1.5 Energy Transfers in and between Organisms: 30-minute Pack

AQA 7402 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 The nitrogen cycle involves several groups of soil bacteria that convert nitrogen between different chemical forms.

(a) Name the type of bacteria responsible for each of the following processes: (i) conversion of atmospheric nitrogen gas (N_2) into ammonium compounds; (ii) conversion of ammonium ions into nitrite ions; (iii) conversion of nitrate ions into atmospheric nitrogen gas. **(3)**

(b) Explain the mutualistic relationship between Rhizobium bacteria and leguminous plants (e.g. peas, clover) growing in root nodules. **(2)**

(c) Farmers can increase nitrate availability in soil either by growing leguminous crops as part of a crop rotation, or by applying inorganic nitrogen fertiliser. Evaluate the environmental impact of using inorganic nitrogen fertiliser instead of crop rotation with legumes. **(3)**

(Total for Question 1 is 8 marks)

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2 Identify the correct answer for each of the following.

(a) Which molecule acts as the final electron acceptor in the electron transport chain during aerobic respiration? **(1)**

- ☐ A) NAD
- ☐ B) Oxygen
- ☐ C) FAD
- ☐ D) Pyruvate

(b) Which process converts nitrite ions (NO_2^-) into nitrate ions (NO_3^-)? **(1)**

- ☐ A) Nitrogen fixation
- ☐ B) Ammonification
- ☐ C) Nitrification
- ☐ D) Denitrification

(c) Which enzyme catalyses the fixation of carbon dioxide by combining it with RuBP in the light-independent reactions? **(1)**

- ☐ A) ATP synthase
- ☐ B) RuBisCO
- ☐ C) DNA polymerase
- ☐ D) Catalase

(d) Which statement best describes gross primary productivity (GPP)? **(1)**

- ☐ A) The total energy available to primary consumers after respiratory losses
- ☐ B) The total chemical energy store in producer biomass at a single point in time
- ☐ C) The total chemical energy fixed by photosynthesis per unit area per unit time
- ☐ D) The total energy transferred to secondary consumers

(e) Which term describes the loss of nitrogen from soil as nitrogen gas, occurring under anaerobic (waterlogged) soil conditions? **(1)**

- ☐ A) Nitrification
- ☐ B) Denitrification
- ☐ C) Ammonification
- ☐ D) Nitrogen fixation

(Total for Question 2 is 5 marks)

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3 This question concerns respiratory energy yield and rates. A sample of actively respiring yeast is provided in a sealed respirometer chamber with glucose substrate. The chamber has internal volume 250 cm^3. Over 5.0 minutes the drop in internal oxygen partial pressure corresponds to 8.0×10^{-3} mol of O_2 consumed. Assume aerobic respiration of glucose is $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ and that each mole of O_2 consumed in oxidative phosphorylation leads to synthesis of 2.5 mol ATP (the P:O ratio for NADH-linked respiration).

(a) Calculate the mean rate of oxygen consumption in mol s^{-1} for the yeast sample over the 5.0 minute period. **(2)**

(b) Using the respiratory stoichiometry and P:O ratio given, calculate the total number of moles of ATP synthesised in the chamber over the 5.0 minute period. **(3)**

(c) Estimate the mean ATP synthesis rate in mol s^{-1} in this sample and the rate expressed in micromol s^{-1} (1 micromol = 1.0×10^{-6} mol). **(3)**

(d) State one experimental factor that could cause the measured O_2 consumption to underestimate true ATP synthesis rate in the cells, and briefly explain why. **(2)**

(Total for Question 3 is 10 marks)

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Mark scheme · 1.5 Energy Transfers in and between Organisms: 30-minute Pack

Question 1

(a) (i) nitrogen-fixing bacteria (e.g. Rhizobium or Azotobacter) **B1**

(a) (ii) nitrifying bacteria (e.g. Nitrosomonas) **B1**

(a) (iii) denitrifying bacteria **B1**

(a) Answer: (i) Nitrogen-fixing bacteria; (ii) Nitrifying bacteria (Nitrosomonas); (iii) Denitrifying bacteria

(b) Rhizobium fixes atmospheric nitrogen into ammonium/nitrogen-containing compounds that the plant can absorb and use, e.g. to make amino acids **B1**

(b) in return, the plant supplies the bacteria with carbohydrates (organic compounds from photosynthesis) as a source of energy/carbon **B1**

(b) Answer: Rhizobium provides fixed nitrogen compounds to the plant; the plant provides carbohydrates to the bacteria.

(c) excess inorganic nitrate not taken up by crops can leach into waterways, causing eutrophication (algal bloom, death of aquatic plants, decomposer respiration depletes dissolved oxygen, death of aquatic animals) **B1**

(c) crop rotation with legumes is more sustainable as it does not rely on manufactured fertiliser, whose production (Haber process) is energy-intensive and produces greenhouse gases **B1**

(c) valid comparative judgement, e.g. inorganic fertiliser gives a faster/more controllable increase in nitrate but at a greater long-term environmental cost than legume rotation **B1**

(c) Answer: Inorganic fertiliser risks leaching/eutrophication and has a high energy/carbon cost of manufacture; legume rotation is more sustainable but slower acting.

Question 2

(a) B (oxygen) **B1**

(a) Answer: B) Oxygen

(b) C (nitrification) **B1**

(b) Answer: C) Nitrification

(c) B (RuBisCO) **B1**

(c) Answer: B) RuBisCO

(d) C **B1**

(d) Answer: C

(e) B (denitrification) **B1**

(e) Answer: B) Denitrification

Question 3

(a) method: divide moles consumed by total time in seconds, i.e. $8.0 \times 10^{-3} / (5.0 \times 60)$ **M1**

(a) 2.67×10^{-5} mol s^{-1} cao **A1**

(a) Answer: 2.67×10^{-5} mol s^{-1}

(b) method: ATP moles = (moles O_2 consumed) x (ATP produced per O_2) = $8.0 \times 10^{-3} \times 2.5$ **M1**

(b) evaluate product to 2 sf or 3 sf **M1**

(b) 2.00×10^{-2} mol ATP, cao **A1**

(b) Answer: 2.00×10^{-2} mol ATP

(c) divide moles ATP (2.00×10^{-2}) by time in seconds (300 s) **M1**

(c) correct numerical evaluation to give mol s^{-1} **M1**

(c) 6.67×10^{-5} mol s^{-1} and 66.7 micromol s^{-1}, cao **A1**

(c) Answer: 6.67×10^{-5} mol s^{-1}; 66.7 micromol s^{-1}

(d) any one correct factor such as some oxygen used for non-ATP producing processes (e.g. reactive oxygen species formation), or leakage of O_2 in apparatus, or cells performing anaerobic metabolism concurrently **B1**

(d) brief explanation linked to factor, e.g. leakage causes measured O_2 decrease to be smaller than true consumption or non-ATP uses mean less ATP per O_2 **B1**

(d) Answer: Leakage of O_2 from the chamber, so measured O_2 decrease is smaller than true cellular O_2 consumption.

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