1.3 Organisms Exchange Substances with their Environment: Test Pack

AQA 7402 · Calculator allowed · about 75 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 This question tests core vocabulary used to describe digestion and absorption.

(a) State the enzyme, and its site of production, that hydrolyses starch to maltose in the human digestive system. **(1)**

(b) State the location and role of maltase in carbohydrate digestion. **(1)**

(c) Define co-transport. **(1)**

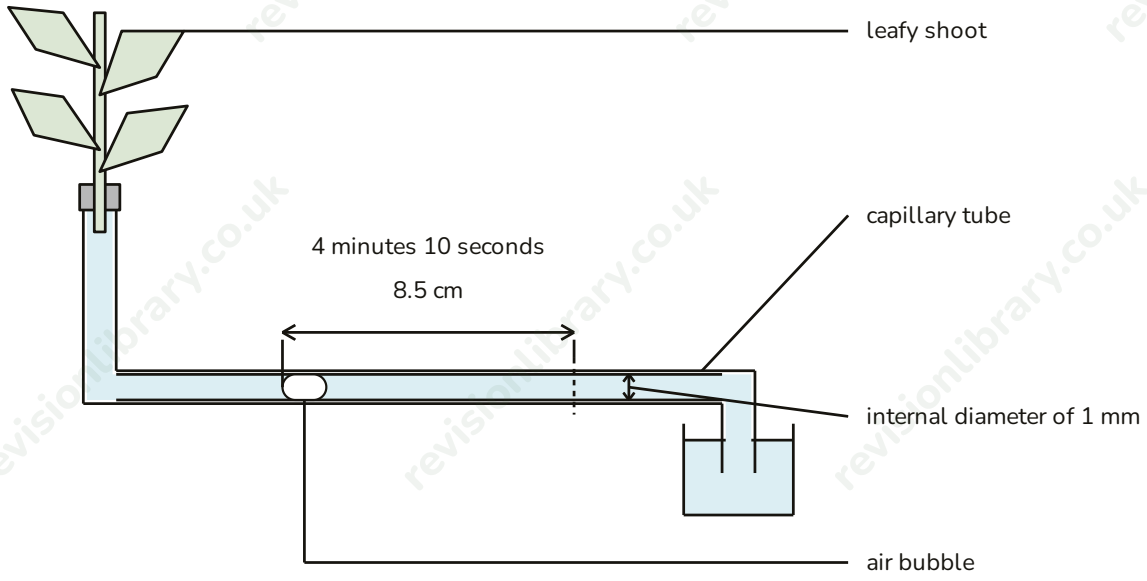
(d) State one structural adaptation of an epithelial cell lining the ileum that increases the rate of absorption. **(1)**

(Total for Question 1 is 4 marks)

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2 This question is based on an investigation of the effect of an environmental factor on the rate of transpiration using a potometer. A leafy shoot was set up in a potometer, and the shoot was left to acclimatise before an air bubble was introduced into the capillary tube.

Diagram NOT accurately drawn



(a) Describe how the potometer should be set up and used to ensure a valid measurement of water uptake, referring to the introduction of air bubbles and the sealing of the apparatus. **(3)**

(b) An air bubble took 4 minutes 10 seconds to travel 8.5 cm along the capillary tube, which had an internal diameter of 1 mm. Calculate the mean rate of water uptake, in mm^3 per minute, giving your answer to 3 significant figures. Use volume of a cylinder = $\pi \times r^2 \times$ length, with $\pi = 3.142$. **(4)**

(c) State two environmental variables, other than the one being investigated, that should be controlled during this investigation. **(2)**

(d) Explain why the rate of water uptake measured by a potometer is assumed to be approximately equal to the rate of transpiration, even though a potometer actually measures water uptake rather than water loss directly. **(2)**

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(e) The investigation was repeated with a fan providing air movement across the shoot; under these conditions, the bubble travelled 15 cm in the same time (4 minutes 10 seconds). Calculate the percentage increase in the rate of water uptake caused by the air movement, compared with your answer to part (b). **(3)**

(Total for Question 2 is 14 marks)

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3 This question is based on the required practical involving the use of qualitative reagents to identify biological molecules produced by digestion, and relates to their subsequent absorption in the small intestine.

