# 1.5 Energy Transfers in and between Organisms: Test Pack

Total Marks

AQA 7402 · Calculator allowed · about 60 minutes

Name: _____ Date: ____ / ____ / _____

**Answer ALL questions. Show all your working.**

**1** This question assesses core definitions and simple recall about energy carriers and processes in organisms.

**(a)** State the name of the molecule that acts as the main immediate energy currency in cells. **(1)**

**(b)** Give the term for the process in which glucose is broken down to release energy in the absence of oxygen. **(1)**

**(c)** Name the organelle where oxidative phosphorylation occurs in eukaryotic cells. **(1)**

**(d)** State one example of an abiotic factor that can reduce the rate of photosynthesis in plants. **(1)**

**(Total for Question 1 is 4 marks)**


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**2** Aerobic respiration releases energy from glucose in four linked stages: glycolysis, the link reaction, the Krebs cycle, and oxidative phosphorylation.

**(a)** Name the stage of aerobic respiration that occurs in the cytoplasm. **(1)**

**(b)** State the net ATP yield from glycolysis per molecule of glucose, and explain why this yield is described as a 'net' gain. **(2)**

**(c)** Explain why the link reaction and the Krebs cycle must take place in the mitochondrial matrix. **(2)**

**(d)** Per molecule of glucose, aerobic respiration produces 10 reduced NAD (NADH) and 2 reduced FAD (FADH2) in total (from glycolysis, the link reaction and the Krebs cycle combined). Oxidative phosphorylation yields 2.5 ATP per NADH and 1.5 ATP per FADH2. In addition, 2 ATP are produced by substrate-level phosphorylation in glycolysis and 2 ATP by substrate-level phosphorylation in the Krebs cycle. Calculate the maximum theoretical total number of ATP molecules produced per molecule of glucose. **(3)**

**(Total for Question 2 is 8 marks)**

**3** Saprobiotic microorganisms (decomposers) play a key role in the carbon cycle.

**(a)** Describe the role of saprobiotic microorganisms in the carbon cycle. **(2)**

**(b)** Explain why deforestation, followed by burning of the cleared vegetation, increases the concentration of carbon dioxide in the atmosphere. **(2)**

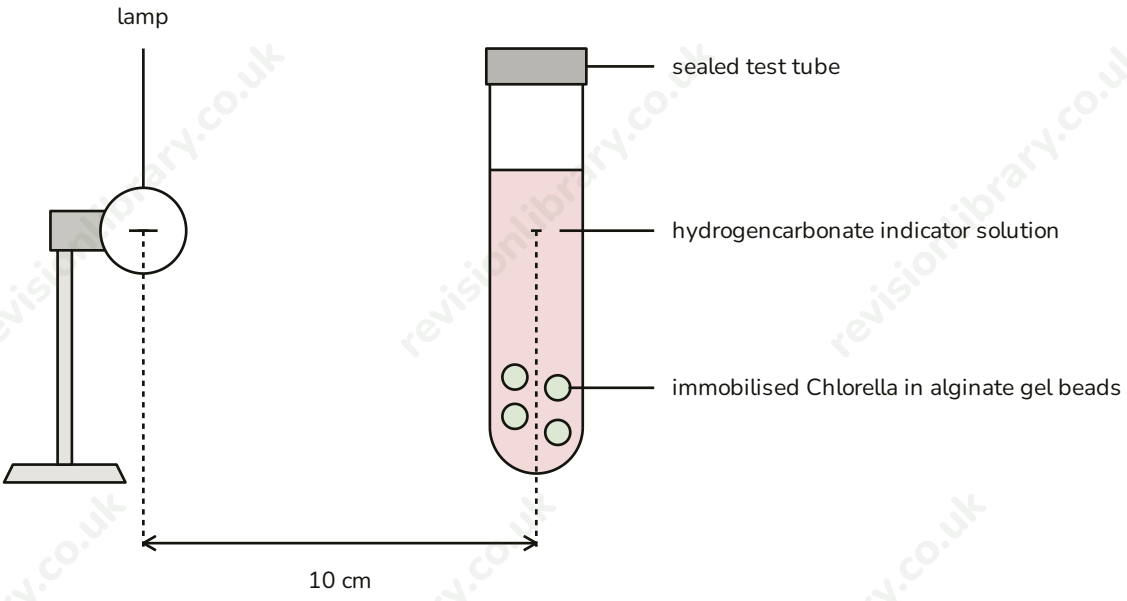
**(c)** State two ways in which carbon can be stored (sequestered) for long periods of time. **(2)**

**(Total for Question 3 is 6 marks)**


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**4** Required practical. A student carried out the required practical method to investigate the effect of light intensity on the rate of photosynthesis using algal balls (immobilised Chlorella suspended in alginate gel beads) placed in hydrogencarbonate indicator solution in sealed test tubes. A lamp was positioned at different distances from a tube, and the time taken for the indicator to change colour from red to purple was recorded as a measure of the rate of photosynthesis.

