HIGHER

B4H Bioenergetics: Higher Tier Practice

AQA 8461 · Calculator allowed · about 95 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Aerobic respiration releases energy that cells use for many metabolic reactions.

(a) Name the organelle in which most of the reactions of aerobic respiration take place. **(1)**

(b) Explain what is meant by the term 'metabolism' and give one example of a reaction, other than respiration itself, that is part of metabolism in living organisms. **(2)**

(Total for Question 1 is 3 marks)

2 Respiration is described as aerobic or anaerobic.

(a) Give one key difference in the reactants or products between aerobic and anaerobic respiration in human cells. **(1)**

(b) State one reason why aerobic respiration releases much more energy per glucose molecule than anaerobic respiration. **(2)**

(Total for Question 2 is 3 marks)

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3 A student measures the rate of oxygen uptake by isolated plant mitochondria at two different oxygen concentrations. The data are given below.

Oxygen concentration in the assay solution / micromol per litre: 5, 20, 50, 100
Rate of O2 uptake / nmol O2 per min per mg protein: 12, 45, 85, 92

Use the table to answer the questions.

(a) Describe how the rate of oxygen uptake changes as oxygen concentration increases from 5 to 100 micromol per litre. **(2)**

(b) Suggest one biological explanation for the plateau seen between 50 and 100 micromol per litre. **(2)**

(Total for Question 3 is 4 marks)

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4 During exercise a runner's muscle cells perform more anaerobic respiration.

(a) Explain why lactic acid builds up during intense exercise. **(2)**

(b) State one short-term effect of lactic acid accumulation on muscles. **(1)**

(Total for Question 4 is 3 marks)

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5 A lamp used in a photosynthesis investigation gives a light intensity of 1200 lux measured 15 cm from a leaf. Light intensity follows the inverse square law with distance from a lamp.

(a) Calculate the light intensity at a distance of 30 cm from the lamp. Show your working. **(4)**

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(Total for Question 5 is 4 marks)

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6 In the required practical investigating the effect of light intensity on the rate of photosynthesis, pondweed is placed close to a lamp and the number of oxygen bubbles produced is counted.

(a) Explain one limitation of using the number of bubbles produced as a measure of the rate of photosynthesis. **(1)**

(b) Explain why a water bath (heat filter) is often placed between the lamp and the beaker of pondweed in this investigation. **(2)**

(Total for Question 6 is 3 marks)

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7 Metabolism is the sum of all the reactions in a cell or the body. Glucose produced by photosynthesis or absorbed from food can be converted into other useful substances.

(a) Explain how the body converts excess glucose into stored fat (lipid). **(2)**

(b) State one reason why the body converts some excess glucose into fat rather than storing it all as glycogen. **(1)**

(Total for Question 7 is 3 marks)

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8 Plants combine glucose from photosynthesis with nitrate ions absorbed from the soil to build larger molecules needed for growth.

(a) Name the type of molecule formed directly from glucose and nitrate ions, and state what these molecules are then used to build. **(2)**

(b) State why a plant needs a supply of nitrate ions from the soil for this process. **(1)**

(Total for Question 8 is 3 marks)

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9 An athlete sprints hard for 30 seconds and then stops. Her breathing rate and heart rate stay higher than normal for several minutes after she stops running.

(a) Name the substance that builds up in muscles during vigorous exercise when the oxygen supply cannot meet demand. **(1)**

(b) Explain why the athlete's breathing rate and heart rate remain high for several minutes after she stops running. **(2)**

(c) State the term used to describe this extra oxygen needed after exercise. **(1)**

(Total for Question 9 is 4 marks)

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10 A respirometer is used to measure the rate of oxygen uptake by germinating peas. Carbon dioxide produced is absorbed by soda lime inside the apparatus, so any movement of the manometer fluid is caused only by oxygen being used up. The manometer fluid moves 3.6 cm along a capillary tube of cross-sectional area 0.05 cm2 in 12 minutes.

(a) Calculate the volume of oxygen absorbed, in cm3, using volume = length moved x cross-sectional area. **(2)**

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(b) Calculate the rate of oxygen uptake in cm3 per minute, then convert this rate to cm3 per hour. **(3)**

.....

(Total for Question 10 is 5 marks)

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11 A grower wants to identify which factor is limiting the rate of photosynthesis in her greenhouse tomatoes at different times of year, and then use this information to increase crop yield sustainably.

Describe an investigation the grower could carry out to identify the limiting factor for photosynthesis in her greenhouse, and explain how she could use the results to increase crop yield sustainably. In your answer, refer to light intensity, carbon dioxide concentration and temperature, to how you would use the inverse square law when varying light intensity, and to interpreting a graph of rate of photosynthesis against a limiting factor.

