B4bD Respiration, Exercise and Metabolism: Exam Drill

AQA 8464 · Calculator allowed · about 90 minutes

Total Marks

Name: ______________________________ Date: ____ / ____ / ______

Answer ALL questions. Show all your working.

1 Cells obtain energy from food by a process called respiration.

(a) State two differences between aerobic respiration and anaerobic respiration in animal cells. **(2)**

(b) Give the waste product produced in human cells during anaerobic respiration. **(1)**

(Total for Question 1 is 3 marks)

2 A student measures their breathing rate at rest and after moderate exercise. They count breaths per minute. The student records 12 breaths per minute at rest and 28 breaths per minute immediately after exercise.

(a) Calculate the percentage increase in breathing rate caused by the exercise. Give your answer to one decimal place. **(2)**

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(b) Give one physiological reason why breathing rate increases during exercise. **(1)**

(Total for Question 2 is 3 marks)

3 The overall word equation for aerobic respiration in cells is:

(a) State the missing product of aerobic respiration shown above that is not water. **(1)**

(b) State the purpose of glucose in respiration. **(1)**

(Total for Question 3 is 2 marks)

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4 During intense exercise some muscle cells respire anaerobically. A sample of muscle produces 18 mmol of lactate in 10 minutes.

(a) Calculate the rate of lactate production in mmol per minute. **(2)**

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(b) Suggest one effect on muscle function of accumulating lactate during prolonged intense exercise. **(1)**

(Total for Question 4 is 3 marks)

5 A student investigates the effect of exercise intensity on breathing volume. They measure tidal volume (the volume of air per breath) and breathing rate for walking and for running. Their results are shown below.

Walking: tidal volume 0.6 litres, breathing rate 14 breaths per minute.
Running: tidal volume 2.0 litres, breathing rate 28 breaths per minute.

Use the equation ventilation rate = tidal volume x breathing rate.

(a) Calculate the ventilation rate in litres per minute for walking. Give your answer to two significant figures. **(2)**

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(b) Calculate the ventilation rate in litres per minute for running and state how many times larger it is than for walking. Give the ratio to one decimal place. **(2)**

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(Total for Question 5 is 4 marks)

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6 The required practical 'effect of exercise on heart rate' involves measuring pulse before and after exercise. In one trial a student recorded resting heart rate 64 beats per minute, immediately after 3 minutes of step-ups the heart rate was 128 beats per minute, and after 6 minutes rest it was 78 beats per minute.

(a) Describe one control variable the student should keep the same between trials and explain why. **(2)**

(b) Suggest one safety precaution that should be included for this practical and give the reason. **(1)**

(Total for Question 6 is 3 marks)

7 A respiration experiment measures oxygen consumption of yeast under aerobic and anaerobic conditions. Results for one trial are shown: aerobic oxygen consumed 2.4 cm3 in 10 minutes; anaerobic oxygen consumed 0.0 cm3 in 10 minutes. The experiment used the same mass of yeast and same glucose concentration.

(a) Explain why oxygen consumption is greater in the aerobic trial compared with the anaerobic trial. **(2)**

(b) Give one improvement to the method that would make the comparison between aerobic and anaerobic trials fairer. **(2)**

(Total for Question 7 is 4 marks)

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8 Metabolism includes many enzyme-controlled reactions. One example is converting excess glucose to glycogen for storage in the liver.

(a) Describe the role of enzymes in metabolism. **(2)**

(b) Give one example of an anabolic process in human metabolism other than glycogen formation. **(1)**

(Total for Question 8 is 3 marks)

9 A student measures oxygen uptake of a small mammal at rest. They use the equation energy released per mole of O2 = 470 kJ. The mammal consumes 0.012 moles of O2 per hour at rest. Calculate the energy released per hour from respiration at rest.

(a) Calculate the energy released per hour in kilojoules. Give your answer to three significant figures. **(3)**

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(b) State one reason why this calculated energy might underestimate the mammal's true metabolic energy expenditure. **(1)**

(Total for Question 9 is 4 marks)

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10 A graph shows heart rate recovery after exercise. At time 0 recovery heart rate is 150 beats per minute, at 1 minute it is 120 bpm, at 3 minutes it is 90 bpm, at 6 minutes it is 75 bpm. Use this data to estimate the half-life of the excess heart rate above resting level if resting heart rate is 60 bpm.

(a) Calculate the excess heart rate at time 0 and at 3 minutes. Then estimate the time it takes for the excess to halve. **(3)**

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(Total for Question 10 is 3 marks)

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11 Higher only: Balance the chemical equation for anaerobic respiration in yeast (fermentation) that produces ethanol and carbon dioxide from glucose.

