HELICATE · AS AND A-LEVEL BIOLOGY · TOPIC BANK

3.3.4 Mass transport

Mark scheme

Version 1 · 9 October 2026

TOTAL MARKS	QUESTIONS
78	12

How to use this mark scheme

;	Separates marking points. Each semicolon marks the end of one creditable point, and each point is worth one mark.
;;	Two marks for this answer (used for calculations).
/	Alternative words or phrases that are credited for the same point.
OR	An alternative answer for the same mark.
( )	Words in brackets are not needed to gain the mark.
max	More marking points are listed than marks available. Award up to the number of marks shown.
Accept	An alternative answer that gains credit.
Reject	A wrong answer. It does not gain credit and cancels a correct point it contradicts.
Ignore	Neither credited nor penalised. Mark the rest of the answer.
ECF	Error carried forward: credit correct working that uses an earlier wrong answer.
AO	Assessment objective: AO1 knowledge and understanding; AO2 applying knowledge; AO3 analysing, interpreting and evaluating.

Where an answer is correct but not listed, credit it if it is biologically accurate and answers the question at the depth the marks require. Right + wrong = wrong: a contradiction cancels a correct point.

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Haemoglobin and oxygen transport 3.3.4.1

Question	Marking guidance	Mark	Comments
01.1	1. At low partial pressures of oxygen, it is difficult for the first oxygen (molecule) to bind (so saturation rises slowly); 2. Binding of the first oxygen changes the shape/tertiary/quaternary structure of haemoglobin; 3. (This) makes it easier for further oxygen (molecules) to bind (so saturation rises steeply) OR uncovers further binding sites;	**2 max** (2 × AO1)	**Accept** associate/combine/load for bind 3. **Accept** cooperative binding/cooperative nature of oxygen binding if explained **Accept** pO_2 for partial pressure of oxygen. Ignore Hb: haemoglobin must be written in full **Ignore** references to carbon dioxide or the Bohr effect

Question	Marking guidance	Mark	Comments
01.2	Correct answer for 2 marks: 82 (%);; Accept for 1 mark: saturations of 97 **and** 17 (%) **OR** 80 (%) (difference in saturation)	**2** (2 × AO2)	Plotted curve: 97% at 13 kPa and 17% at 2 kPa **Accept** answers in the range 81–84 (%) from readings within ±1% of the plotted values **Accept** readings of 96–98 **and** 16–18 (%) for the 1-mark route 80 (%) is the fall in saturation, not the percentage of the oxygen carried that is unloaded: 1 mark only

Question	Marking guidance	Mark	Comments
01.3	1. Midge larva curve is to the left (of the human curve) OR midge larva haemoglobin has a higher affinity for oxygen; 2. (So it) loads/binds/associates with oxygen at the low partial pressure (of oxygen) in the water next to the mud/at the body surface; 3. At 1.5 kPa, midge larva haemoglobin is about 80% saturated compared with about 9% for human haemoglobin; 4. (So the larva) obtains enough oxygen for aerobic respiration (in oxygen-poor water);	**3 max** (1 × AO1) (2 × AO2)	1. **Reject** higher affinity unloads more readily 2. **Do not credit** 'loads faster/more quickly': a dissociation curve has no time element 2. **Do not credit** 'oxygen concentration' in place of partial pressure of oxygen. Accept pO_2 3. **Accept** readings of 77–83% and 6–12% 4. **Accept** respiration if aerobic is implied, eg 'to release enough energy/make enough ATP'

Question	Marking guidance	Mark	Comments
02.1	Correct answer for 2 marks: 17.2 (cm^3);; Accept for 1 mark: 86 (%) **OR** 19.2 **and** 2.0 (cm^3)	**2** (2 × AO2)	**Accept** 17 (cm^3) for 2 marks **Reject** 15.8 (cm^3) (uses the low carbon dioxide column at 2 kPa) for 2 marks; it gains 1 mark only if working shows 96

