Osmosis

4.1.3.2 · Biology · revision notes

Osmosis is the diffusion of water across a partially permeable membrane. Questions ask you to define it, predict and explain the movement of water into or out of cells, and use the results of the osmosis required practical, including percentage change in mass calculations and graphs.

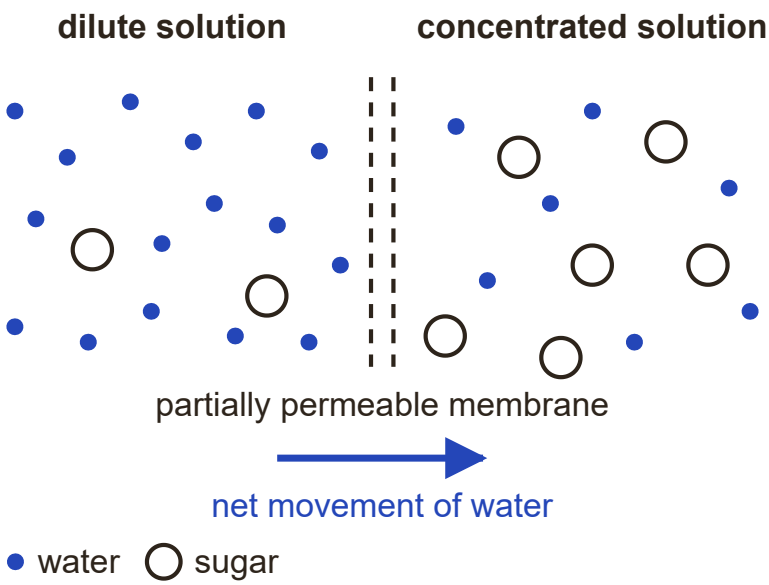
Key facts

- Osmosis: diffusion of water from a dilute to a concentrated solution through a partially permeable membrane
- Partially permeable membrane: lets water through, but not larger solute molecules
- Rate of change in mass = change in mass ÷ time
- Loss in mass: solution more concentrated than the cell contents
- Dilute solution: lots of water, little solute; concentrated solution: more solute, less water
- % change in mass = (final mass − starting mass) ÷ starting mass × 100
- Gain in mass: solution more dilute than the cell contents
- 0% change: solution has the same concentration as the cell contents

Notes

What osmosis is

- **Osmosis** is the diffusion of water from a **dilute solution** to a **concentrated solution** through a **partially permeable membrane**.



Osmosis: water moves from the dilute solution to the concentrated solution. The sugar molecules are too big to pass through the membrane.

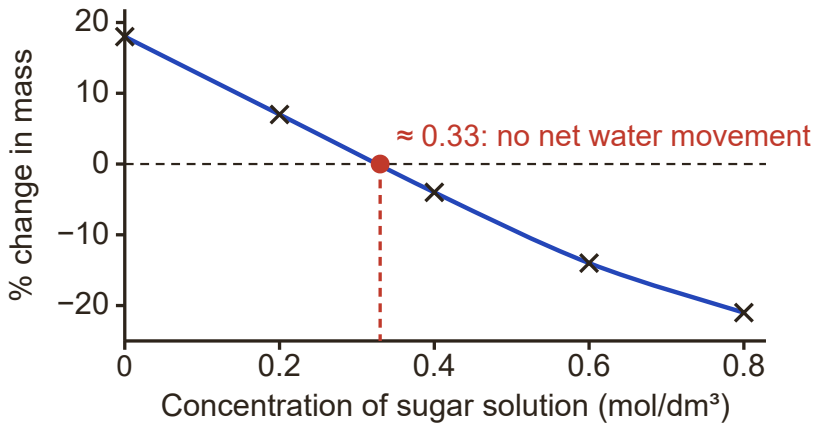
- A dilute solution has a lot of water and little dissolved solute. A concentrated solution has more solute and less water.
- A partially permeable membrane, such as the cell membrane, lets small molecules like water through but not larger molecules like sugar.
- Water molecules move both ways, but the net movement is into the more concentrated solution. Osmosis is passive: it needs no energy from respiration.

