Surface Area to Volume Ratio: AQA A Level Biology Exam Questions by T

14 questions · 30 marks · about 39 minutes. Answer in the spaces, then check the mark schemes at the end.

Question 1 · AS Paper 2 · June 2018 · Q03.1 · 1 mark

0 3 . 1 Describe the relationship between size and surface area to volume ratio of organisms.

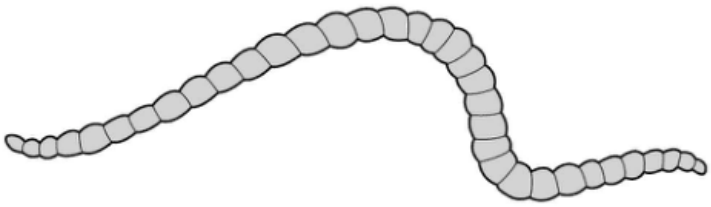
[1 mark]

Question 2 · information from earlier in the question

0 3 Tubifex worms are small, thin animals that live in water. They have no specialised gas exchange or circulatory system.

Figure 2 shows a tubifex worm.

Figure 2



Question 2 · AS Paper 2 · June 2016 · Q03.2 · 2 marks

0 3 . 2 Using the information provided, explain how **two** features of the body of the tubifex worm allow efficient gas exchange.

[2 marks]

1

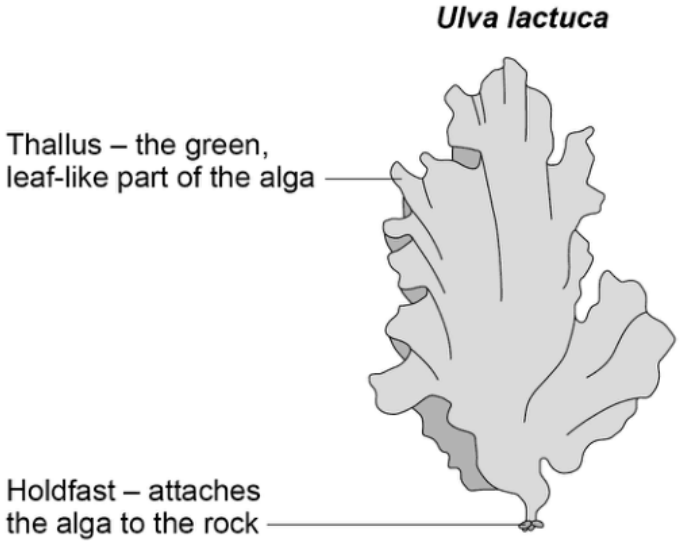
2

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0 7 *Ulva lactuca* is an alga that lives on rocks on the seashore. It is regularly covered by seawater.

Figure 6 shows a diagram of one *Ulva lactuca* alga.

Figure 6



0 7 . 1 Unlike plants, *Ulva lactuca* does not have xylem tissue.

Suggest how *Ulva lactuca* is able to survive without xylem tissue.

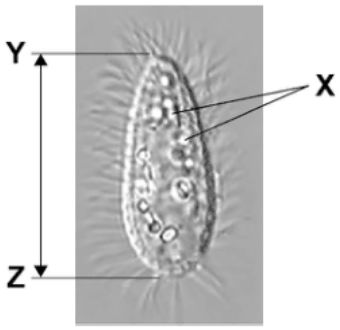
[1 mark]

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Question 4 · information from earlier in the question

0 3 *Uronema marinum* is a single-celled eukaryotic organism. **Figure 3** is a photograph of *U. marinum* taken through an optical microscope.

Figure 3



Question 4 · AS Paper 1 · November 2021 · Q03.4 · 2 marks

0 3 . 4 In large cells of *U. marinum*, most mitochondria are found close to the cell-surface membrane. In smaller cells, the mitochondria are distributed evenly throughout the cytoplasm. Mitochondria use oxygen during aerobic respiration.

Use this information and your knowledge of surface area to volume ratios to suggest an explanation for the position of mitochondria in **large** *U. marinum* cells.

[2 marks]

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Question 5 · A level Paper 1 · November 2021 · Q02.1 · 2 marks

0 2 . 1 Explain the advantage for larger animals of having a specialised system that facilitates oxygen uptake.

[2 marks]

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Question 6 · information from earlier in the question

Scientists captured a large number of three species of fish.

The scientists measured:

- the water depth where fish were caught
- the concentration of dissolved oxygen at all water depths
- the mean gill surface area and mean body mass of each species of fish caught.

The scientists calculated the ratio of gill surface area to fish body mass.

The results are shown in **Figure 5** and **Table 4**.