(Total for Question 11 is 6 marks)

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12 The complete aerobic respiration of one mole of glucose releases about 2880 kJ of energy. When the same amount of glucose is respired anaerobically, only about 120 kJ of energy is released, because the glucose is only partially broken down into lactic acid.

(a) Calculate how many times more energy is released by aerobic respiration of one mole of glucose than by anaerobic respiration of the same amount of glucose. Show your working. **(3)**

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(b) Use your answer to part (a) to explain why the body cannot sustain anaerobic respiration for long periods of intense exercise. **(1)**

(Total for Question 12 is 4 marks)

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Mark scheme · B4H Bioenergetics: Higher Tier Practice

Question 1

- (a) **B1** mitochondria / mitochondrion cao
- **(a) Answer: Mitochondria**
- (b) **B1** metabolism is the sum of all the reactions in a cell or the body, oe
- (b) **B1** any one example: conversion of glucose to glycogen (or starch, or cellulose); formation of lipids from glycerol and fatty acids; formation of amino acids from glucose and nitrate ions; breakdown of excess protein to form urea for excretion, oe
- **(b) Answer: Metabolism is the sum of all the reactions in a cell or the body; for example, glucose can be converted to glycogen for storage.**

Question 2

- (a) **B1** aerobic uses oxygen and produces carbon dioxide and water; anaerobic does not use oxygen and produces lactic acid, oe
- **(a) Answer: Aerobic uses oxygen and produces carbon dioxide and water; anaerobic produces lactic acid and does not use oxygen.**
- (b) **B1** aerobic respiration completely breaks down (oxidises) glucose into carbon dioxide and water, releasing all the energy stored in it, oe
- (b) **B1** anaerobic respiration only partially breaks down glucose into lactic acid, which still contains most of the chemical energy, so much less energy is released, oe
- **(b) Answer: Aerobic respiration completely breaks down glucose into carbon dioxide and water, releasing all its energy; anaerobic respiration only partially breaks glucose down into lactic acid, which still holds most of the energy, so much less is released.**

Question 3

- (a) **B1** rate increases as oxygen concentration increases, with larger increases at low concentrations (5 to 50) and approaching a plateau by 100 micromol per litre, oe
- (a) **B1** recognises that from 50 to 100 there is little increase indicating a limiting factor, oe
- **(a) Answer: The rate increases with oxygen concentration, steeply from 5 to 50 micromol per litre then leveling off so that from 50 to 100 there is little further increase, indicating a plateau.**
- (b) **B1** mitochondrial enzymes or electron transport chain become saturated so oxygen is no longer limiting, oe
- (b) **B1** other factors such as ADP availability, substrate or temperature limit the rate, oe
- **(b) Answer: Possible explanation: components of the electron transport chain or enzymes are saturated so oxygen is no longer limiting; another factor such as ADP or substrate availability limits the rate.**

Question 4

- (a) **B1** during intense exercise oxygen supply to muscles is insufficient for aerobic respiration, oe
- (a) **B1** muscle cells switch to anaerobic respiration, producing lactic acid as a product, oe
- **(a) Answer: Because oxygen supply is insufficient for aerobic respiration during intense exercise, muscle cells perform anaerobic respiration which produces lactic acid.**
- (b) **B1** muscle fatigue or cramp or pain or reduced contraction efficiency, oe
- **(b) Answer: Muscle fatigue or cramp or pain or reduced contraction efficiency.**

Question 5

- (a) **M1** recalls that light intensity is inversely proportional to the square of the distance from the lamp
- (a) **M1** substitutes into intensity(2) = intensity(1) x (distance(1) / distance(2))^2, i.e. 1200 x (15/30)^2
- (a) **M1** evaluates (15/30)^2 = 0.25
- (a) **A1** 300 lux cao
- **(a) Answer: 300 lux**

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Question 6

- (a) **B1** bubbles are not all the same size, so counting bubbles is not always proportional to the volume of gas produced (collecting gas in a syringe and measuring volume is more accurate), oe
- **(a) Answer: Bubbles vary in size, so the number of bubbles is not always proportional to the actual volume of oxygen produced.**
- (b) **M1** a lamp placed close to the pondweed also warms the water, which would raise the temperature, oe
- (b) **A1** a rise in temperature would independently increase the rate of photosynthesis, so the water bath removes heat and keeps temperature constant, making light intensity the only variable being changed, oe
- **(b) Answer: The lamp would otherwise heat the water and raise its temperature, which would also increase the rate of photosynthesis; the water bath absorbs this heat so temperature stays constant and light intensity is the only variable changing.**

