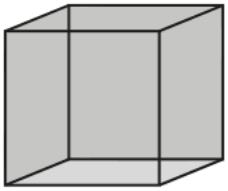
Geometry and Surface Area to Volume (M4): OCR A Level Biology Exam

10 questions · 25 marks · about 30 minutes. Answer in the spaces, then check the mark schemes at the end.

Question 1 · AS Paper 2 · June 2023 · Q1(a)(i) · 2 marks

1 (a) **Fig. 1.1** shows two cubes that represent a large and a small multicellular plant.

Fig. 1.1

Large multicellular plant	Small multicellular plant
	
Length = 2 cm Width = 2 cm Depth = 2 cm	Surface area : volume = 6:1

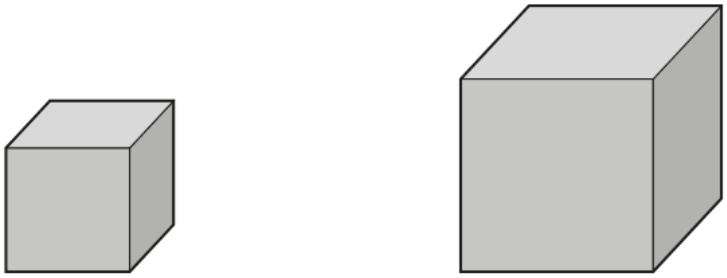
(i) Using the data provided in **Fig. 1.1**, calculate the surface area : volume of the large multicellular plant.

Surface area : volume = ... **[2]**

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Question 2 · AS Paper 2 · November 2020 · Q6(a) · 2 marks

6 (a) The cubes shown in Fig. 6.1 represent two different sized animals.



Small multicellular animal
Volume = 8 cm^3
Surface area = 24 cm^2

Large multicellular animal
Volume = 64 cm^3
Surface area = 96 cm^2

Fig. 6.1

Explain how Fig. 6.1 demonstrates the need for larger multicellular animals to have specialised exchange surfaces.

.....

.....

.....

.....

..... **[2]**

Turn over

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Question 3 · information from earlier in the question

(d) A student was investigating the effect of cell size on the rate of diffusion into model cells. They had two cubes of agar containing phenolphthalein indicator as shown in Fig. 21.2.

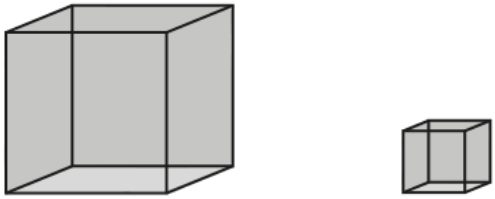


Fig. 21.2

The student placed the cubes in beakers of dilute hydrochloric acid, which caused the indicator to become colourless. They then measured how much of each cube became colourless over time.

(i) State **two** ways the student could have ensured they had confidence in their results.

1 .....

.....

2 .....

.....

[2]

Turn over

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Question 3 · AS Paper 1 · June 2018 · Q21(d)(ii) · 2 marks

(ii) In Fig. 21.2, Cube A is 10 mm along each side and Cube B is 4 mm along each side. Calculate the surface area to volume ratio (SA:V) for both cubes A and B.

Show your working. Give your answers to **one** decimal place.

Cube A .....

Cube B .....

[2]

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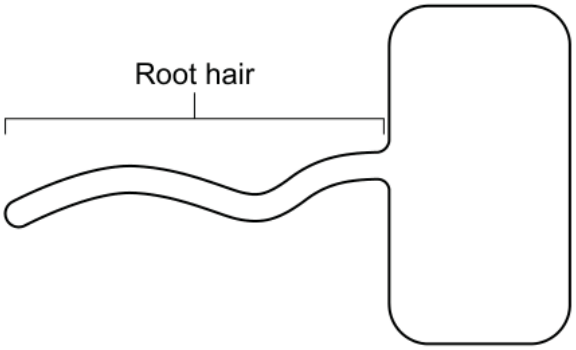
(b) The outer surface of a root is made up of root epidermal cells.