Figure 5

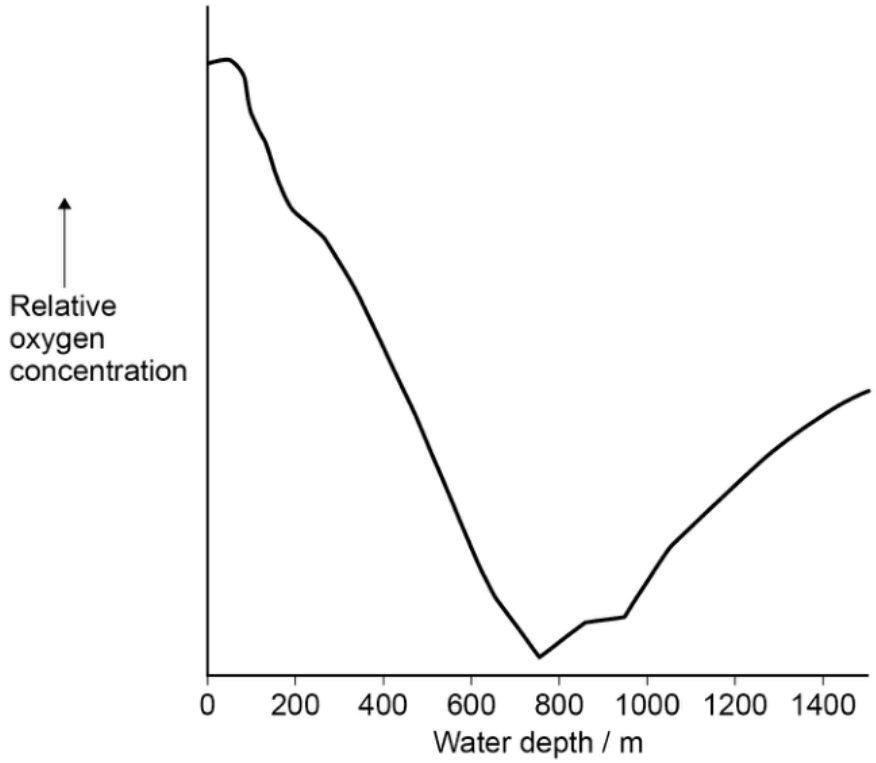


Table 4

Fish species	Water depth where fish were caught / m	Ratio of gill surface area to body mass
Anoplopoma fimbria	450–1280	148:1
Careproctus melanurus	850–1307	124:1
Embassichtys bathybius	1205–1307	20:1

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Question 6 · AS Paper 1 · June 2019 · Q06.4 · 2 marks

0 6 . 4 Using information from **Figure 5** and **Table 4**, what can you conclude about the adaptation of the gas exchange surfaces of these species of fish?

[2 marks]

Question 7 · A level Paper 3 · June 2024 · Q03.1 · 3 marks

0 3 . 1 Describe **and** explain the relationship between surface area to volume ratio of the human body and metabolic rate.

[3 marks]

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Question 8 · AS Paper 2 · June 2018 · Q03.5 · 1 mark

0 3 . 5 Explain why oxygen uptake is a measure of metabolic rate in organisms.

[1 mark]

Question 9 · information from earlier in the question

0 9 A scientist investigated the affinity for oxygen of horse haemoglobin and mouse haemoglobin.

Some of their results are shown in **Table 7**.

Table 7

Animal	Partial pressure of oxygen when haemoglobin is 50% saturated / kPa	Partial pressure of oxygen when haemoglobin is 25% saturated / kPa	Body mass of one animal / g
Horse	3.2	1.9	550 000
Mouse	6.5	3.3	23

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Question 9 · A level Paper 1 · June 2019 · Q09.4 · 3 marks

0 9 . 4 Mammals such as a mouse and a horse are able to maintain a constant body temperature.

Use your knowledge of surface area to volume ratio to explain the higher metabolic rate of a mouse compared to a horse.

[3 marks]

[Extra space]

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Question 10 · information from earlier in the question

The scientist calculated the ratio of surface area to mass for eggs, tadpoles and frogs. He also determined the mean rate of oxygen uptake by tadpoles and frogs.

His results are shown in **Table 2**.

Table 2

Stage of frog development	Ratio of surface area to mass	Mean rate of oxygen uptake / μmol g^{-1} h^{-1}
Egg	2904 : 1	no information
Tadpole	336 : 1	5.7
Adult	166 : 1	1.3

Question 10 · AS Paper 2 · June 2018 · Q03.6 · 3 marks

0 3 . 6 A student who looked at these results said that they could not make a conclusion about the relationship between stage of development and metabolic rate.