(a) (i) State the reagent(s) used, and the observation that indicates a positive result, in the Benedict's test for a reducing sugar. (ii) State the reagent used, and the observation that indicates a positive result, in the Biuret test for protein. **(4)**

(b) Suggest how the Benedict's test could be adapted, using a colorimeter, to estimate the concentration of reducing sugar in a food sample, rather than simply showing that reducing sugar is present. **(3)**

(c) Describe how glucose, a product of carbohydrate digestion, is absorbed across the epithelial cells lining the ileum into the blood. **(4)**

(d) In a hypothetical model of the ileum, villi increase the surface area for absorption by a factor of 600 compared with a smooth-walled tube, and microvilli increase this further by a factor of 20. These factors are model assumptions, not measured biological values. Calculate the overall factor by which the total surface area for absorption is increased in this model, compared with a smooth-walled tube. **(2)**

(Total for Question 3 is 13 marks)

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4 Phloem tissue transports the products of photosynthesis (mainly sucrose) from sources to sinks. The mass flow hypothesis is the accepted explanation for translocation in phloem.

(a) Name the cells found alongside sieve tube elements that carry out the active loading of sucrose into the phloem, and name the type of transport process used to load sucrose into the sieve tubes at the source. **(2)**

(b) Explain, using the mass flow hypothesis, how a hydrostatic pressure gradient is generated between a source and a sink, resulting in the mass flow of phloem sap through the sieve tubes. **(5)**

(c) In a 'ringing experiment', a complete ring of bark (containing the phloem but not the xylem) is removed from around a tree trunk. Predict and explain what would happen, over the following weeks, to (i) the region of bark just above the ring and (ii) the tissue below the ring. **(3)**

(d) State one piece of experimental evidence that supports the mass flow hypothesis, and one observation that is more difficult for the mass flow hypothesis to fully explain. Explain how the supporting evidence supports the hypothesis and why the difficult observation is a challenge to it. **(4)**

(Total for Question 4 is 14 marks)

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5 Ringing experiments involve removing a ring of bark (including the phloem but not the xylem) from around the trunk of a tree, to investigate the function of phloem in translocation.

(a) State the type of cell in phloem tissue responsible for the mass flow of sugars, and the type of cell closely associated with it that provides the metabolic energy for loading sugars. **(2)**

(b) Predict and explain what would be observed in the region of the trunk directly above the ring (relative to the ground), over the following weeks, and explain your reasoning. **(3)**

(c) Predict and explain what would happen to the region of the trunk below the ring over an extended period. **(2)**

(Total for Question 5 is 7 marks)

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Mark scheme · 1.3 Organisms Exchange Substances with their Environment: Test Pack

Question 1

(a) amylase, produced in the salivary glands and/or pancreas oe **B1**

(a) Answer: Amylase, produced in the salivary glands and the pancreas.

(b) found on the cell-surface membrane (microvilli) of epithelial cells lining the ileum; hydrolyses maltose to glucose oe **B1**

(b) Answer: Maltase is bound to the cell-surface membrane of epithelial cells in the ileum, and hydrolyses maltose into glucose.

(c) the movement of one molecule/ion across a membrane linked to (facilitated by) the movement of a different molecule/ion, using a shared membrane protein oe **B1**

(c) Answer: The movement of one molecule across a membrane linked to the movement of a different molecule, via a shared transport protein.

(d) e.g. microvilli, increasing surface area; many mitochondria, providing ATP for active transport; oe (any one valid feature) **B1**

(d) Answer: Microvilli on the cell surface, which increase the surface area for absorption.

Question 2

(a) the shoot should be cut under water (at a slant), and the whole apparatus assembled/the shoot inserted under water, to prevent air entering the xylem and blocking water uptake oe **B1**

(a) all joints (e.g. where the shoot enters the apparatus) should be sealed, for example with petroleum jelly, to ensure the apparatus is airtight/watertight oe **B1**

(a) a single air bubble is introduced by briefly removing the end of the capillary tube from the beaker of water (or opening a tap), then returning the tube end to the water/closing the tap, and timing the position of the bubble as it moves along a scale oe **B1**

(a) Answer: Cut and assemble the shoot under water, seal joints (e.g. with petroleum jelly), then introduce a single air bubble and time its movement along the scale.