A root hair cell is a type of root epidermal cell that has a hair-like extension called a root hair.

A typical root epidermal cell has a surface area to volume ratio (SA:V) of 0.3:1.

A root hair cell has a higher SA:V than a typical root epidermal cell.

The diagram shows a root hair cell. The diagram is not to scale.



The root hair has:
- a diameter of 10 μm
- a length of 800 μm.

(i) Calculate the SA:V of the root hair.

Assume the root hair is cylindrical.

Use the equations:

Surface area of cylinder = $2\pi r(r + l)$

Volume of cylinder = $\pi r^2 l$

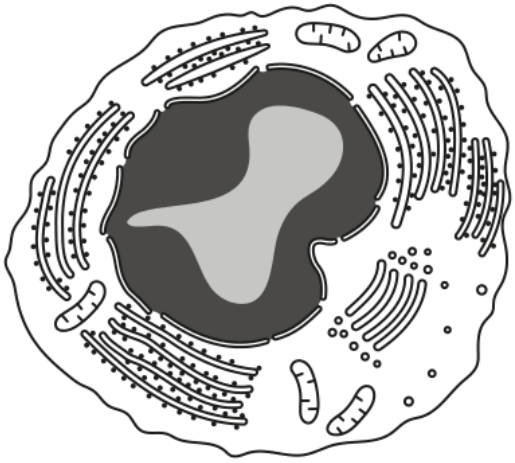
SA:V of root hair = ... **[3]**

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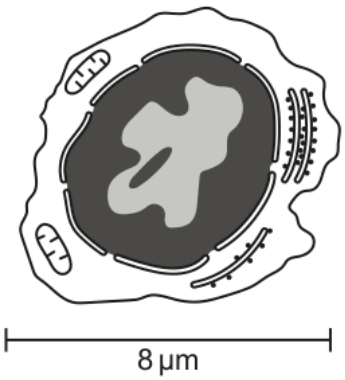
Question 5 · AS Paper 1 · June 2025 · Q23(a)(i) · 2 marks

23

(a) The diagram below shows a drawing of a plasma cell and a B lymphocyte. The actual size of the diameter of each cell is shown with a scale bar.



Plasma cell



B lymphocyte

(i) Calculate the surface area to volume ratio (SA:V) of the plasma cell. Assume the plasma cell is spherical.

Use the formulas:

surface area of sphere = $4\pi r^2$

volume of sphere = $\frac{4}{3}\pi r^3$

SA:V = ... **[2]**

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Question 6 · A level Paper 3 · June 2023 · Q1(b)(i) · 3 marks

(b) Alveoli increase the surface area to volume ratio (SA:V) in the lungs of cats and other mammals.

(i) An alveolus in the lung of a cat has:

- a spherical shape
- a diameter of 0.13 mm
- a surface area of 0.053 mm^2.

Calculate the SA:V of this alveolus.

Use the formula: volume of sphere = $\frac{4}{3}\pi r^3$

SA:V = ... **[3]**

Question 7 · AS Paper 1 · June 2022 · Q24(b) · 2 marks

(b) The student measured the increase in the level of the coloured liquid in the capillary tube after 2 minutes. It had risen by 8 mm. The capillary tube has a diameter of 1 mm.

Calculate the rate of osmosis as the volume of water moved per second.

Use the formula: Volume of cylinder = $\pi r^2 l$

Rate of osmosis = ... $mm^3 s^{-1}$ **[2]**

Turn over

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Question 8 · A level Paper 1 · June 2017 · Q17(b)(i) · 3 marks

(b) Fig. 17.2 is an image of a Kupffer cell from the liver.