Question	Marking guidance	Mark	Comments
02.2	1. Without the rise in carbon dioxide, saturation at 2 kPa would still fall to 17%, so 79%/15.8 cm^3 would be unloaded anyway; 2. (So) the carbon dioxide adds only 7 percentage points (of saturation)/1.4 cm^3 (about 8% of the oxygen unloaded), so the conclusion is not supported OR most is unloaded because of the low partial pressure of oxygen;	**2** (2 × AO3)	**ECF** from the answer to 02.1 **Accept** pCO_2 and pO_2 for partial pressures 2. **Accept** a correct comparison of percentage points without a volume **Ignore** 'the Bohr effect increases unloading' unless linked to the size of the effect in Table 1

Question	Marking guidance	Mark	Comments
03	It is made of more than one polypeptide chain;	**1** (1 × AO1)	

The heart and the cardiac cycle 3.3.4.1

Question	Marking guidance	Mark	Comments
04.1	0.16–0.40 s;	**1** (1 × AO2)	Blood leaves the ventricle only while the semi-lunar valve is open: ventricular pressure is above aortic pressure from 0.16 s to 0.40 s.

Question	Marking guidance	Mark	Comments
04.2	Correct answer for 2 marks: 68 (cm^3);; Accept for 1 mark: heart rate of 75 (beats min^{-1}) **OR** 5100 ÷ 75 OR 5.1 ÷ 75	**2** (2 × AO2)	One cycle lasts 0.8 s, eg ventricular pressure starts to rise at 0.10 s and again at 0.90 s, or peaks at 0.28 s and 1.08 s; 60 ÷ 0.8 = 75 **Accept** 0.068 dm^3 for 2 marks 0.068 given with the unit cm^3 (not converted from dm^3) gains 1 mark only

Question	Marking guidance	Mark	Comments
04.3	1. Atrioventricular valve closes at 0.10 s, when pressure in the ventricle becomes higher than in the atrium; 2. (Closed atrioventricular valve) prevents backflow of blood into the atrium (when the ventricle contracts); 3. Semi-lunar valve opens at 0.16 s, when pressure in the ventricle becomes higher than in the aorta, so blood is forced into the aorta; 4. Semi-lunar valve closes at 0.40 s, when pressure in the aorta becomes higher than in the ventricle, preventing backflow into the ventricle; 5. Atrioventricular valve opens at 0.48 s, when pressure in the atrium becomes higher than in the ventricle, so blood flows from the atrium into the ventricle;	**4 max** (2 × AO1) (2 × AO2)	**Max 2** if no times from Figure 2 are given **Accept** times within ±0.02 s 1, 3, 4 and 5. The correct pressure comparison is needed; a time alone does not gain the mark **Accept** bicuspid/mitral valve for the left atrioventricular valve, and aortic valve for the semi-lunar valve. Neither is required **Reject** A-V valve, AV valve and S-L valve: valve names must be written in full **Ignore** references to valve size

Question	Marking guidance	Mark	Comments
05.1	Capillaries in the lungs;	**1** (1 × AO2)	Vein → vena cava → right atrium → right ventricle → pulmonary artery → lungs.

Question	Marking guidance	Mark	Comments
05.2	Pulmonary artery;	**1** (1 × AO1)	**Reject** pulmonary vein **Reject** aorta

Question	Marking guidance	Mark	Comments
05.3	1. (The left ventricle has a) thicker (muscular) wall; 2. (Left ventricle) contracts more strongly/produces a higher pressure to pump blood around the (whole) body, whereas the right ventricle pumps blood only to the lungs;	**2** (2 × AO1)	2. **Accept** the right ventricle pumps blood only to the lungs, which are close to the heart 2. **Reject** the left ventricle pumps a greater volume of blood **Reject** thicker 'cell wall'

Question	Marking guidance	Mark	Comments
05.4	1. The water (pressure) closes the semi-lunar valve (at the base of the aorta); 2. Pressure (of water) in the aorta is higher than in the ventricle; 3. (The semi-lunar valve) prevents backflow (of blood) from the aorta into the ventricle (when the ventricle relaxes/during diastole);	**2 max** (2 × AO2)	**Accept** aortic valve for semi-lunar valve **Reject** atrioventricular valve **Reject** S-L valve: write in full 1. **Accept** water fills the pockets/cusps of the valve, pushing it shut

Blood vessels and tissue fluid 3.3.4.1

Question	Marking guidance	Mark	Comments
06.1	Smooth muscle in their walls relaxes, so the lumen widens;	**1** (1 × AO1)	

