1.10 Biology: Energy Transfers in Organisms: 30-minute Pack

Total Marks

AQA 7402 · Calculator allowed · about 30 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Required practical. Kwame used a respirometer to investigate the rate of oxygen uptake by germinating pea seeds at 25°C, following the required practical method. The respirometer had two identical tubes connected to a manometer: one containing the germinating peas plus soda lime, the other (the control tube) containing an equal volume of inert glass beads plus soda lime. The tubes were sealed and left to equilibrate before timing began.

(a) Explain the function of the soda lime in this investigation, and the purpose of the control tube. **(3)**

(b) After 10 minutes, the manometer fluid had moved 15 mm towards the respiring seeds. A repeat run using the control tube alone showed a movement of 2 mm in the same direction over the same time, due to a change in atmospheric pressure. Calculate the corrected distance moved by the manometer fluid due to oxygen uptake alone. **(1)**

(c) The internal diameter of the capillary tube was 2.0 mm. Using volume = $\pi * r^2 *$ length, calculate the volume of oxygen taken up by the seeds in 10 minutes, using the corrected distance from part (b). Give your answer to 3 significant figures. **(3)**

(d) The total mass of the germinating peas used was 3.0 g. Using your answer to part (c), calculate the rate of oxygen uptake per gram of seeds per minute. **(2)**

(e) Suggest one reason the calculated rate of oxygen consumption may be an underestimate of the true respiration rate of the seeds. **(1)**

(Total for Question 1 is 10 marks)

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2 The respiratory quotient (RQ) is the ratio of the volume of CO_2 released to the volume of O_2 consumed during respiration in a given time: RQ = volume of CO_2 produced / volume of O_2 consumed.

(a) Aisha used a respirometer without soda lime to measure a student's gas exchange over 5 minutes: 250 cm^3 of O_2 was consumed and 250 cm^3 of CO_2 was produced. Calculate the RQ and state which type of respiratory substrate this value indicates is being used. **(2)**

(b) Explain, in terms of the chemical composition of the substrate molecules, why the RQ for lipid respiration (approximately 0.7) is lower than for carbohydrate respiration (RQ = 1.0). **(3)**

(c) A person's measured RQ was found to be 0.85. Suggest what this value indicates about the respiratory substrate(s) being used. **(2)**

(Total for Question 2 is 7 marks)

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3 The light-dependent reactions of photosynthesis take place across the thylakoid membrane of the chloroplast.

(a) Describe how water is used in the light-dependent reactions, name this process, and give a balanced equation for it, including state symbols. **(3)**

(b) Explain how the light-dependent reactions generate a proton gradient across the thylakoid membrane, and how this gradient is used to synthesise ATP. **(4)**

(c) Cyclic photophosphorylation involves only photosystem I. State two ways in which cyclic photophosphorylation differs from non-cyclic photophosphorylation. **(2)**

(Total for Question 3 is 9 marks)

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Mark scheme · 1.10 Biology: Energy Transfers in Organisms: 30-minute Pack

Question 1

(a) soda lime absorbs the CO_2 produced by respiration, so any change in the volume/pressure of gas in the tube is due only to the uptake of oxygen **B1**

(a) the control tube corrects for changes in fluid movement caused by factors other than respiration, such as changes in atmospheric pressure or temperature during the experiment **B1**

(a) any movement of fluid recorded in the control tube can be subtracted from (or added to) the movement in the experimental tube, to give a corrected value due to respiration alone **B1**

(a) Answer: Soda lime removes CO_2 so fluid movement reflects O_2 uptake only; the control corrects for pressure/temperature changes unrelated to respiration.

(b) 13 mm (15 - 2), since the control's movement is an artefact unrelated to respiration and is subtracted from the test movement in the same direction) cao **B1**

(b) Answer: 13 mm.

(c) correct radius from diameter: r = 2.0/2 = 1.0 mm **M1**

(c) correct substitution: volume = $\pi * (1.0)^2 * 13$ (ecf from (b)) **M1**

(c) 40.8 mm^3 (0.0408 cm^3), awrt, ecf from (b) **A1**

(c) Answer: 40.8 mm^3 (0.0408 cm^3), to 3 significant figures.

