1.20 Respiration, Exercise and Metabolism: 1-hour Pack

AQA 8464 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Yeast cells are single-celled fungi that can respire without oxygen. This process is called fermentation.

(a) State the word equation for anaerobic respiration (fermentation) in yeast cells. **(2)**

(b) Give one industrial use of fermentation by yeast. **(1)**

(Total for Question 1 is 3 marks)

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2 Metabolism is the sum of all the reactions taking place in a cell or in the body.

(a) Define metabolism. **(1)**

(b) Name the storage carbohydrate that excess glucose is converted into in the liver and muscles. **(1)**

(c) State what happens to glucose that is not needed for respiration or converted into glycogen. **(1)**

(d) Explain, in terms of metabolism, why taking regular exercise can help a person control their body mass. **(2)**

(Total for Question 2 is 5 marks)

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3 Metabolism includes reactions that build larger molecules from smaller ones, and reactions that break large molecules down.

(a) Name the two types of molecule that combine to form lipids (fats and oils) in metabolism. **(2)**

(b) Describe how plants use glucose and nitrate ions to make amino acids, and how amino acids then form proteins. **(2)**

(c) Excess amino acids in the human body cannot be stored, so they are broken down in the liver. Name this process, name the waste product formed, and state how this waste product is removed from the body. **(2)**

(Total for Question 3 is 6 marks)

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4 The table shows the resting metabolic rate (RMR) of four people with different amounts of muscle mass.

Person	Muscle mass (kg)	Resting metabolic rate (kJ per day)
Kwame	25	6800
Olivia	30	7400
Mei	22	6300
Dafydd	34	7900

(a) Describe the relationship shown by the data between muscle mass and resting metabolic rate. **(2)**

(b) Suggest, in terms of respiration, why a person with more muscle mass has a higher resting metabolic rate. **(2)**

(c) A personal trainer claims: 'Building muscle through exercise will increase how much energy a client uses even when resting.' Using the data, evaluate this claim. **(2)**

(Total for Question 4 is 6 marks)

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5 A 400 m runner sprints as fast as possible for the whole race. A marathon runner runs at a much slower, steady pace for over two hours.

Compare the type of respiration used by the two runners' leg muscles, and explain what happens in the sprinter's body during and after the race to deal with the effects of anaerobic respiration.

(Total for Question 5 is 6 marks)

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6 A student investigated the rate of anaerobic respiration in yeast by measuring the volume of carbon dioxide gas produced in 5 minutes at different temperatures, using flasks of yeast and glucose solution connected to a gas syringe.

Temperature (°C)	Volume of CO_2 collected in 5 minutes (cm^3)
10	4
20	12
30	26
40	30
50	6

(a) Calculate the mean rate of carbon dioxide production at 30°C, in cm^3 per minute. **(2)**

.....

(b) Describe the trend shown by the results between 10°C and 40°C. **(2)**

.....

.....

(c) Explain, in terms of enzymes, why the volume of carbon dioxide produced falls at 50°C compared with 40°C. **(3)**

.....

.....

.....

(Total for Question 6 is 7 marks)

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7 Higher tier only. The word equation for aerobic respiration can also be written as a balanced symbol equation.

(a) Balance the symbol equation for aerobic respiration by writing the correct number in front of each formula where needed: $C_6H_{12}O_6$ + __O2 -> __CO2 + __H2O **(3)**

(Total for Question 7 is 3 marks)

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8 Complete the table below to compare aerobic and anaerobic respiration in human muscle cells. Each lettered blank is worth one mark.