Question	Marking guidance	Mark	Comments
06.2	1. Blood pressure in veins is low (0.9 kPa compared with 12.0 kPa in arteries); 2. (So) thin wall/little muscle and elastic tissue, because the wall does not need to withstand/smooth out high pressure; 3. Wide lumen, so there is little resistance to blood flow (at low pressure) back to the heart; 4. Valves prevent the backflow of blood/keep blood flowing towards the heart;	**3 max** (2 × AO1) (1 × AO2)	**Max 2** if Table 2 is not used 2. **Reject** veins have no muscle 4. **Accept** valves stop blood flowing backwards (because pressure is low) **Ignore** veins carry deoxygenated blood

Question	Marking guidance	Mark	Comments
06.3	Correct answer for 2 marks: 1.9×10^{-2} (cm s^{-1});; Accept for 1 mark: 0.01875 OR 0.019 OR 1.875×10^{-2} (not in standard form to two significant figures)	**2** (2 × AO2)	90 ÷ 4800 = 0.01875 **Reject** 1.8×10^{-2} (truncated) for 2 marks

Question	Marking guidance	Mark	Comments
06.4	1. (The total cross-sectional area is very large/4800 cm^2, so) there are many (branched) capillaries, giving a large surface area (for exchange); 2. (The large cross-sectional area means) blood flows slowly, giving more time for exchange/diffusion; 3. Wall is one cell thick/thin endothelium, giving a short diffusion distance/pathway; 4. Narrow lumen, so red blood cells are close to the wall OR capillaries are close to all cells, giving a short diffusion distance;	**3 max** (2 × AO1) (1 × AO2)	**Max 2** if Table 2 is not used (point 1 or point 2) 1. **Reject** SA unless surface area is written in full 3. **Reject** thin cell wall 3. **Accept** walls are permeable/have gaps that let small molecules through

Question	Marking guidance	Mark	Comments
07.1	0.4 (mm);	**1** (1 × AO2)	**Accept** 0.38–0.42 (mm)

Question	Marking guidance	Mark	Comments
07.2	1. Near the arterial end/up to 0.4 mm, the hydrostatic pressure (4.4 kPa) is greater than the osmotic effect (3.0 kPa); 2. (So) water and small molecules (eg glucose, ions, amino acids) are forced out of the capillary (to form tissue fluid); 3. (Plasma) proteins are too large to leave/remain in the capillary; 4. (Plasma proteins) lower the water potential of the blood (below that of the tissue fluid); 5. (Beyond 0.4 mm/near the venous end) hydrostatic pressure is lower than the osmotic effect, so water moves back into the capillary by osmosis; 6. (Excess) tissue fluid is returned (to the blood) through the lymph (system);	**4 max** (3 × AO1) (1 × AO2)	**Max 3** if Figure 3 is not used 2. **Reject** water forced out by osmosis 4. **Accept** more negative water potential. Accept Ψ. Reject WP: water potential must be written in full 5. **Ignore** 'tissue fluid' moves back by osmosis: water must be named 6. **Credit** lymph/lymphatic system, but it is not required for full marks

Question	Marking guidance	Mark	Comments
07.3	1. Hydrostatic pressure is now higher than the osmotic effect (3.0 kPa) along the whole length of the capillary/at the venous end; 2. (So) fluid is forced out along the whole capillary OR (little/no) water returns to the capillary by osmosis; 3. More tissue fluid forms than returns to the blood (so excess tissue fluid builds up);	**2 max** (2 × AO2)	3. **Credit** 'the lymph (system) cannot remove all the excess', but it is not required **Reject** water potential of the blood changes

Risk factors for cardiovascular disease 3.3.4.1

Question	Marking guidance	Mark	Comments
08.1	Correct answer for 2 marks: 33 (%);; Accept for 1 mark: 19 ÷ 58	**2** (2 × AO2)	**Accept** 32.8 or 32.76 (%) for 2 marks **Reject** 48.7 (%) (divides by 39) for 2 marks

Question	Marking guidance	Mark	Comments
08.2	1. It shows a correlation, which does not show a causal relationship; 2. People who eat more oily fish may differ in other (risk) factors, eg smoke less/exercise more/eat less saturated fat; 3. Diet was recorded only at the start/may have changed during the 12 years OR diet was self-reported, so may be inaccurate; 4. No statistical test, so it is not known whether the differences are significant;	**2 max** (2 × AO3)	2. A named factor is needed **Reject** the sample is too small **Ignore** 'not a fair test' unqualified