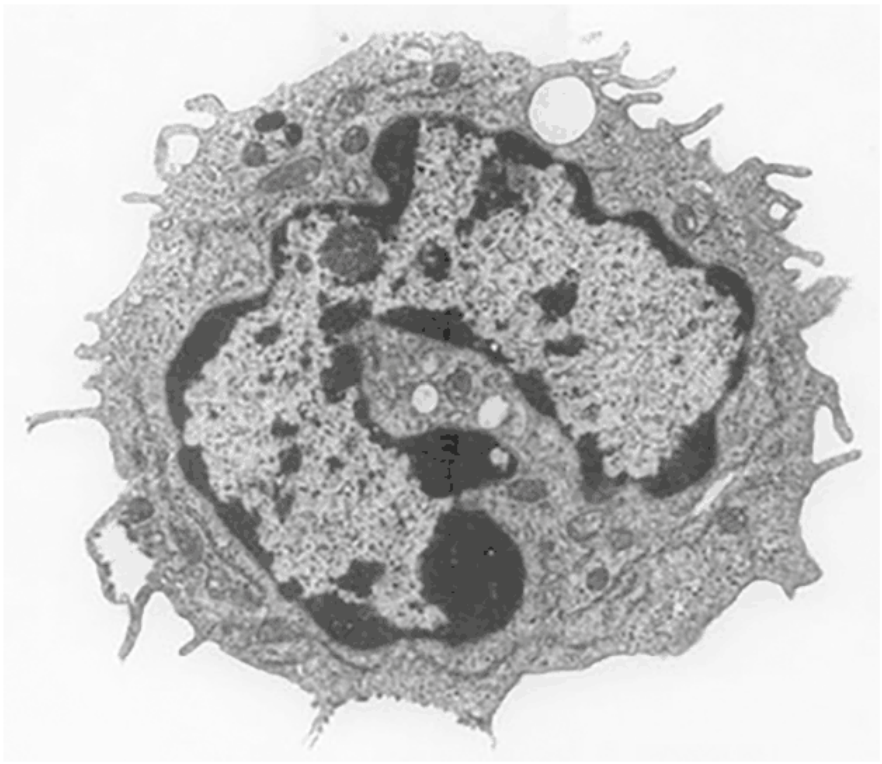


Fig. 17.2

(i) The diameter of the Kupffer cell in the image is 9.1 cm. Assuming it is spherical, calculate the actual volume of this cell.

Give your answer to **four** significant figures. Show your working.

Answer = ... **[3]**

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Question 9 · A level Paper 1 · June 2018 · Q22(a)(i) · 3 marks

22 (a) A scientist used a respirometer to investigate the rate of respiration and photosynthesis of maize in different light intensities.

- The scientist placed ten maize seedlings in a respirometer and kept it in the dark for three hours.
- The respirometer contained soda-lime to remove any CO_2 produced by the seedlings.
- The scientist placed ten maize seedlings in a separate respirometer without soda-lime and placed it in different light intensities for three hours at a time.

Light intensity (lux)	Distance moved by fluid in respirometer (mm)
0	–3.7
1020	–0.8
1510	0.0
1700	1.2
2000	2.9

Table 22.1

(i) The diameter of the capillary tubing was 0.1 mm.

The volume of a cylinder can be calculated using the following formula:
volume of cylinder = $\pi r^2 l$

Calculate the **rate of oxygen uptake** by the seedlings in the dark. Give your answer to **two** significant figures. Show your working.

Answer = ... $mm^3 h^{-1}$ **[3]**

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Question 10 · AS Paper 1 · June 2019 · Q24(a) · 3 marks

24 Plants need water to survive.

(a) Water enters plants through the roots. Most roots are covered in root hairs.

The number of root hairs per mm^2 of root surface is described as the density of root hairs. The density of root hairs can vary between and within species.

A scientist examined a plant root. The plant root had a diameter of 2 mm. In 1 mm of root **length** the scientist counted 440 root hairs.

Calculate the density of root hairs on the root the scientist examined.

