

1.3 Transport in cells

Name: _____ Class: _____ Date: _____

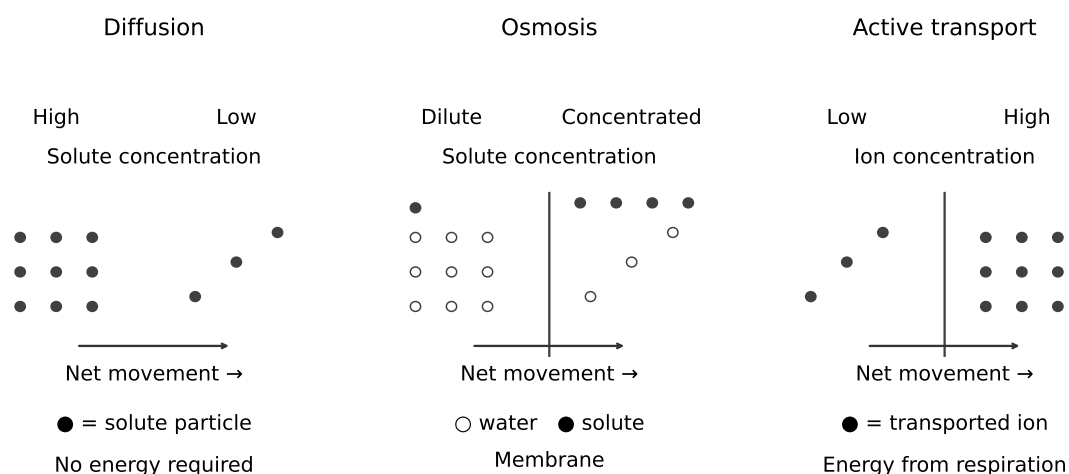
Total: 23 marks**KEY WORDS** diffusion • osmosis • active transport

Objective

Define and compare diffusion, osmosis and active transport; calculate percentage change in mass and SA:V ratios; interpret RP3. Original questions for spec statement 4.1.3 and RP3.

1 Key knowledge and worked examples

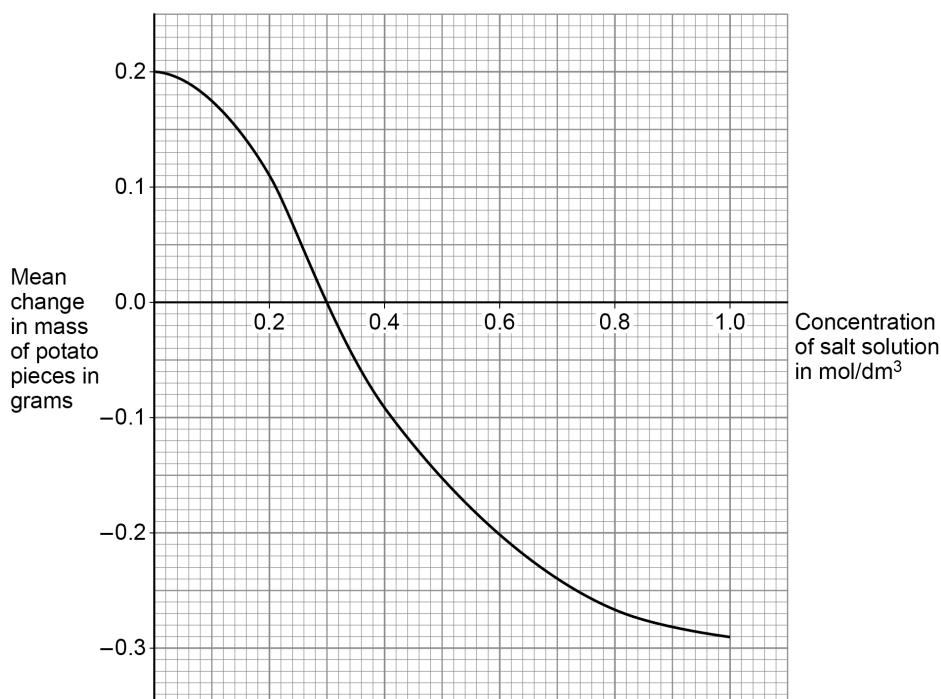
Teacher models: filled circles are solute particles / transported ions; open circles are water. Arrows show net movement. Osmosis labels refer to solute concentration, not the number of water particles.



Process	Net direction	Energy from respiration
Diffusion	Substance: high → low concentration	Not required
Osmosis	Water: dilute → concentrated solution	Not required
Active transport	Substance: low → high concentration	Required

Diffusion is net particle movement high $\rightarrow$ low in a gas/solution. O_2/CO_2 exchange and urea from cells to blood are examples. Rate increases with a steeper gradient, higher temperature or more membrane area. Root-hair active transport moves the named mineral ion from lower soil concentration to higher cell concentration, using respiration energy; glucose uptake is another example. Osmosis moves water through a partially permeable membrane. Potato gains mass in dilute solution and loses it in concentrated solution. No change means no **net** movement, not stationary water.

Figure 4



Original Figure 4 uses grams, not %. Zero is near 0.30 mol/dm³. Original Q05.2 [3]: at 0.6 mol/dm³ water leaves; the cell solution is less concentrated than outside; the movement is osmosis. Q05.3 [2]: at 1.0 mol/dm³ the steeper gradient causes more water loss.

