HELICATE · AS AND A-LEVEL BIOLOGY · TOPIC BANK

3.3.1 Surface area to volume ratio

Mark scheme

Version 1 · 2 October 2026

TOTAL MARKS	QUESTIONS
38	4

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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Size, shape and surface area to volume ratio 3.3.1

Question	Marking guidance	Mark	Comments
01.1	Volume increases more than surface area, so the surface area to volume ratio decreases;	**1** (1 × AO1)	Surface area increases with the square of length, but volume increases with the cube of length.

Question	Marking guidance	Mark	Comments
01.2	Correct answer of 0.21 : 1 for 3 marks;;; Accept for 2 marks, surface area = 2.32×10^4 μm^2 **and** volume = 1.13×10^5 μm^3 **OR** a correct ratio not given to 2 significant figures, eg 0.206 : 1 / 0.2056 : 1 **OR** 0.21 not given in the form *x* : 1 Accept for 1 mark, surface area = 2.32×10^4 μm^2 OR volume = 1.13×10^5 μm^3	**3** (3 × AO2)	**Accept** surface area as 7400π / 23248 μm^2 and volume as 36 000π / 113097 μm^3 **Accept** 0.21 : 1 from any correct method, eg 7400π ÷ 36 000π A ratio of 0.20 : 1 (circular ends left out of the surface area) gains 1 mark for the correct volume only **Reject** the inverted ratio (volume to surface area), 4.9 : 1, for the third mark **Ignore** the ratio also given as a fraction

Question	Marking guidance	Mark	Comments
01.3	1. Q has a larger surface area to volume ratio (about twice that of P) OR more surface/cell-surface membrane (area) per unit volume; 2. So faster (rate of) diffusion of oxygen/gases (into the cell) per unit volume OR enough oxygen diffuses in to meet the cell's demand; 3. Shorter diffusion distance/pathway to the centre of the cell (10 µm compared with 30 µm), so gases diffuse to/from all parts of the cell faster;	**2 max** (1 × AO1) (1 × AO2)	**ECF** for a comparison using the student's ratio from 01.2 1. **Reject** larger surface area unless linked to volume, eg per unit volume / relative to volume 2. **Accept** more oxygen/carbon dioxide can diffuse in/out per unit volume 2. **Reject** 'less diffusion' for P unqualified 3. **Accept** Q is thinner/narrower so no part of the cell is far from the surface **Reject** active transport of oxygen

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Body shape and exchange systems in larger organisms 3.3.1

Question	Marking guidance	Mark	Comments
02.1	Correct answer of 11 : 1 for 2 marks;; Accept for 1 mark, surface area = 78 mm^2 **and** volume = 7.2 mm^3 **OR** a correct ratio not given to 2 significant figures, eg 10.8 : 1 / 10.83 : 1 **OR** 11 not given in the form *x* : 1	**2** (2 × AO2)	**Reject** the inverted ratio (volume to surface area) for the second mark **Ignore** the ratio also given as a fraction

Question	Marking guidance	Mark	Comments
02.2	Halving the thickness;	**1** (1 × AO2)	Ratios: doubling the length 10.75 : 1; doubling the width 10.50 : 1; doubling the thickness 5.83 : 1; halving the thickness 20.83 : 1 (original 10.83 : 1).

Question	Marking guidance	Mark	Comments
02.3	1. Earthworm is thicker/larger, so it has a smaller surface area to volume ratio (than the flatworm); 2. Long diffusion distance/pathway from the body surface to cells in the centre of the earthworm; 3. Diffusion (alone) is too slow to supply (enough) oxygen to the inner cells/to meet the demand of all the cells; 4. Blood carries oxygen (by mass transport) from the body surface/capillaries under the surface to all (inner) cells/tissues; 5. Blood (flow) removes oxygen from the body surface, so maintaining a (steep) concentration/diffusion gradient; 6. Capillaries are close to all cells, so there is a short diffusion distance from blood to each cell; 7. In the flatworm, all cells are close to the surface (no more than 0.1 mm) OR the diffusion distance is short, so diffusion across the body surface is enough;	**5 max** (4 × AO1) (1 × AO2)	**Max 4** unless the answer refers explicitly to the flatworm, ie point 1 written as a comparison with the flatworm, or point 7 1. **Accept** converse, eg the flatworm is flat/thin so has a larger surface area to volume ratio 3. **Reject** 'less diffusion' unqualified; accept 'not enough oxygen diffuses to the inner cells' 4. **Accept** blood carries oxygen around the body/to where it is needed 5. **Accept** 'keeps the oxygen concentration low under the surface' **Ignore** references to lungs, gills or other named gas exchange organs

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Surface area to volume ratio and metabolic rate 3.3.1

Question	Marking guidance	Mark	Comments
03.1	1. Smaller rodents have a larger surface area to volume ratio; 2. (So smaller rodents) lose (more) heat faster/more easily (per gram); 3. Higher rate of (aerobic) respiration/metabolism (per gram) releases/replaces heat OR maintains (constant) body temperature; 4. (Aerobic) respiration uses oxygen;	**3 max** (3 × AO1)	**Accept** converse for larger rodents throughout 3. **Accept** respiration releases energy / produces or generates heat 3. **Reject** respiration produces energy / produces heat energy **Ignore** references to faster diffusion, gas exchange or exchange surfaces (not creditworthy here)

Question	Marking guidance	Mark	Comments
03.2	1. Weasel 3.1 : 1; 2. Rodent 2.1 : 1;	**2** (2 × AO2)	If neither is given to 2 significant figures, award 1 mark for both correct, eg 3.125 : 1 **and** 2.125 : 1 **Reject** inverted ratios, 0.32 : 1 and 0.47 : 1 **Ignore** ratios also given as fractions