Feature	Aerobic respiration	Anaerobic respiration (muscles)
Oxygen needed?	(i)	(ii)
Waste product(s)	carbon dioxide and water	(iii)
Relative energy released per glucose molecule	(iv)	less
Can it be sustained for a long period of exercise?	(v)	(vi)

(Total for Question 8 is 6 marks)

9 During exercise, several changes take place in the body to help meet the increased demand for energy in muscle cells.

(a) Describe how breathing rate and breath volume change during exercise. **(2)**

(b) Explain why breathing rate and breath volume increase during exercise. **(2)**

(c) Explain why heart rate increases during exercise. **(2)**

(Total for Question 9 is 6 marks)

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Mark scheme · 1.20 Respiration, Exercise and Metabolism: 1-hour Pack

Question 1

(a) glucose as the only reactant **B1**

(a) ethanol and carbon dioxide as the two products **B1**

(a) Answer: glucose -> ethanol + carbon dioxide

(b) any correct use, e.g. brewing beer/wine (ethanol production) or bread-making (carbon dioxide makes the dough rise) **B1**

(b) Answer: Brewing, to produce alcoholic drinks, or bread-making, where the carbon dioxide produced makes the dough rise.

Question 2

(a) the sum of all the chemical reactions in a cell or the body, oe **B1**

(a) Answer: The sum of all the chemical reactions that take place in a cell, or in the body (oe).

(b) glycogen **B1**

(b) Answer: Glycogen.

(c) it is converted into fat/lipid for storage, oe **B1**

(c) Answer: It is converted into fat (lipid) and stored in the body.

(d) exercise increases the rate of aerobic respiration in muscle cells, so more glucose is broken down for energy rather than stored, oe **B1**

(d) exercise increases overall metabolic rate/energy use; if energy used is greater than energy taken in from food, stored glycogen and fat are broken down, reducing body mass, oe **B1**

(d) Answer: Exercise increases the rate of respiration in muscle cells, so more glucose is used for energy rather than being stored as glycogen or fat. It also raises the body's overall metabolic rate, so more energy is used; if this energy use is greater than the energy taken in from food, stored glycogen and fat reserves are broken down, helping to control body mass (oe).

Question 3

(a) glycerol **B1**

(a) fatty acids **B1**

(a) Answer: Glycerol and fatty acids.

(b) glucose is combined with nitrate ions, absorbed from the soil, to form amino acids, oe **B1**

(b) amino acids are joined together in long chains to form proteins, oe **B1**

(b) Answer: Plants combine glucose with nitrate ions, absorbed from the soil through their roots, to form amino acids. These amino acids are then joined together in long chains to form proteins (oe).

(c) deamination, producing urea **B1**

(c) urea is removed by the kidneys, in urine, oe **B1**

(c) Answer: The process is deamination, which produces urea. Urea is removed from the body by the kidneys, as a component of urine (oe).

Question 4

(a) as muscle mass increases, resting metabolic rate increases (positive correlation), oe **B1**

(a) reference to data, e.g. Mei has the lowest muscle mass (22 kg) and lowest RMR (6300 kJ/day), while Dafydd has the highest muscle mass (34 kg) and highest RMR (7900 kJ/day) **B1**

(a) Answer: There is a positive correlation: as muscle mass increases, resting metabolic rate increases. Mei has the lowest muscle mass (22 kg) and the lowest RMR (6300 kJ/day), while Dafydd has the highest muscle mass (34 kg) and the highest RMR (7900 kJ/day).

(b) muscle tissue is more metabolically active than fat tissue / contains more mitochondria, oe **B1**

(b) so more cells are respiring aerobically, releasing more energy even at rest, increasing metabolic rate, oe **B1**

(b) Answer: Muscle tissue is more metabolically active than fat tissue and contains more mitochondria, so even at rest more cells are respiring aerobically and releasing energy, giving a person with more muscle mass a higher resting metabolic rate (oe).

(c) the data supports the claim, as there is a clear positive trend between muscle mass and RMR across all four people, oe **B1**

(c) limitation, e.g. only four people were compared, or other factors such as age, sex or genetics that could also affect RMR were not controlled, so the data alone cannot prove the trend is caused only by muscle mass, oe **B1**

(c) Answer: The data does support the trainer's claim, since resting metabolic rate rises consistently as muscle mass increases across all four people. However, only four people were compared, and other factors that can affect RMR, such as age, sex or genetics, were not controlled, so this small dataset alone cannot prove that muscle mass is the only cause of the differences seen (oe).