Question 7

- (a) **B1** glucose is converted into glycerol and fatty acids, oe
- (a) **B1** the glycerol and fatty acids combine to form lipids, which are stored (for example in adipose tissue), oe
- **(a) Answer: Glucose is converted into glycerol and fatty acids, which combine to form lipids that are stored in the body.**
- (b) **B1** the body's glycogen stores are limited (in the liver and muscles), so fat provides a larger, longer-term energy store, oe
- **(b) Answer: Glycogen stores in the liver and muscles are limited, so fat provides a larger, longer-term energy store.**

Question 8

- (a) **B1** amino acids are formed from glucose and nitrate ions cao
- (a) **B1** amino acids are joined together to build proteins, oe
- **(a) Answer: Glucose and nitrate ions are combined to form amino acids, which are then used to build proteins.**
- (b) **B1** nitrate ions provide the nitrogen needed to make amino acids/proteins, which glucose alone cannot supply, oe
- **(b) Answer: Nitrate ions supply the nitrogen needed to make amino acids and proteins, which glucose alone does not contain.**

Question 9

- (a) **B1** lactic acid cao
- **(a) Answer: Lactic acid**
- (b) **M1** extra oxygen is needed to break down (oxidise) the lactic acid that has built up in the muscles and blood, mainly in the liver, oe
- (b) **A1** the raised breathing rate and heart rate deliver this extra oxygen to the blood and muscles/liver more quickly, oe
- **(b) Answer: Extra oxygen is needed to break down the lactic acid that built up during exercise, mainly in the liver; the raised breathing and heart rate deliver this oxygen faster.**
- (c) **B1** oxygen debt cao
- **(c) Answer: Oxygen debt**

Question 10

- (a) **M1** substitutes: 3.6 cm x 0.05 cm2
- (a) **A1** 0.18 cm3 cao
- **(a) Answer: 0.18 cm3**
- (b) **M1** substitutes: rate = 0.18 cm3 / 12 min
- (b) **A1** 0.015 cm3 per minute cao
- (b) **A1** converts to 0.9 cm3 per hour cao
- **(b) Answer: 0.015 cm3 per minute (0.9 cm3 per hour)**

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Question 11

- **Level 3** (5-6): Detailed, coherent plan that varies one factor at a time while controlling the others, uses the inverse square law to set known light intensities at measured distances, describes plotting rate of photosynthesis (for example, oxygen produced per minute) against the factor, explains that a plateau on the graph shows a different factor has become limiting, and links this to at least one sustainable way to raise crop yield (for example, using recovered/waste carbon dioxide, or better insulation to save heating energy).
- **Level 2** (3-4): Partial plan describing how to vary one or two factors (light, CO2 or temperature) with some reference to controlling other variables and reading a graph, but with limited detail on the inverse square law or on sustainable action from the results.
- **Level 1** (1-2): Basic statements, such as naming the three limiting factors or stating that light/CO2/temperature could be changed, with little explanation of method or how the results would be used.
- **Indicative content:**
  - Vary one factor at a time (light intensity, CO2 concentration or temperature) while keeping the other two controlled/constant.
  - For light intensity: change the distance between the lamp and the plant and use the inverse square law (intensity proportional to 1 / distance squared) to calculate the actual light intensity at each distance, rather than assuming it from lamp power alone.
  - Measure the rate of photosynthesis, for example the volume of oxygen produced per minute, at each level of the chosen factor, repeating and averaging to reduce random error.
  - Plot a graph of rate of photosynthesis against the factor tested; where the graph is still rising, that factor is limiting; where the graph levels off into a plateau, a different factor has become limiting.
  - Repeat for the other two factors (or test at different times of year, since light intensity and temperature vary seasonally) to find which factor is limiting at each time of year.
  - Use the results to raise the limiting factor sustainably, for example enriching CO2 using waste gas from another process rather than burning extra fuel, improving greenhouse insulation/glazing to maintain optimum temperature with less energy, or using LED grow-lights that use less electricity than filament lamps.

Question 12

- (a) **M1** substitutes: 2880 / 120
- (a) **A1** evaluates to 24
- (a) **A1** 24 times (as many as / more) cao
- **(a) Answer: 24 times**
- (b) **B1** anaerobic respiration releases much less energy per glucose molecule, so far more glucose must be broken down to supply the same energy, and lactic acid builds up quickly causing fatigue, oe
- **(b) Answer: Anaerobic respiration releases much less energy per glucose molecule, so much more glucose has to be used and lactic acid builds up quickly, causing muscle fatigue.**

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