(b) time = 4 + (10/60) = 4.167 minutes **M1**

(b) radius = 1/2 = 0.5 mm; length = 8.5 cm = 85 mm; volume = $3.142 \times 0.5^2 \times 85$ **M1**

(b) volume = 66.77 mm^3 (3 s.f.) **M1**

(b) rate = 66.77 / 4.167 = 16.0 mm^3/min (3 s.f.) awrt 16.0 **A1**

(b) Answer: 16.0 mm^3 per minute (3 s.f.).

(c) any one suitable controlled environmental variable: light intensity; humidity; air movement/wind speed; temperature (excluding the variable being investigated) **B1**

(c) a second distinct suitable environmental variable from the same list, excluding the variable being investigated **B1**

(c) Answer: Any two of light intensity, humidity, air movement and temperature, excluding the variable being investigated; for example, temperature and humidity when investigating air movement.

(d) almost all of the water taken up by the shoot is eventually lost as water vapour by transpiration from the leaves, since only a very small proportion is used in processes such as photosynthesis or retained for cell turgor/growth oe **M1**

(d) so the rate of water uptake by the shoot is assumed to be approximately equal to (a reasonable estimate of) the rate of water loss by transpiration oe **A1**

(d) Answer: Almost all water taken up is eventually transpired (only a tiny fraction is used elsewhere), so uptake rate closely approximates transpiration rate.

(e) new volume = $3.142 \times 0.5^2 \times 150 = 117.8$ mm^3; new rate = 117.8 / 4.167 = 28.3 mm^3/min (3 s.f.) **M1**

(e) percentage increase = ((28.3 - 16.0) / 16.0) x 100 (dependent on a correct rate from part (b) and the new rate calculated above) **dM1**

(e) = 76.9% (accept awrt 76 to 77%) ft from candidate's own value in part (b) **A1**

(e) Answer: About 77% increase (awrt 76 to 77%).

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Question 3

(a) (i) add Benedict's reagent and heat in a boiling water bath oe **B1**

(a) (i) a positive result is a green, yellow, orange or brick-red precipitate after heating with Benedict's reagent; the colour depends on reducing-sugar concentration oe **B1**

(a) (ii) add Biuret reagent (sodium hydroxide followed by dilute copper sulfate, or premixed Biuret reagent) oe **B1**

(a) (ii) a positive result is a colour change from blue to purple/lilac/violet oe **B1**

(a) Answer: Benedict's: heat with Benedict's reagent; a green, yellow, orange or brick-red precipitate is positive. Biuret: add Biuret reagent; a purple/lilac colour is positive.

(b) prepare a range of glucose (reducing sugar) standard solutions of known concentration, carry out the Benedict's test on each and filter to remove the precipitate, then measure the absorbance/percentage transmission of light through each using a colorimeter oe **B1**

(b) plot a calibration curve of absorbance (or % transmission) against known glucose concentration oe **B1**

(b) carry out the same Benedict's test and colorimeter reading on the unknown food sample, and use the calibration curve to read off its glucose concentration oe **B1**

(b) Answer: Use colorimeter readings from a range of known-concentration standards to build a calibration curve, then read the unknown sample's absorbance against it.

(c) sodium ions are actively transported out of the epithelial cells into the blood (by the sodium-potassium pump), maintaining a low sodium ion concentration inside the epithelial cells oe **B1**

(c) sodium ions diffuse from the lumen of the ileum into the epithelial cells down their concentration gradient, through a cotransporter protein in the cell surface membrane, carrying glucose into the cell at the same time (against its own concentration gradient) oe **B1**

(c) glucose then moves out of the epithelial cell into the blood by facilitated diffusion, through a separate carrier protein, down its concentration gradient oe **B1**

(c) the large surface area of the villi and microvilli maximises the number of transport proteins/rate of absorption oe **B1**

(c) Answer: Sodium is pumped out of epithelial cells, creating a gradient that drives sodium-glucose cotransport into the cell from the lumen; glucose then leaves into the blood by facilitated diffusion.