Signed percentage change: subtract initial from final; divide by initial mass.

$$\Delta m = m_{\text{final}} - m_{\text{initial}}$$

$$p = \frac{\Delta m}{m_{\text{initial}}} \times 100\%$$

Teacher example: initial 2.5 g, final 2.9 g.

$$\Delta m = 2.9 \text{ g} - 2.5 \text{ g} = +0.4 \text{ g}$$

$$p = \frac{+0.4 \text{ g}}{2.5 \text{ g}} \times 100\% = +16\%$$

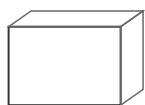
Sheet Q2.2: a loss is negative; $p = (-0.45 \text{ g} / 3.0 \text{ g}) \times 100\% = -15\%$.

One workable teacher setup: 1 cm peeled cubes; 0.0–1.0 mol/dm³ salt solutions in 0.2 steps; equal 30 mL volumes fully covering the cubes; 20 minutes at 20°C; three pieces per concentration. These are stated design choices, not values supplied by the original method.

RP3 plan (original 2024 Q05.1): peeled equal-sized pieces from the same potato; blot/record initial mass; immerse in several known concentrations with equal time, temperature and volume; remove/blot/weigh; calculate changes; repeat each concentration and calculate means. Plot mean mass change in grams for Figure 4, or calculate percentage changes for a percentage graph.

Evaluate (original 2025 Q03.1): before/after masses and several concentrations are strengths. Cubes need specified equal size. Blotting excludes surface liquid; equal time/temperature/volume isolates concentration; repeats and means reduce random variation; percentage change compares unequal starting masses. Include a strength, linked improvement/reason and judgement, not just named controls.

Side length: 2 mm

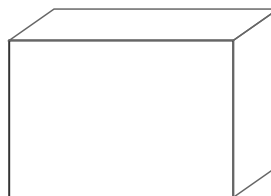


Surface area = 24 mm²

Volume = 8 mm³

SA:V = 3:1

Side length: 4 mm



Surface area = 96 mm²

Volume = 64 mm³

SA:V = 1.5:1

Teacher cubes, proportional side lengths: use stated dimensions. Six faces give SA; three dimensions give V.

$$SA = 6a^2 \quad V = a^3 \quad R = \frac{SA}{V}$$

$$SA = 6(2 \text{ mm})^2 = 24 \text{ mm}^2$$

$$V = (2 \text{ mm})^3 = 8 \text{ mm}^3$$

$$R = \frac{24 \text{ mm}^2}{8 \text{ mm}^3} = 3 \text{ mm}^{-1}$$

For $a = 4 \text{ mm}$: $SA = 96 \text{ mm}^2$, $V = 64 \text{ mm}^3$, $R = 1.5 \text{ mm}^{-1}$. Numerical SA:V shorthand: 3:1 versus 1.5:1 using matching mm units. Doubling length gives four times the area and eight times the volume: the bigger cube has more area but half the ratio.

Single cells can meet demand by exchange across their cell surface; a large organism's lower SA:V and longer paths require specialised exchange organs and a transport system. Large area allows more transfer; thin walls shorten the path; blood supply and ventilation maintain gradients. Examples: intestine, lungs, gills, roots, leaves. Fewer working alveoli reduce exchange area and oxygen delivery; greater breathing can help ventilate those remaining.

2 Practice

2.1 Define diffusion. [2]

2.2 A 3.0 g potato piece loses 0.45 g in a concentrated sugar solution. Calculate the percentage change. [2]

2.3 Explain why root hair cells use active transport rather than diffusion to absorb mineral ions. [2]

3 Exam-style questions

3.1 A student places potato pieces in salt solutions of 0.2–1.0 mol/dm³ (RP3).

(a) State three control variables. [3]

(b) In 0.2 mol/dm³ the pieces gained mass. Explain why. [2]

(c) In 0.8 mol/dm³ the percentage change was –12%. Suggest what this shows about the cell contents. [2]

3.2 Explain why a single-celled organism does not need a transport system, but a human does. Use surface area to volume ratio in your answer. [4]

3.3 The alveoli in lungs are thin-walled, numerous, and surrounded by capillaries.

(a) Explain how each feature speeds gas exchange. [3]

(b) A disease halves the number of working alveoli. Explain why the patient becomes breathless. [3]

Solutions

2.1 The spreading out of particles of a substance in solution or a gas, with a net movement from an area of higher concentration to lower concentration.

2.2

$$p = \frac{\Delta m}{m_{\text{initial}}} \times 100\%$$
$$p = \frac{-0.45 \text{ g}}{3.0 \text{ g}} \times 100\% = -\mathbf{15\%}$$

(method 1, answer with sign 1)

2.3 The concentration of the mineral ion is lower in the soil solution than inside the root hair cell; active transport moves that ion against its concentration gradient using energy from respiration – net diffusion cannot produce this uptake.

3.1 (a) Any three: volume of solution; temperature; time in solution; surface area / dimensions of pieces; same potato / starting concentration of tissue; blotting method. (b) The solution outside is more dilute than the potato cells; water enters by osmosis through the partially permeable membrane, increasing the mass. (c) Water left the cells by osmosis; so the solution in the cells is less concentrated than the external 0.8 mol/dm^3 solution. The external solution is hypertonic to the cells, so net water movement is outward through the partially permeable membrane.

3.2 A single-celled organism is small, so its surface area to volume ratio is large; enough molecules cross the cell surface by diffusion to meet its needs. A human is large, so SA:V is small; diffusion alone would be too slow over the distances inside – exchange surfaces and a transport system (blood circulation) deliver molecules to all cells.

3.3 (a) Numerous alveoli give a large surface area; thin walls give a short diffusion path; capillaries maintain the concentration gradient by carrying blood away and bringing fresh supply. (b) The working surface area for gas exchange halves; less oxygen diffuses into the blood per second; so the rate of supply cannot meet the demand – breathing rate rises to try to ventilate the remaining alveoli more.