Question	Marking guidance	Mark	Comments
08.3	1. (For:) in Study 1, new cases of CHD fall as oily fish intake rises (from 58 to 39 per 1000) OR there is a negative correlation; 2. (For:) Study 1 was large (24 000 people) and long (12 years); 3. (For:) the fish-oil group in Study 2 had slightly fewer new cases (34 compared with 36 per 1000); 4. (Against:) Study 2 found no significant difference, and it was randomised/used a placebo/was double-blind, so it controls other factors better than Study 1; 5. (Against:) Study 1 is about eating fish, not capsules: the lower risk may come from other substances in fish OR from eating less of other foods, eg red meat; 6. (Limitation of Study 2:) 5 years may be too short for CHD to develop OR the olive oil placebo may itself lower the risk of CHD; 7. (Limitation:) the studies used different age groups, so the results may not apply to everyone OR the website does not consider who might benefit, eg people who eat no fish;	**5 max** (5 × AO3)	**Max 4** if only points for, or only points against or limiting the advice, are given **Max 3** if no data from Table 3 or Table 4 are used **Reject** Study 1 or Study 2 has a small sample **Ignore** 'correlation does not mean causation' unless applied to Study 1

Xylem and transpiration 3.3.4.2

Question	Marking guidance	Mark	Comments
09.1	1. Prevents air entering the xylem/the cut end of the stem; 2. Air would break the (continuous) column of water OR water molecules would no longer be held together by cohesion along the whole column; 3. (So) water would not be pulled up the xylem OR water uptake would stop/slow (and readings would be inaccurate);	**2 max** (2 × AO2)	2. **Accept** hydrogen bonds between water molecules for cohesion 2. **Reject** adhesion used to mean attraction between water molecules **Ignore** 'to make it airtight' unqualified

Question	Marking guidance	Mark	Comments
09.2	Correct answer for 2 marks: 2.7 (mm^3 min^{-1});; Accept for 1 mark: rate of bubble movement of 3.5 (mm min^{-1}) **OR** 2.7475/2.75 (not to two significant figures)	**2** (2 × AO2)	Plotted line: 35 mm in 10 min **Accept** 0.785 × 3.5 as working for 1 mark **Reject** 11 (uses the diameter as the radius) for 2 marks

Question	Marking guidance	Mark	Comments
09.3	1. Moving air removes water vapour from around the leaf/stomata OR reduces humidity next to the leaf; 2. (So) a steeper water potential gradient (between the air spaces in the leaf and the air outside); 3. Faster diffusion of water vapour out through the stomata OR faster transpiration/evaporation; 4. Greater tension (in the xylem), so water is pulled up/taken up faster;	**3 max** (2 × AO1) (1 × AO2)	2. **Accept** diffusion/concentration gradient of water vapour. Reject WP: write water potential in full (Ψ accepted) **Reject** stomata open wider because of the fan **Ignore** 'the fan dries the leaves' unqualified

Question	Marking guidance	Mark	Comments
09.4	Some water (taken up) is used in photosynthesis/hydrolysis OR used to keep cells turgid/for growth (so is not lost by transpiration);	**1** (1 × AO1)	**Accept** water is produced in respiration **Accept** water may leak from the apparatus **Ignore** 'water is used by the plant' unqualified

Question	Marking guidance	Mark	Comments
09.5	1. Calculate the rate per unit (leaf) surface area OR divide the rate by the total area of the leaves; 2. (Because) the shoots will have different numbers/sizes of leaves/different total leaf areas; 3. Find leaf area by drawing round the leaves on graph paper/squared paper and counting squares;	**2 max** (2 × AO3)	1. **Reject** SA unless surface area is written in full **Ignore** 'use the same number of leaves' **Ignore** controlling environmental variables: the question asks about processing results