Use the formula: Surface area of cylinder = $2\pi r(r+l)$

Give your answer to **2** significant figures.

density = ... **[3]**

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Mark schemes

Question 1 · AS Paper 2 · June 2023 · Q1(a)(i) · 2 marks

1 (a) (i)	**FIRST CHECK ON ANSWER LINE** **2** (SA:V cube is) 3:1 ✓✓

2.6	**ALLOW** one mark for: Surface area/SA (of cube): 2 x 2 = 4 , 4 x 6 = 24 Volume/V (of cube): 2 x 2 x 2 = 8 **OR** 24:8 ✓

Question 2 · AS Paper 2 · November 2020 · Q6(a) · 2 marks

6	(a)	2.2 3.1	surface area to volume ratio = 3 : 1 (small) and 1.5 : 1 (large) **or** large, cube / animal, has smaller SA:vol **or** small, cube / animal, has larger SA:vol ✓ diffusion, distance / pathway, long / deep, in large, cube / animal **or** diffusion time long in large, cube / animal ✓ relatively / proportionally, small(er) surface cannot supply large(r) volume of cells ✓ specialised exchange surfaces needed for, oxygen / carbon dioxide / gases / nutrients / waste products ✓

2 max	**ALLOW** SA : volume or SA : V for surface area to volume ratio **ALLOW** 3 : 2 for 1.5 : 1 **DO NOT ALLOW** reverse ratios 1 : 3 and 1 : 1.5 (unless volume : SA stated) **IGNORE** diffusion, easier / harder **ALLOW** ora diffusion, distance / pathway / time, shorter in small, cube / animal

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Question 3 · AS Paper 1 · June 2018 · Q21(d)(ii) · 2 marks

	(ii)	cube A = 0.6 (: 1) ✓ cube B = 1.5 (: 1) ✓	2

ALLOW 1 mark for 600 : 1000 **and** 96 : 64
6 : 10 **and** 3 : 2
3 : 5 **and** 3 : 2
(as correct ratios but not expressed correctly)
Allow these ratios if written anywhere in the answer space.

DO NOT ALLOW if units given

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Question 4 · A level Paper 3 · June 2025 · Q1(b)(i) · 3 marks

1	(b)	(i)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 0.4 : 1 award three marks** surface area of the root hair = 2 x π x 5 x (5 + 800) = 25,289.8208614 ✓ volume of the root hair = π x 5^2 x 800 = 62,831.8530718 ✓ SA:V of root hair = 25,289.82 / 62,831.853 = 0.4025 = 0.4 : 1 ✓	3

2.2	**2 marks** for '0.4' alone **or** '0.40 : 1' **or** '0.4025 : 1' **or** '0.403 : 1' **or** '2 : 5' **or** '1 : 2.5' **or** '4 : 10' **or** '161 : 400' **or** any other correct ratio as final answer **If final answer incorrect, award marks for correct SA or volume calculations.** **ALLOW** standard form and correct rounding to minimum of 5 significant figures in working **ALLOW** 25,211.28 (area of circle deducted) **or** 25,277 (using 3.14 as π) **or** 25,293.1 (using 3.142) **or** 25,300 (using 22/7) **or** 8050π **ALLOW** 62,800 (using 3.14 as π) **or** 62,840 (using 3.142) **or** 62,857.14286 (using 22/7) **or** 20,000π **ECF marks:** 0.2:1 (diameter used in both calculations) = **1 mark** 0.8:1 (diameter in SA calculation) = **2 marks** 0.1:1 (diameter in vol calculation) = **2 marks** 4:1 (not squaring in vol calculation) = **2 marks**
Element	

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Question 5 · AS Paper 1 · June 2025 · Q23(a)(i) · 2 marks

23	**(a)**	**(i)**	**FIRST CHECK ON ANSWER LINE** **If answer = 0.6:1 , award 2 marks** ✓✓ Surface area = 4 x π x 5^2 = 314 - 314.1592654 **AND** Volume = 4/3 x π x 5^3 = 523.5987756 - 524✓	**2**	2.2

Max 1 mark for 0.6 alone on answer line
Max 1 if ratio has not been simplified e.g. 3:5, 314:524 , 314.2:523.6 , 157:262
DO NOT ALLOW fractions e.g. 5/3:1
ALLOW any (correct) dp in range when rounded correctly e.g. 314.2