Diagram NOT accurately drawn




**(a)** Give two variables, other than light intensity, that should be controlled in this investigation to ensure a valid comparison between tubes. **(2)**

**(b)** Explain why the hydrogencarbonate indicator changes colour from red to purple as the rate of photosynthesis increases. **(2)**

**(c)** The rate of photosynthesis is directly proportional to light intensity, and light intensity follows the inverse square law with distance from the lamp (intensity is proportional to $1/\text{distance}^2$). At a distance of 10 cm from the lamp, the indicator took 40 s to change from red to purple. Assuming light remains the limiting factor throughout, calculate the time you would predict for the colour change to occur at a distance of 20 cm. **(3)**

**(d)** Suggest one limitation of using the time taken for a full colour change as a measure of the rate of photosynthesis. **(1)**

**(Total for Question 4 is 8 marks)**


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**5** ATP hydrolysis and coupling. Describe the mechanism by which ATP hydrolysis can be coupled to an endergonic transport process across a cell membrane. Your answer should include the role of enzyme conformational change and the fate of phosphate and ADP.

**(a)** Give the sequence of events in a P-type ATPase that uses ATP to pump ions against their concentration gradient, including ATP binding, phosphorylation, conformational change, ion release, and dephosphorylation. **(6)**

**(b)** State two reasons why coupling via phosphorylation is advantageous compared with simply allowing ions to flow down their electrochemical gradient. **(2)**

**(Total for Question 5 is 8 marks)**

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**6** Experiment design and analysis: measuring effect of temperature on rate of respiration in plant tissue. A student measures $CO_2$ production (as a proxy for respiration) from 5 g leaf samples at four temperatures: 10, 20, 30 and 40°C. Recorded mean $CO_2$ production rates are 0.015, 0.028, 0.051 and 0.032 micromol $s^{-1}$ respectively (each mean from three replicates).

**(a)** Calculate the Q10 value for respiration between 10 and 20°C using the mean rates provided. Give your answer to 2 significant figures. **(3)**

**(b)** Calculate the Q10 value between 20 and 30°C and comment briefly on how Q10 changes across the temperature range studied. **(3)**

**(c)** Suggest one experimental improvement to make the Q10 estimates more reliable and briefly justify your suggestion. **(1)**

**(Total for Question 6 is 7 marks)**


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# Mark scheme · 1.5 Energy Transfers in and between Organisms: Test Pack

## Question 1

(a) ATP **B1**

**(a) Answer: ATP**

(b) anaerobic respiration or fermentation **B1**

**(b) Answer: Anaerobic respiration**

(c) mitochondrion or mitochondria **B1**

**(c) Answer: Mitochondrion**

(d) any one correct abiotic factor such as low light intensity, low carbon dioxide concentration, low temperature, or water shortage **B1**

**(d) Answer: Low light intensity**

## Question 2

(a) glycolysis **B1**

**(a) Answer: Glycolysis**

(b) net yield = 2 ATP **B1**

(b) because 2 ATP are used (invested) early in glycolysis (phosphorylation of glucose/intermediates) while 4 ATP are produced later, giving a net gain of 2 **B1**

**(b) Answer: Net yield = 2 ATP; 4 ATP produced minus 2 ATP invested = 2 ATP net.**

(c) the enzymes that catalyse the reactions of the link reaction and Krebs cycle are located in the matrix **B1**

(c) this places the reduced coenzymes (NAD, FAD) produced close to the electron transport chain on the inner mitochondrial membrane, allowing efficient transfer of electrons/hydrogen **B1**

**(c) Answer: Matrix enzymes catalyse these reactions and their products (reduced NAD/FAD) are positioned next to the inner membrane electron transport chain.**

(d) ATP from NADH = 10 x 2.5 = 25 **M1**

(d) ATP from FADH2 = 2 x 1.5 = 3 **M1**

(d) total = 25 + 3 + 2 + 2 = 32 (ATP) cao **A1**

**(d) Answer: 32 ATP**

## Question 3

(a) they secrete digestive enzymes onto dead organic matter/waste, breaking it down extracellularly (saprobiotic nutrition) and absorbing the soluble products **B1**

(a) carbon dioxide is released back into the atmosphere as a result of the decomposers' own respiration **B1**