Use information in **Table 2** to explain reasons why they were unable to make a conclusion.

[3 marks]

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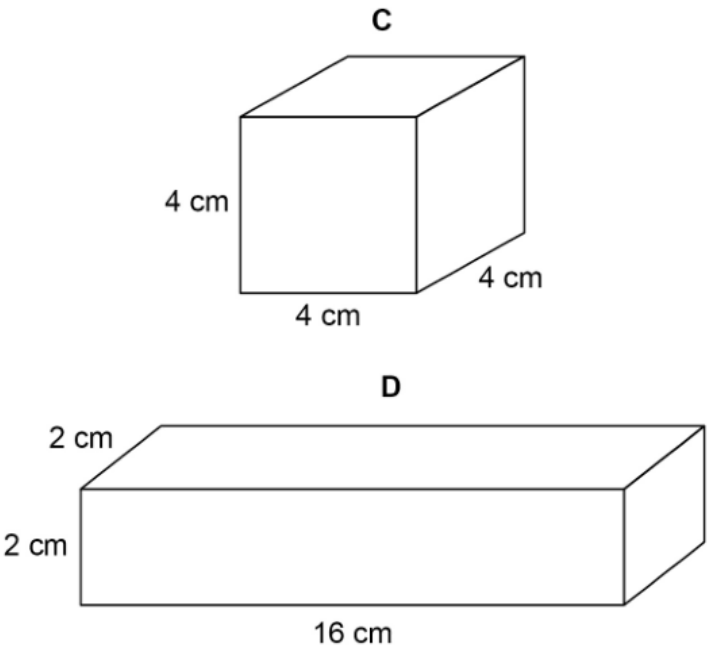
Question 11 · AS Paper 1 · June 2023 · Q05.1 · 2 marks

0 5 A student investigated the effect of changing surface area on the rate of diffusion of a solution into the centre of agar blocks.

She used agar coloured by an indicator. The indicator is pink at pH > 8 and colourless at pH 8 and pH < 8

She cut blocks in different shapes as shown in **Figure 6**.

Figure 6



0 5 . 1 Complete **Table 2** to show the surface area and the surface area to volume ratio for the two shapes.

Table 2

Shape	Surface area / cm^2	Volume / cm^3	Surface area to volume ratio
C	_____	64	_____ : 1
D	_____	64	_____ : 1

[2 marks]

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Question 12 · A level Paper 1 · June 2022 · Q08.2 · 2 marks

0 8 . 2 Using **Figure 11**, the scientists calculated the surface area to volume ratios for each gill filament in these two fish. Some of their results are shown in **Table 4**.

Complete **Table 4**. State your calculated volume and surface area:volume ratio to 2 significant figures.

[2 marks]

Table 4

Fish gill	Surface area / μm^2	Volume / μm^3	Surface area:volume ratio
Healthy	7.4×10^3	2.3×10^4	_____
Damaged	1.1×10^4	_____	0.13:1

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Table 2 shows the height and mass of two adults.

Table 2

Person	Height / cm	Mass / kg
A	181	90.90
B	149	62.62

The surface area of a person is estimated using the following formula:

$$\text{Surface area in m}^2 = \sqrt{\frac{\text{height in cm} \times \text{mass in kg}}{3600}}$$

The volume of a person is estimated using the following formula:

$$\text{Volume in m}^3 = \frac{\text{mass in kg}}{1010}$$

0 3 . 2 Using suitable calculations, deduce which person has the smaller surface area to volume ratio.

Show your working **and** complete the sentence below.

Give your answer to 3 significant figures.

[3 marks]