Calculations:
Surface area = 4 x π x 5^2 = 314.1592654

Volume = 4/3 x π x 5^3 = 523.5987756

314.1592654÷ 523.5987756 = 0.6

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1	(b)	(i)	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer = 46:1 award three marks** (radius =) 0.065 (mm) ✓ (volume = (4/3) x 3.14 x 0.065^3 =) 0.00115 (mm^3)✓ 0.053/0.00115 = 46:1 ✓	3

2.2 **Element**	**ALLOW 46.1:1 for 3 marks** **If answer given to more than 3 sig figs =2 max** **ALLOW ECF for mp2 and 3 if incorrect radius used** **ALLOW** 0.065 or 0.13/2 seen anywhere in working **ALLOW** $1.15x10^{-3}$ (mm^3) **ALLOW ECF for mp3 if incorrect volume used** (volume =) (4/3) x 3.14 x 0.065^3 = 0.00115 (mm^3) =2 marks (mp1 and 2) **If correct answer not given as ratio e.g. 46 or 46.1 alone = 2 marks**

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Question 7 · AS Paper 1 · June 2022 · Q24(b) · 2 marks

24	**(b)**		0.05 ✓✓	2

Question	Answer	Mark

FIRST CHECK THE ANSWER ON ANSWER LINE
If answer = 0.05 (mm^3s^{-1}) award 2 marks
ALLOW correct answer anywhere in answer space

ALLOW 0.052(4) for two marks
ALLOW additional significant figures for one mark e.g. 0.0523667

If correct answer not given then,
ALLOW one mark for:

6.28 / 6.3 (mm^3)
Note: allow additional figures after the decimal point

x / 120 (i.e. a mark for knowing that the volume must be divided by the time)

Guidance

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Question 8 · A level Paper 1 · June 2017 · Q17(b)(i) · 3 marks

17	**(b)**	**(i)**	3157 μm^3 / 3.157 x10^3 μm^3 **OR** 3155 μm^3 / 3.155 x10^3 μm^3 *(3.14 used for value of π)* **OR** 3158 μm^3 / 3.158 x10^3 μm^3 *(22/7 used for value of π)* **OR** 3.157 / 3.155 / 3.158 , ×10^{-15} m^3 *(answer using SI units)* ✓✓✓

3	**ALLOW for two marks** *correctly calculated value not given to 4SF* e.g. 3156.55 μm^3 3157.82 μm^3 (22/7used) 3154.95 μm^3 (3.14 used) **OR** *correctly calculated value without units* e.g. 3157 / 3.157 **OR** *correctly calculated value with inappropriate units* e.g. 3.157x10^{-6} mm^3 3.157x10^{-9} cm^3 ***If two or three marks were not awarded for the correct answer or calculated value:*** *for **one mark** look for evidence of use of the formula:* $(4/3) \times \pi \times r^3$

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Question 9 · A level Paper 1 · June 2018 · Q22(a)(i) · 3 marks

22	(a)	(i)	3	**IGNORE** + or - **ALLOW two marks** if answer is correct but not to two S.F. **ALLOW two marks** if answer is incorrect for correct calculation e.g. $\frac{0.05^2 \times \pi \times 3.7}{3}$ **OR** $\frac{0.029}{3}$ **ALLOW one mark** for $0.05^2 \times \pi \times 3.7$ **OR** 0.029

9.7×10^{-3}
OR
0.0097 ✓✓✓

Question 10 · AS Paper 1 · June 2019 · Q24(a) · 3 marks

24	(a)	70 ✓✓ (root hairs) mm^{-2} ✓	3

ALLOW 35
two marks for correct answer
ALLOW one mark if not given to 2 s.f.
if answer incorrect **ALLOW** one mark for correct surface area calculated
(6.28 - 6.284 or 12.56 -12.57)
ALLOW / mm^2

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