(a) Balance the symbol equation for fermentation: C6H12O6 -> C2H5OH + CO2 **(4)**

(Total for Question 11 is 4 marks)

12 A student is troubleshooting a respiration practical where a gas syringe should measure CO2 produced by germinating seeds. They notice the syringe reading increases when the seeds are removed, which is unexpected.

(a) Suggest two possible experimental errors or reasons that could cause the syringe reading to increase when seeds are removed. **(2)**

(b) Give one improvement to reduce the chance of this error occurring. **(1)**

(Total for Question 12 is 3 marks)

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13 Metabolic rate varies with activity and with body mass. State two factors, other than exercise, that can increase basal metabolic rate.

(a) Give two factors that increase basal metabolic rate. **(2)**

(Total for Question 13 is 2 marks)

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14 A fitness coach compares recovery heart rates for two athletes after the same exercise. Athlete A recovery heart rate after 5 minutes is 70 bpm, Athlete B recovery heart rate after 5 minutes is 86 bpm. Resting heart rate for both is 56 bpm. The coach defines 'percent recovery' as (reduction in heart rate from peak to 5 min) / (peak - resting) x 100. For both athletes peak heart rate immediately after exercise was 160 bpm.

(a) Calculate percent recovery for Athlete A and Athlete B. Give answers to one decimal place. **(3)**

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(Total for Question 14 is 3 marks)

15 Explain how and why the body changes the supply of oxygen and glucose to muscle cells during the transition from rest to vigorous exercise. In your answer include references to the circulatory and respiratory systems and to changes at the cellular level. Use the data in earlier questions where helpful.

(Total for Question 15 is 6 marks)

Mark scheme · B4bD Respiration, Exercise and Metabolism: Exam Drill

Question 1

- (a) **B1** aerobic uses oxygen; anaerobic does not use oxygen, oe
- (a) **B1** aerobic produces more ATP per glucose than anaerobic, oe
- **(a) Answer: Aerobic uses oxygen while anaerobic does not; aerobic produces more ATP per glucose than anaerobic.**
- (b) **B1** lactic acid (lactate) cao
- **(b) Answer: Lactic acid (lactate)**

Question 2

- (a) **M1** substitutes into percentage change: (28 - 12) / 12 x 100
- (a) **A1** 133.3% cao
- **(a) Answer: 133.3%**
- (b) **B1** to increase oxygen uptake for increased aerobic respiration/energy release, oe
- **(b) Answer: To increase oxygen uptake for increased aerobic respiration and energy release.**

Question 3

- (a) **B1** carbon dioxide cao
- **(a) Answer: Carbon dioxide**
- (b) **B1** to provide a chemical store of energy (oxidised to release energy for ATP), oe
- **(b) Answer: To provide a store of chemical energy that is released during respiration.**

Question 4

- (a) **M1** substitutes: rate = 18 mmol / 10 min
- (a) **A1** 1.8 mmol per minute cao
- **(a) Answer: 1.8 mmol per minute**
- (b) **B1** muscle fatigue or cramp or decreased contraction efficiency due to lowered pH, oe
- **(b) Answer: Muscle fatigue or cramp due to accumulation of lactate lowering pH and reducing contraction efficiency.**

Question 5

- (a) **M1** substitutes: ventilation = 0.6 x 14
- (a) **A1** 8.4 litres per minute cao
- **(a) Answer: 8.4 litres per minute**
- (b) **M1** substitutes: ventilation running = 2.0 x 28
- (b) **A1** 56.0 litres per minute and 56.0 / 8.4 = 6.7 times cao
- **(b) Answer: 56.0 litres per minute; 6.7 times larger**

Question 6

- (a) **M1** identifies a control variable, e.g. same step height or same duration of exercise or same rest period
- (a) **A1** explains that changing it would affect heart rate and confound comparison between trials, oe
- **(a) Answer: Keep step height and exercise duration the same so that differences in heart rate are due to other variables, not different exercise intensity.**
- (b) **B1** ensure a clear area and supervised step-ups to prevent trips or falls, oe
- **(b) Answer: Ensure a clear area and supervision during step-ups to prevent trips and falls.**

Question 7

- (a) **M1** states that aerobic respiration uses oxygen to fully oxidise glucose
- (a) **A1** explains this produces more ATP and consumes oxygen whereas anaerobic does not consume oxygen, oe
- **(a) Answer: Aerobic respiration uses oxygen to fully oxidise glucose, so oxygen is consumed; anaerobic respiration does not use oxygen, so no oxygen is consumed.**
- (b) **B1** use multiple repeats and calculate a mean, oe
- (b) **B1** ensure same temperature and same yeast mass and same substrate concentration, oe
- **(b) Answer: Do multiple repeats and calculate a mean; ensure temperature, yeast mass and glucose concentration are the same for each trial.**

