oxygen is available **(1 mark)**.

e. Wine rarely exceeds 14% alcohol content despite there being an excess of natural sugars available and many years of storage. Suggest what occurs during this process that limits the alcohol content. (1 mark)

High levels of alcohol kill the yeast cells, thereby stopping any further fermentation **(1 mark)**.

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