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Question 5

Level 1 Basic, isolated statement(s) about one type of respiration or one runner, with little or no explanation. The answer may be a simple list. **1-2**

Level 2 Some accurate comparison between the two runners' respiration and/or some explanation of the sprinter's recovery, but the answer is incomplete or the links between ideas are not always clear. **3-4**

Level 3 A clear, logically structured comparison of aerobic and anaerobic respiration in the two runners, with a detailed and correctly linked explanation of oxygen debt and how the sprinter's body recovers. **5-6**

Indicative content:

- The marathon runner's steady pace means oxygen supply can meet demand, so their leg muscles respire aerobically for the whole race
- Aerobic respiration completely breaks glucose down using oxygen, releasing a large amount of energy, and can be sustained for a long time
- The sprinter's all-out effort means oxygen demand in the leg muscles is greater than the oxygen that can be supplied
- So the sprinter's leg muscles respire anaerobically, breaking glucose down without oxygen
- Anaerobic respiration releases much less energy per glucose molecule and produces lactic acid instead of carbon dioxide and water
- Anaerobic respiration can only be sustained for a short time before lactic acid builds up and causes muscle fatigue/cramp
- After the race, the sprinter's breathing rate and heart rate remain high to repay an oxygen debt
- The oxygen debt is the extra oxygen needed to break down/oxidise the lactic acid that built up in the muscles, e.g. by converting it back to glucose in the liver
- The marathon runner will have little or no oxygen debt to repay because their muscles mostly respired aerobically throughout the race

Question 6

(a) 26 / 5 **M1**

(a) 5.2 cm^3 per minute cao **A1**

(a) Answer: 5.2 cm^3 per minute

(b) as temperature increases from 10 to 40°C, the volume of CO_2 produced (rate of respiration) increases, oe **B1**

(b) reference to data, e.g. from 4 cm^3 at 10°C to 30 cm^3 at 40°C **B1**

(b) Answer: As temperature increases from 10°C to 40°C, the volume of carbon dioxide produced, and so the rate of anaerobic respiration, increases, from 4 cm^3 at 10°C up to 30 cm^3 at 40°C.

(c) the enzymes involved in respiration have gained more kinetic energy and are vibrating more, oe **B1**

(c) this breaks the bonds holding the enzyme's (tertiary structure/active site) shape, so the enzyme denatures, oe **B1**

(c) the substrate (glucose) can no longer fit/bind to the active site, so the rate of reaction decreases, oe **B1**

(c) Answer: At 50°C the respiratory enzymes in the yeast cells have gained enough kinetic energy to vibrate more, breaking the bonds that hold their active site in shape. The enzymes denature and their active sites change shape, so glucose can no longer bind to them, and the rate of respiration (and CO_2 production) falls (oe).

Question 7

(a) $6O_2$ on the reactant side **B1**

(a) $6CO_2$ on the product side **B1**

(a) $6H_2O$ on the product side **B1**

(a) Answer: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Question 8

(i) yes **B1**

(ii) no **B1**

(iii) lactic acid **B1**

(iv) more **B1**

(v) yes, as long as oxygen supply is sufficient, oe **B1**

(vi) no, only for short bursts, because lactic acid builds up and causes fatigue, oe **B1**

Answer: (i) yes (ii) no (iii) lactic acid (iv) more (v) yes (vi) no, only for short bursts, because lactic acid builds up and causes muscle fatigue.

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Question 9

(a) breathing rate increases **B1**

(a) breath volume (depth of breathing) increases **B1**

(a) Answer: Both breathing rate and breath volume increase during exercise.

(b) to take in more oxygen (and remove carbon dioxide) more quickly, oe **B1**

(b) to supply the muscles' increased demand for aerobic respiration, oe **B1**

(b) Answer: Increased breathing rate and breath volume bring more oxygen into the blood and remove carbon dioxide more quickly, to supply the muscles' increased demand for aerobic respiration (oe).

(c) blood is pumped around the body faster/more often, oe **B1**

(c) to deliver oxygen and glucose to the muscles faster and to remove carbon dioxide and lactic acid faster, oe **B1**

(c) Answer: A faster heart rate pumps blood around the body more quickly, delivering oxygen and glucose to the muscles faster and removing waste products, such as carbon dioxide and lactic acid, more quickly (oe).

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