Question 8

- (a) **B1** enzymes speed up metabolic reactions by lowering activation energy, oe
- (a) **B1** they are specific and control pathways such as synthesis and breakdown, oe
- **(a) Answer: Enzymes speed up metabolic reactions by lowering activation energy and are specific catalysts that control synthesis and breakdown pathways.**
- (b) **B1** protein synthesis from amino acids cao
- **(b) Answer: Protein synthesis from amino acids.**

Question 9

- (a) **M1** substitutes: energy = 0.012 mol x 470 kJ per mol
- (a) **M1** multiplies correctly to get 5.64 kJ
- (a) **A1** 5.64 kJ cao
- **(a) Answer: 5.64 kJ**
- (b) **B1** the value assumes a fixed energy per mole O2 and ignores anaerobic respiration or variations in respiratory quotient, oe
- **(b) Answer: It ignores anaerobic respiration or variations in the respiratory quotient, so real energy expenditure may be higher.**

Question 10

- (a) **M1** calculates excess: time 0 excess = 150 - 60 = 90 bpm; time 3 min excess = 90 - 60 = 30 bpm
- (a) **M1** identifies half of initial excess = 90 / 2 = 45 bpm and compares to data
- (a) **A1** estimates half-life is between 1 and 3 minutes, closer to 2 minutes (2 minutes stated) cao
- **(a) Answer: Half-life approximately 2 minutes**

Question 11

- (a) **M1** shows 2 molecules of C2H5OH and 2 molecules of CO2 to account for carbon: C6H12O6 -> 2C2H5OH + 2CO2 suggested
- (a) **M1** checks hydrogen: LHS 12 H; RHS 2 x 6 H = 12 H
- (a) **M1** checks oxygen: LHS 6 O; RHS 2 x 1 O in ethanol = 2 + 2 x 2 O in CO2 = 4; total 6 O
- (a) **A1** fully balanced equation: C6H12O6 -> 2C2H5OH + 2CO2 cao
- **(a) Answer: C6H12O6 -> 2C2H5OH + 2CO2**

Question 12

- (a) **B1** a leak in the apparatus allowing air in when the seal is disturbed, oe
- (a) **B1** temperature change increasing gas volume when seeds are removed, oe
- **(a) Answer: Possible errors: a leak or disturbed seal letting air in when removing seeds; also a temperature increase causing gas expansion.**
- (b) **B1** seal apparatus thoroughly and allow temperature to stabilise before measuring; remove seeds using a side port or pause measurement, oe
- **(b) Answer: Seal the apparatus thoroughly and allow temperature to stabilise; remove seeds via a side port or pause measurement to avoid disturbing the seal.**

Question 13

- (a) **B1** higher body mass or more muscle mass, oe
- (a) **B1** higher thyroid hormone levels or fever/infection, oe
- **(a) Answer: Higher muscle mass/body mass; higher thyroid hormone levels or fever/infection.**

Question 14

- (a) **M1** calculates reduction A = 160 - 70 = 90; peak-rest = 160 - 56 = 104; percent = 90/104 x 100
- (a) **M1** calculates reduction B = 160 - 86 = 74; percent = 74/104 x 100
- (a) **A1** A = 86.5% and B = 71.2% cao
- **(a) Answer: Athlete A 86.5%; Athlete B 71.2%**

Question 15

- **Level 3** (5-6): Detailed explanation linking systems and cellular processes. Clear causal chain showing increased ventilation and cardiac output, blood redistribution to muscles, increased delivery of oxygen and glucose, and increased cellular respiration producing more ATP; includes relevant mechanisms such as increased heart rate and stroke volume, vasodilation in muscles, and role of haemoglobin unloading, with correct use of examples or data.
- **Level 2** (3-4): Good explanation with most links present. Describes increased breathing rate and heart rate, increased blood flow to muscles and increased cellular respiration, but with less detail on mechanisms such as stroke volume or haemoglobin unloading.
- **Level 1** (1-2): Simple statements about increases in breathing and heart rate and that more oxygen and glucose reach muscles. Limited or no explanation of mechanisms.
- **Indicative content:**
  - Exercise increases demand for ATP in muscle cells so respiration rate increases; more glucose and oxygen needed to produce ATP.
  - Respiratory system increases ventilation: higher tidal volume and breathing rate increase oxygen uptake into blood (see earlier ventilation calculations).
  - Circulatory system responds with increased heart rate and stroke volume, raising cardiac output and delivering more oxygen and glucose to muscles.
  - Blood vessels supplying active muscles vasodilate while vessels to non-essential organs vasoconstrict, redistributing blood flow to muscles.
  - At cellular level haemoglobin releases more oxygen due to increased temperature and lowered pH in muscles; mitochondria increase rate of aerobic respiration; if oxygen becomes limiting cells switch to anaerobic respiration producing lactate.
  - Result: more ATP produced aerobically while lactate accumulates if exercise intensity exceeds oxygen supply; recovery requires oxygen to metabolise lactate.