Person _____ has the smaller surface area to volume ratio which = _____

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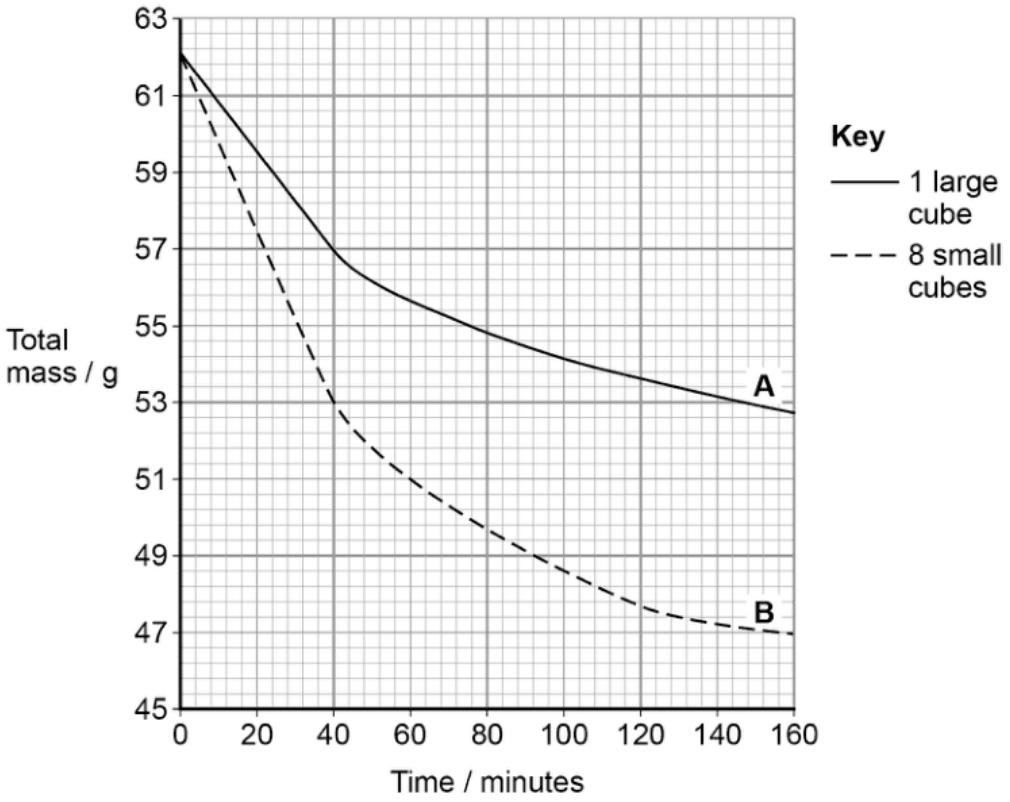
Question 14 · information from earlier in the question

0 2 A student investigated the effect of surface area on osmosis in cubes of potato.

- He cut two cubes of potato tissue, each with sides of 35 mm in length.
- He put one cube into a concentrated sucrose solution.
- He cut the other cube into eight equal-sized smaller cubes and put them into a sucrose solution of the same concentration as the solution used for the large cube.
- He recorded the masses of the cubes at intervals.

His results are shown in **Figure 3**.

Figure 3



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Question 14 · A level Paper 1 · June 2018 · Q02.2 · 3 marks

0 2 . 2 The loss in mass shown in **Figure 3** is due to osmosis. The rate of osmosis between 0 and 40 minutes is faster in **B** (the eight small cubes) than in **A** (single large cube).

Is the rate of osmosis per mm^2 per minute different between **A** and **B** during this time? Use appropriate calculations to support your answer.

[3 marks]

[Extra space]

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Mark schemes

Question 1 · AS Paper 2 · June 2018 · Q03.1 · 1 mark

03.1	As size increases, ratio (of surface area to volume) decreases;	1	Accept converse. Comparison required, e.g., smaller organisms have a larger ratio

Question 2 · AS Paper 2 · June 2016 · Q03.2 · 2 marks

03.2	1. Thin/small **so** short diffusion pathway; 2. Flat/long/small/thin **so** large surface area to volume ratio/surface area : volume;	2	1. Reject: thin membrane/wall/cells. 2. Accept: small volume to surface area ratio.

Question 3 · A level Paper 1 · June 2019 · Q07.1 · 1 mark

7.1	Short diffusion pathway (to cells) **OR** It has a surface permeable (to water/ions into cells);	1	Accept the idea of not needing structural support as supported by the water. Ignore pores/stomata

Question 4 · AS Paper 1 · November 2021 · Q03.4 · 2 marks

03.4	1. Large(r) cells have small(er) surface area to volume ratio; 2. (Takes) longer for oxygen to <u>diffuse</u> (to mitochondria) **OR** Less/no oxygen <u>diffuses</u> (to mitochondria) **OR** <u>Diffusion</u> distance/pathway is long(er);	2	Accept converse for all marking points.
TOTAL		**9**	

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Question 5 · A level Paper 1 · November 2021 · Q02.1 · 2 marks

02.1	1. Large(r) organisms have a small(er) surface area:volume (ratio); **OR** Small(er) organisms have a large(r) surface area:volume (ratio); 2. Overcomes long <u>diffusion</u> pathway **OR** Faster <u>diffusion</u>;	2	2. Accept short diffusion pathway 2. Accept for 'faster', more

Question 6 · AS Paper 1 · June 2019 · Q06.4 · 2 marks

06.4	1. (Generally) lower the oxygen concentration, the higher ratio/(gill) surface area to body mass; 2. Supplies (enough) oxygen for respiration;	2
TOTAL		**8**