(d) overall factor = 600 x 20 **M1**

(d) = 12000 (times) cao **A1**

(d) Answer: 12000 times.

Question 4

(a) companion cells **B1**

(a) active transport, using a proton (H^+) cotransport mechanism **B1**

(a) Answer: Companion cells; active transport (via a proton/H^+ cotransport mechanism).

(b) at the source (e.g. a photosynthesising leaf), sucrose is actively loaded into the companion cells and sieve tube elements, lowering their water potential oe **B1**

(b) water moves into the sieve tube elements from the xylem/surrounding cells by osmosis, down the water potential gradient, increasing the hydrostatic (turgor) pressure inside the sieve tube at the source oe **B1**

(b) at the sink (e.g. a growing root or storage organ), sucrose is unloaded/used up (e.g. converted to starch or used in respiration), raising the water potential of the sieve tube elements there oe **B1**

(b) water therefore leaves the sieve tube elements by osmosis at the sink, lowering the hydrostatic pressure there oe **B1**

(b) this difference in hydrostatic pressure (high at the source, low at the sink) causes phloem sap to flow (mass flow) along the sieve tubes from source to sink oe **B1**

(b) Answer: Active loading of sucrose at the source lowers water potential there, drawing water in and raising pressure; unloading at the sink has the opposite effect, so sap flows from the high-pressure source to the low-pressure sink.

(c) (i) the bark just above the ring would swell, because sucrose (and water drawn in by osmosis) continues to arrive from the leaves/source but can no longer move past the ring, since the phloem has been removed, so it accumulates above the ring oe **M1**

(c) (ii) the tissue and roots below the ring would gradually be starved of sucrose, although xylem, and therefore water/mineral transport, is unaffected since it is left intact oe **M1**

(c) so over time the tissue below the ring would be unable to respire sufficiently and would eventually die, while the tree may survive short-term only on stored reserves below the ring oe **A1**

(c) Answer: Bark above the ring swells as sucrose accumulates; tissue below the ring is deprived of sucrose (though not water) and eventually dies, since only the phloem, not the xylem, has been removed.

(d) one supporting observation, e.g. sugar accumulates above and is depleted below a ring where phloem has been removed oe **B1**

(d) explanation linked to that observation: removing phloem interrupts sucrose transport from source to sink, consistent with transport through phloem as predicted by the hypothesis oe **B1**

(d) one difficult observation, e.g. measured sap flow is faster than expected given the resistance of sieve plates; accept different solutes moving at different rates oe **B1**

(d) explanation linked to that observation: sieve plates/partially obstructed pores resist flow, so a simple passive pressure-driven model may not account for the measured speed; alternatively, bulk flow of a single solution predicts solutes moving together at the same rate oe **B1**

(d) Answer: Supporting: sugar accumulation above a ring/depletion below shows source-to-sink movement via phloem. Against: sieve plates should slow mass flow more than observed, so a purely passive mechanism does not fully account for the measured flow rate.

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Question 5

(a) sieve tube element(s) **B1**

(a) companion cell(s) **B1**

(a) Answer: Sieve tube elements carry out mass flow; companion cells provide the metabolic support/energy.

(b) the region above the ring would show little change / continue to receive water and mineral ions normally, since xylem (which is unaffected by the ring) continues to supply these upward oe **B1**

(b) however, since phloem has been removed, sugars produced by photosynthesis above the ring cannot be transported down past the ring oe **B1**

(b) sugars would accumulate above the ring, potentially causing swelling of the bark just above the cut, as the region above continues to receive water/support growth oe **B1**

(b) Answer: Above the ring, water and mineral supply (via xylem) continue as normal, but sugars made by photosynthesis cannot move down past the missing phloem, so sugar accumulates and the bark may swell just above the ring.

(c) the region below the ring would eventually die back/show reduced growth, because it can no longer receive sugars (an energy/carbon source) transported from photosynthesising leaves above oe **B1**

(c) the roots in particular would be starved of sugars needed for respiration and growth, since roots cannot photosynthesise oe **B1**

(c) Answer: The region below the ring, including the roots, would eventually be starved of sugar and die back, since roots cannot photosynthesise and can no longer receive sugars from the leaves via the phloem.

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