FREE SAMPLE: THE FIRST QUESTION

Question One (16 marks)

(a) Two cubic cells have side lengths of 15 µm (cell X) and 100 µm (cell Y).

(i) Calculate the surface area, the volume and the surface area to volume ratio (SA:V) of each cell.

(ii) Explain which cell can exchange materials with its surroundings more efficiently, and why.

(iii) Explain how a large cell such as a bacterial cell can overcome the problem of a small SA:V ratio.

[8 marks]

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(b) Potato cylinders were weighed and placed in sucrose solutions of different concentrations for 24 hours, then blotted dry and weighed again. The results are shown in the table.

(i) Calculate the percentage change in mass of the potato cylinder in each solution.

(ii) Use your results to estimate the sucrose concentration that is isotonic with the potato cells (no net change in mass).

(iii) Explain, using the movement of water (osmosis), the change in mass in the 0.0 mol L^{-1} solution and in the 1.0 mol L^{-1} solution.

Sucrose concentration (mol L□¹)	0.0	0.2	0.4	0.6	0.8	1.0
Initial mass (g)	2.50	2.50	2.50	2.50	2.50	2.50
Final mass (g)	2.95	2.80	2.65	2.50	2.35	2.20

[8 marks]

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THE WORKED ANSWER TO THAT QUESTION

Question 1 (16 marks) [Cells and transport]

(a) Two cubic cells have side lengths of 15 µm (cell X) and 100 µm (cell Y). (i) Calculate the surface area, the volume and the surface area to volume ratio (SA:V) of each cell. (ii) Explain which cell can exchange materials with its surroundings more efficiently, and why. (iii) Explain how a large cell such as a bacterial cell can overcome the problem of a small SA:V ratio.

(a) Answer: (i) X: SA:V = 0.400, Y: SA:V = 0.0600; (ii) the smaller cell X exchanges materials faster

- Evidence level: Excellence (surface area = 6 × side² for a cube; volume = side³; ratio = SA ÷ V).
- (i) Cell X: SA = 6 × 15² = 1350 µm²; V = 15³ = 3375 µm³; SA:V = 1350 : 3375 = 0.400 : 1. Cell Y: SA = 6 × 100² = 60000 µm²; V = 100³ = 1000000 µm³; SA:V = 0.0600 : 1.
- Achievement: (ii) States that cell X has the greater SA:V ratio.
- Merit: Links to diffusion: materials enter and leave through the surface, so a larger surface for each unit of volume exchanges materials faster.
- Excellence: Full explanation: the SA:V of cell X (0.400 : 1) is greater than that of cell Y (0.0600 : 1); as a cell gets bigger its volume (and need for oxygen and nutrients, and its waste production) increases faster than its surface area, so in the larger cell the distance for diffusion is greater and the membrane surface per unit volume is smaller, and diffusion is too slow to supply the whole cell.
- Achievement: (iii) States that the cell can have folds or microvilli.
- Merit: Links to surface: folding the membrane increases the surface area without increasing volume.
- Excellence: Full explanation: a large cell can increase its SA:V by flattening or elongating its shape, folding its membrane into microvilli or invaginations to increase the surface area, and by having transport systems (cytoplasmic streaming, a transport network) or by dividing into smaller cells, so exchange keeps pace with the needs of the whole volume.

> **KEY TAKEAWAY**
> SA:V: for a cube SA = 6L², V = L³, SA:V = 6/L, so ratio falls as cells grow; exchange across the surface cannot keep up with the needs of a large volume.

(b) Potato cylinders were weighed and placed in sucrose solutions of different concentrations for 24 hours, then blotted dry and weighed again. The results are shown in the table. (i) Calculate the percentage change in mass of the potato cylinder in each solution. (ii) Use your results to estimate the sucrose concentration that is isotonic with the potato cells (no net change in mass). (iii) Explain, using the movement of water (osmosis), the change in mass in the 0.0 mol L^{-1} solution and in the 1.0 mol L^{-1} solution.

(b) Answer: (i) 0.0: 18.0%; 0.2: 12.0%; 0.4: 6.00%; 0.6: 0%; 0.8: −6.00%; 1.0: −12.0%; (ii) about 0.60 mol L^{-1}; (iii) water in at 0.0, out at 1.0

- Evidence level: Excellence (percentage change = (final − initial) ÷ initial × 100; the isotonic concentration is where the change is zero).
- (i) 0.0 mol L^{-1}: 18.0%; 0.2 mol L^{-1}: 12.0%; 0.4 mol L^{-1}: 6.00%; 0.6 mol L^{-1}: 0%; 0.8 mol L^{-1}: −6.00%; 1.0 mol L^{-1}: −12.0%.
- (ii) The percentage change crosses zero between 0.6 and 0.8 mol L^{-1}; by linear interpolation the isotonic concentration ≈ 0.6 + (0 ÷ (0 − (−6.00))) × 0.2 = 0.60 mol L^{-1}.

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• Achievement: (iii) States that water entered the cells in pure water and left in 1.0 mol L^{-1} sucrose.

• Merit: Links to water potential: water moves from the solution with the higher water potential to the lower.

• Excellence: Full explanation: in 0.0 mol L^{-1} (pure water) the solution has a higher water potential than the cell contents, so water moves into the cells by osmosis through the partially permeable membrane and the cylinder gains mass (the cell becomes turgid); in 1.0 mol L^{-1} sucrose the solution has a lower water potential than the cells, so water moves out of the cells by osmosis and the cylinder loses mass (the cells become flaccid / plasmolysed).

KEY TAKEAWAY

Osmosis data: percentage change = change ÷ initial × 100; the isotonic concentration is where the percentage change is zero (read or interpolate); water moves to the lower water potential through a partially permeable membrane.

LOS: Cells and transport (91156)

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