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Question	Marking guidance	Mark	Comments
03.3	1. (For) Weasel and rodent have the same body mass (80 g), so the difference is not caused by size; 2. (For) Weasel's rate is higher (3.8 compared with 2.4 cm^3 g^{-1} h^{-1}) OR about 1.6 times higher; 3. (For) Weasel's shape gives a larger surface area to volume ratio (3.1 : 1 compared with 2.1 : 1), so it loses heat faster and needs more respiration to maintain body temperature; 4. (Against) Only one weasel species/one species of each shape compared OR number of animals of each species not given; 5. (Against) No measure of variation/standard deviations/error bars OR no statistical test, so cannot tell whether the difference is significant; 6. (Against) Other differences between the species may affect the rate, eg fur thickness/insulation, activity, diet OR correlation does not show cause; 7. (Against) Surface areas are estimates OR volume is assumed from mass; 8. (For or against) Compares how many times higher the weasel's rate is (about 1.6, 1.58 from the plotted values) with how many times larger its surface area to volume ratio is (about 1.5, 1.47), and concludes either that they are similar, so shape could account for the difference, OR that the rate factor is clearly larger, so shape may not explain all of the difference;	**4 max** (2 × AO2) (2 × AO3)	**Max 3** if only points for, or only points against, the conclusion are given The comparison point (factor of rate v factor of ratio) can count as for or against, depending on the conclusion drawn from the student's own values 2. **Accept** 58% higher; accept readings of 3.7–3.9 and 2.3–2.5 3. **ECF** from the student's ratios in 03.2 3. **Reject** respiration produces energy **Ignore** 'not enough data' unqualified **Ignore** 'no repeats' (each point is a mean)

Question	Marking guidance	Mark	Comments
03.4	1. Reduces the surface area exposed to the air (for the same volume) OR reduces the (effective) surface area to volume ratio; 2. So less heat is lost; 3. Less respiration needed to maintain body temperature, so less respiratory substrate/glucose/fat used;	**2 max** (1 × AO1) (1 × AO2)	2. **Accept** heat is lost more slowly 3. **Reject** respiration produces energy **Ignore** 'keeps it warm' unqualified

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Investigating diffusion into agar cubes 3.3.1

Question	Marking guidance	Mark	Comments
04.1	Correct answer of 48.8 (%) for 2 marks;; Accept for 1 mark, volumes of 8000 **and** 4096 (mm^3) OR volume reached = 3904 (mm^3) **OR** 51.2 (%) (percentage not reached) **OR** 49 (%) (not to 3 significant figures)	**2** (2 × AO2)	

Question	Marking guidance	Mark	Comments
04.2	1. Percentage (of volume) reached decreases as the surface area to volume ratio decreases (from 99.2% to 34.9%); 2. Acid diffuses the same distance (about 2 mm) into every cube, but in larger cubes more of the volume is further than this from the surface OR less surface (area) for the acid to diffuse across per unit volume;	**2** (1 × AO2) (1 × AO3)	1. **Accept** the converse 2. **Accept** larger cubes have a longer diffusion distance/pathway to the centre **Ignore** 'acid diffuses more slowly into larger cubes'

Question	Marking guidance	Mark	Comments
04.3	Pink region is only 1 mm wide, the same as the smallest division on the ruler, so a (reading) error of ±0.5 mm/1 mm is a large proportion of the measurement;	**1** (1 × AO3)	**Accept** any small error in measuring or cutting has the greatest effect on the smallest measurement **Ignore** 'human error' unqualified

Question	Marking guidance	Mark	Comments
04.4	1. Animals (may) have a circulatory/mass transport system that carries oxygen to (inner) cells; 2. Animals (may) have specialised exchange surfaces OR the body surface may not be permeable to oxygen; 3. Animals are not cube-shaped OR body shape may be flattened/elongated (giving a larger surface area to volume ratio); 4. Oxygen must cross cell(-surface) membranes, but agar is a uniform gel with no membranes/cells; 5. Oxygen is a different substance from (hydrochloric) acid, so it may diffuse at a different rate; 6. Animal (may be) at a different temperature (from 20 °C);	**2 max** (2 × AO3)	**Ignore** 'agar is not alive' unqualified

Question	Marking guidance	Mark	Comments
04.5	1. Use a range of (at least five) concentrations of hydrochloric acid, made by diluting a stock solution (with distilled water); 2. Use cubes of the same size/side length (so same surface area to volume ratio), cut from the same batch of agar; 3. Each cube fully covered by the acid OR whole surface of each cube in contact with the acid; 4. Same temperature, using a (thermostatically controlled) water bath; 5. Leave each cube in the acid for the same time (before removing and cutting); 6. Measure the width of the pink region and calculate the distance diffused, eg (side length − width) ÷ 2; 7. Calculate the rate of diffusion as distance ÷ time (mm min^{-1}) OR time how long the whole cube takes to become colourless and use 1 ÷ time; 8. Repeat (at least three times) at each concentration and calculate a mean; 9. Plot a graph of (mean) rate of diffusion against concentration of acid;	**6 max** (2 × AO1) (4 × AO3)	1. **Accept** a named range, eg 0.02 to 0.10 mol dm^{-3} 1. **Reject** using different acids 2. **Accept** same concentration of alkali and indicator in the agar 2. **Ignore** 'same agar' or 'same cubes' unqualified 3. **Ignore** 'same volume of acid' unqualified 4. **Ignore** 'room temperature' unless a way of keeping it constant is given **Ignore** safety precautions

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