Question	Marking guidance	Mark	Comments
10.1	1. Water evaporates (from cells inside the leaf) and water vapour diffuses out through the stomata (transpiration); 2. Water molecules are held together by hydrogen bonds/cohesion, so water is pulled up the xylem as a continuous column; 3. (This) creates tension (in the xylem); 4. Tension pulls the xylem walls inwards, so the diameter decreases, reaching a minimum (-100 µm) at 12 hours, when transpiration is highest; 5. After 12 hours, transpiration decreases, so tension decreases and the diameter increases again;	**4 max** (2 × AO1) (2 × AO2)	**Max 3** if the change in diameter is not linked to the rate of transpiration 2. **Accept** H bonds for hydrogen bonds 2. **Reject** adhesion used to mean attraction between water molecules 3. **Accept** negative pressure/suction **Reject** root pressure as the cause

Question	Marking guidance	Mark	Comments
10.2	1. The diameter at the top decreases first/reaches its minimum earlier (12 hours) than at the base (14 hours); 2. Tension is created at the top/in the leaves, where water evaporates; 3. Tension is passed down the (continuous) water column (by cohesion), so water is pulled up (from above), not pushed from the roots;	**2 max** (2 × AO3)	1. **Accept** the minimum at the base is 2 hours later **Reject** root pressure pushes water up

Question	Marking guidance	Mark	Comments
10.3	When a xylem vessel in a transpiring shoot is cut, air is drawn into the vessel;	**1** (1 × AO2)	

Phloem and translocation 3.3.4.2

Question	Marking guidance	Mark	Comments
11.1	1. Removing a ring (almost) stops transport past it, eg below leaf L falls from 30% to 2% OR above leaf L falls from 18% to 1%; 2. (So) organic substances are transported in the phloem, because the xylem was not damaged; 3. They are transported both up (to the shoot tip) and down (to the roots) from leaf L (18% above and 30% below in group A); 4. Leaf L is a source, and the shoot tip/young leaves and roots are sinks OR the radioactive carbon was fixed in photosynthesis into sugars/sucrose that were then transported;	**3 max** (3 × AO3)	**Max 2** if no data from Table 5 are used 2. **Accept** sieve tubes for phloem; not required **Reject** 'transported in the xylem' 4. **Reject** glucose as the main sugar transported

Question	Marking guidance	Mark	Comments
11.2	1. Organic substances/sucrose could not move down past the ring to the roots (sinks below leaf L); 2. (So) more was transported upwards to the shoot tip/young leaves OR the shoot tip was the only remaining sink; 3. More remained in leaf L (52% to 72%), so more was available to move upwards;	**2 max** (2 × AO3)	**Accept** sucrose/sugars for organic substances **Reject** glucose **Ignore** 'the xylem carried it upwards'

Question	Marking guidance	Mark	Comments
12	1. Sucrose is actively transported/co-transported into the phloem at the source (leaf); 2. This lowers the water potential in the phloem, so water enters (from the xylem) by osmosis; 3. This produces a high hydrostatic pressure at the source, so (a pressure gradient causes) mass flow to the sink, where sucrose is removed/used (in respiration)/stored; 4. Observation 1 supports it: the phloem contents are under (high hydrostatic) pressure; 5. Observation 2 supports it: there is a sucrose concentration gradient (and so a water potential/pressure gradient) from source to sink; 6. Observation 3 supports it: loading at the source needs ATP/respiration, as for active transport; 7. Observation 4 opposes it: mass flow would carry all solutes (in the same phloem) at the same speed; 8. Observation 5 opposes it: mass flow should move in only one direction (in one part of the phloem at one time); 9. Evaluative comment, eg observation 5 does not disprove mass flow if the tracers were in different phloem cells OR observations 1–3 are consistent with mass flow but do not prove it;	**6 max** (3 × AO1) (3 × AO3)	**Max 4** from points 4–9 For full marks, the answer must include at least one of points 1–3, and at least one of points 4–6 and one of points 7–9 1. **Accept** co-transport with hydrogen ions; credit companion/transfer cells, but they are not required. Ignore facilitated diffusion for loading 2. **Accept** Ψ. Reject WP: water potential must be written in full 3. **Accept** a named sink, eg roots, shoot tip, growing tissue, storage organ. Credit unloading at the sink by active transport/diffusion/facilitated diffusion, but it is not required **Accept** sieve tubes/sieve elements for phloem; not required **Reject** sucrose moving along the phloem by diffusion as the mechanism. Reject cohesion-tension as the mechanism of translocation **Reject** glucose as the sugar loaded into the phloem

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