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03.1	1. As surface area to volume ratio increases, metabolic rate increases **OR** (Humans with) a large surface area to volume ratio have a high/fast metabolic rate; 2. (A large(r) surface area to volume ratio will) lose **more** heat; 3. (A high(er) rate of metabolism/respiration) releases/provides/replaces heat **OR** (A high(er) rate of metabolism/respiration) maintains body temperature;	3 (3 x AO1)

Accept the converse for all marking points

1. Accept the relationship is proportional
1. Ignore 'directly' if prefixing proportional
1. Accept the relationship is **positively** correlated
2. Accept lose heat faster/**more** easily
3. Accept (a higher rate of metabolism/ respiration) releases energy

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Question 8 · AS Paper 2 · June 2018 · Q03.5 · 1 mark

03.5	(Oxygen used in) respiration, **which** provides energy / ATP; **OR** (Oxygen is used in) respiration, **which** is a metabolic process / chemical reaction;	1	Reject produces energy Reject references to anaerobic respiration

Question 9 · A level Paper 1 · June 2019 · Q09.4 · 3 marks

9.4	Mouse 1. (Smaller so) larger surface area to volume ratio; 2. More/faster heat loss (per gram/in relation to body size); 3. (Faster rate of) respiration/metabolism releases heat;	3	Accept converse answers in relation to the horse. 1. Accept larger SA:V. 1. and 2. must be comparative. 2. Ignore heat lost more easily/readily. 3. Accept respiration/metabolism replaces heat. 3. Reject produce/generate heat/energy.

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Question 10 · AS Paper 2 · June 2018 · Q03.6 · 3 marks

03.6	1. No information about egg; 2. So cannot compare all stages (in Table 2); 3. No statistical information / test / t-test / comparison of standard deviations; **OR** No measure of significant differences;	3

2. Idea of comparing all three stages needed 3. Reject statements that "results" are not significant 3. Reject references to chi squared or correlation coefficient

Question 11 · AS Paper 1 · June 2023 · Q05.1 · 2 marks

05.1		2 (2 x AO2)	Mark as columns Allow ECF for ratio Allow 2.1:1 and 2.13:1 for D Ignore fractions for ratio

Shape	**Surface area / cm^2**	**Volume / cm^3**	**Surface area to volume ratio**
C	96	64	1.5 : 1
D	136	64	2.125 : 1

; ;

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Question 12 · A level Paper 1 · June 2022 · Q08.2 · 2 marks

08.2

1 mark for each correct row

		Volume / μm^3	Surface area:volume ratio
			0.32:1
		8.5×10^4 OR 85 000	

If no marks awarded, accept for 1 mark,

0.3217 (correct ratio calculation not given to 2 significant figures)

OR

Number that can be rounded to 85 000 eg 84615 (correct calculation not given to 2 significant figures)

2

(2 x AO2)

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03.2	Person **A and** correct ratio of 23.7:1 **OR** 23.8:1 = **3 marks**;;; Person **A and** correct ratio (23.75349227:1) not to 3 sf = **2 marks** Person **A and** correct answer not expressed as a ratio = **2 marks** Person **A and** 2.14:0.09 = **2 marks** Person **B and** correct ratio of 23.7 **OR** 23.8:1 = **2 marks** Person **B and** 26.0:1 = **2 marks** (correct calculations, wrong person) Person **A and** answer not expressed as a ratio (23.75349227) **and** not to 3 sf = **1 mark** Evidence of 2.14 **and** 1.61 in working = **1 mark** Evidence of 0.09 **and** 0.06(2) in working = **1 mark** 1.61:0.06(2) = **1 mark**	3 (2 x AO1, 1 x AO3)

Ignore named person alone If no person remove 1 mark

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02.2	Yes or No (no mark) Calculation of rate per mm^2 for both sets of data, accept answers in the range 1.6×10^{-5} to 1.8×10^{-5} **and** 1.5×10^{-5} to 1.6×10^{-5};;; Both correct = 3 One correct = 2 Neither correct – look below for max 2 Allow 1 mark for calculation of surface area of two (sets of) cubes 7350 (mm^2) and 14700 (mm^2) Allow 1 mark for calculation of both rates of osmosis shown in first 40 minutes – between 0.12 and 0.13 **and** between 0.22 and 0.23 If surface area and/or rate of osmosis is incorrect then, allow 1 mark for (their) calculated rate divided by (their) calculated surface area

3	Accept answers not given in standard form or to any number of significant figures ≥2sf as long as rounding correct.

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