(d) correct method: divides the volume from (c) by time (10 min), then by mass (3.0 g), ecf from (c) **M1**

(d) $1.36 * 10^{-3}$ cm^3 g^{-1} min^{-1} (0.00136 cm^3 g^{-1} min^{-1}), awrt, ecf from (c) **A1**

(d) Answer: 1.36×10^{-3} cm^3 g^{-1} min^{-1} (0.00136 cm^3 g^{-1} min^{-1}).

(e) accept any valid suggestion, e.g. heat released by respiration could warm and expand the gas in the tube, partially opposing the fluid movement and reducing the apparent volume change; or not all seeds used were respiring (e.g. some dormant or non-viable seeds were included), reducing the measured total; or some oxygen/CO_2 may dissolve in moisture on the seeds or apparatus rather than affecting the gas volume measured **B1**

(e) Answer: Any valid suggestion, e.g. respiratory heat expanding the gas and opposing fluid movement, or some seeds not actively respiring.

Question 2

(a) RQ = 250/250 = 1.0 cao **B1**

(a) indicates carbohydrate (e.g. glucose) is the primary respiratory substrate being used **B1**

(a) Answer: RQ = 1.0; indicates carbohydrate is the primary respiratory substrate.

(b) lipids contain a much higher proportion of hydrogen (and carbon) relative to oxygen than carbohydrates do, i.e. lipids are more reduced molecules **B1**

(b) fully oxidising this extra hydrogen to water requires relatively more oxygen to be consumed per molecule of substrate than for carbohydrate oxidation **B1**

(b) since RQ = CO_2 produced / O_2 consumed, this greater O_2 consumption relative to CO_2 produced gives a lower RQ (around 0.7) for lipids; carbohydrates already contain more oxygen in their structure, so relatively less additional O_2 is needed per CO_2 released, giving RQ = 1.0 **B1**

(b) Answer: Lipids are more reduced (higher H:O ratio) so need more O_2 per CO_2 released during oxidation, giving a lower RQ than carbohydrates.

(c) an RQ of 0.85 lies between the values for pure carbohydrate (1.0) and pure lipid (0.7) respiration **B1**

(c) this suggests the person is respiring using a mixture of both carbohydrate and lipid as respiratory substrates, rather than either exclusively **B1**

(c) Answer: RQ of 0.85 suggests a mixture of carbohydrate and lipid is being respired.

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Question 3

(a) the process is called photolysis: light energy is used to split water molecules, associated with photosystem II **B1**

(a) products are protons (H^+), electrons and oxygen **B1**

(a) correctly balanced equation with state symbols: $2H_2O(l) -> 4H^+(aq) + 4e- + O_2(g)$ **B1**

(a) Answer: Photolysis: $2H_2O(l) -> 4H^+(aq) + 4e- + O_2(g)$

(b) excited electrons from photosystem II pass along a chain of electron carriers (the electron transport chain), releasing energy at each transfer **B1**

(b) this energy is used to actively pump protons (H^+) from the stroma into the thylakoid space (lumen), so $[H^+]$ becomes higher in the lumen than in the stroma **B1**

(b) protons diffuse back into the stroma down their concentration (electrochemical) gradient through ATP synthase; this process is called chemiosmosis **B1**

(b) the flow of protons through ATP synthase drives the phosphorylation of ADP + inorganic phosphate (Pi) to form ATP (photophosphorylation) **B1**

(b) Answer: Electron transport pumps H^+ into the thylakoid lumen, building a gradient; H^+ flows back through ATP synthase (chemiosmosis), driving ADP + Pi -> ATP.

(c) cyclic involves only photosystem I, whereas non-cyclic involves both photosystem I and photosystem II (any two of these points, one mark each) **B1**

(c) cyclic does not involve photolysis of water and does not produce oxygen; cyclic produces only ATP (no reduced NADP), whereas non-cyclic produces both ATP and reduced NADP; in cyclic the electron returns to photosystem I, whereas in non-cyclic the electron passes to NADP+ and is not returned **B1**

(c) Answer: Any two of: cyclic uses only PSI (non-cyclic uses PSI and PSII); cyclic produces no reduced NADP and no oxygen; in cyclic the electron returns to PSI rather than reducing NADP+.

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