**(a) Answer: Decomposers digest dead matter extracellularly and release $CO_2$ through respiration, returning carbon to the atmosphere.**

(b) burning releases the carbon stored in the biomass directly into the atmosphere as $CO_2$ (combustion) **B1**

(b) with fewer trees/plants remaining, less $CO_2$ is removed from the atmosphere by photosynthesis, so the net concentration of atmospheric $CO_2$ rises **B1**

**(b) Answer: Combustion releases stored carbon as $CO_2$, and reduced photosynthetic uptake means less $CO_2$ is removed, so atmospheric $CO_2$ rises.**

(c) as fossil fuels (coal, oil, natural gas or peat) **B1**

(c) as calcium carbonate in limestone or in the shells/skeletons of marine organisms, or as wood in long-lived trees/forests **B1**

**(c) Answer: Any two of: fossil fuels; limestone/marine shells (calcium carbonate); wood in long-lived trees.**

## Question 4

(a) temperature (any two from this list, one mark each) **B1**

(a) volume of hydrogencarbonate indicator solution / number and size of algal balls / concentration of hydrogencarbonate indicator / time left before readings begin **B1**

**(a) Answer: Any two of: temperature; volume of indicator solution; number/size of algal balls; concentration of indicator.**

(b) photosynthesis removes carbon dioxide from solution (as $CO_2$ is used in the light-independent reactions) **B1**

(b) less dissolved $CO_2$ means a lower concentration of carbonic acid/$H^+$ ions, so pH rises and the indicator turns purple (more alkaline) **B1**

**(b) Answer: $CO_2$ is used up by photosynthesis, so $[H^+]$ falls, pH rises, and the indicator turns purple.**

(c) recognises that doubling the distance (10 cm to 20 cm) reduces light intensity, and therefore rate, to 1/4 of its original value (inverse square law: $(10/20)^2 = 1/4$) **M1**

(c) time taken is inversely proportional to rate, so time increases by a factor of 4 **M1**

(c) 160 (s) cao **A1**

**(c) Answer: 160 s**

(d) the colour change is gradual and the exact end point is subjective/difficult to judge precisely (or: assumes rate is constant throughout, which may not be true), so results may be imprecise **B1**

**(d) Answer: Judging the exact colour end-point is subjective, reducing precision.**


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## Question 5

(a) ATP binds to the transporter on the cytosolic side and is hydrolysed with transfer of phosphate to the protein (phosphorylation) **M1**

(a) phosphorylation induces a conformational change in the transporter that reduces affinity for the bound ion on the cytosolic side and increases affinity on the extracellular side (or vice versa) **M1**

(a) ion is released on the other side of the membrane against its concentration gradient **M1**

(a) ADP is released and the phosphate remains transiently on the pump **M1**

(a) dephosphorylation returns the pump to its original conformation ready for another cycle **M1**

(a) overall coupling: chemical energy from ATP hydrolysis is converted into work of moving ions, with phosphate acting to stabilise the high-energy conformational state **M1**

**(a) Answer: ATP binds and is hydrolysed, phosphorylating the pump and causing a conformational change that moves the ion across the membrane; ADP is released and later dephosphorylation restores the original conformation.**

(b) allows active transport against a gradient to maintain cellular ion homeostasis, enabling processes like nutrient uptake or membrane potential maintenance **B1**

(b) provides an energy-controlled and regulatable mechanism rather than passive uncontrolled flow **B1**

**(b) Answer: It allows active transport of ions against their gradient, maintaining homeostasis and enabling controlled, regulated transport.**

## Question 6

(a) method: Q10 = rate at higher temp / rate at lower temp for 10 degree interval = 0.028 / 0.015 **M1**

(a) numerical evaluation **M1**

(a) 1.9 (to 2 s.f.), cao **A1**

**(a) Answer: 1.9**

(b) method: Q10 = 0.051 / 0.028 **M1**

(b) numerical evaluation **M1**

(b) 1.8 and comment that Q10 decreases slightly or is similar, and respiration drops at 40 degrees indicating enzyme denaturation or stress, cao **A1**

**(b) Answer: Q10 between 20 and 30°C = 1.8. Q10 is similar to between 10 and 20°C but respiration decreases at 40°C suggesting enzymes begin to denature.**

(c) one sensible improvement with brief justification, e.g. increase number of replicates to reduce random error, control humidity to prevent desiccation, ensure rapid equilibration time at each temperature so measurements reflect steady-state rates **B1**

**(c) Answer: Increase replicates to at least five per temperature to reduce random error and give more reliable mean rates for Q10 calculation.**


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