Osmosis in cells

- If the solution outside a cell is more dilute than the cell contents, water moves into the cell.
- If the solution outside is more concentrated than the cell contents, water moves out of the cell.
- If the concentrations are the same, there is no net movement of water.
- Animal cells have no cell wall: in pure water they swell and may burst; in a concentrated solution they shrivel.
- Plant cells in water swell and become firm (turgid), but the cell wall stops them bursting. In a concentrated solution they lose water and become soft (flaccid).
- Once a plant cell is fully turgid, the stretched cell wall stops any more water entering, so its mass stops increasing.

Required practical: osmosis in plant tissue

- Cut potato cylinders of the same size (e.g. with a cork borer), blot them dry and record the starting mass of each.
- Put one cylinder in each of a range of sugar or salt solutions (e.g. 0.0 to 1.0 mol/dm^3), with the same volume, for the same time and at the same temperature.
- Remove the cylinders, blot them dry to remove surface solution, and reweigh them.
- Calculate the percentage change in mass. Use percentage change because the cylinders start with different masses.
- Repeat at each concentration and calculate a mean percentage change, to make the results more reliable.
- Rate of water uptake = change in mass ÷ time, e.g. in g per hour.
- Plot % change in mass against concentration. Where the line of best fit crosses 0%, the solution has the same concentration as the cell contents.



Where the curve crosses 0%, the solution has the same concentration as the cell contents (here about 0.33 mol/dm³).

How to answer each type of question

Predict and explain the movement of water

2 marks | **Grade 4**

1. Decide which solution is more dilute and which is more concentrated.
2. Water moves from the dilute solution to the concentrated solution.
3. Name the process (osmosis) and the partially permeable membrane.

Example. The contents of a plant cell have a solute concentration of 0.3 mol/dm^3. The cell is placed in a sugar solution with a concentration of 0.5 mol/dm^3.
Describe and explain the movement of water.

Model answer. Water moves out of the cell (1), by osmosis from the more dilute solution inside the cell to the more concentrated solution outside, through the partially permeable cell membrane (1).

Calculate percentage change and rate of change in mass

2 to 3 marks | **Grade 5**

1. Change in mass = final mass − starting mass (negative for a loss).
2. Divide by the STARTING mass and multiply by 100.
3. For a rate, divide the change in mass by the time taken.

Example. A potato cylinder had a mass of 2.50 g. After 30 minutes in a salt solution its mass was 2.20 g.
(a) Calculate the percentage change in mass.
(b) Calculate the mean rate of mass loss in g per minute.

Model answer.

(a) 2.20 − 2.50 = −0.30 g (1)
−0.30 ÷ 2.50 × 100 = −12% (1)
(b) 0.30 ÷ 30 = 0.01 g per minute (1)

Explain what happens to animal and plant cells in water

3 marks | **Grade 6**

1. Say which way water moves, and why, using 'osmosis' and 'dilute'.
2. Say what happens to the animal cell, and why (no cell wall).
3. Say what the plant cell wall does.

Example. Red blood cells placed in pure water swell and burst. Plant cells placed in pure water do not burst.
Explain these observations.

Model answer. Water moves into both types of cell by osmosis, because the water is more dilute than the cell contents (1). Red blood cells have no cell wall, so they swell until they burst (1). Plant cells have a strong cell wall, which stops them bursting (1).

6-mark: describe the osmosis practical

6 marks (level of response) **Grade 5**

1. Describe preparing the tissue: same size pieces, blotted and weighed.
2. Describe the range of concentrations and what you keep the same.
3. Describe reweighing after the same time, and calculating percentage change in mass.
4. Mention repeats and a graph of the results.

Example. Describe a method to investigate the effect of the concentration of sugar solution on the mass of potato tissue.

Model answer.

Model answer: Use a cork borer to cut several potato cylinders of the same diameter, and trim them to the same length. Blot each cylinder dry and measure its mass on a balance. Put the same volume of sugar solution into a set of boiling tubes, using a range of concentrations, for example 0.0, 0.2, 0.4, 0.6, 0.8 and 1.0 mol/dm^3, and put one cylinder into each tube. Leave all the tubes for the same time, for example 30 minutes, at the same temperature. Remove each cylinder, blot it dry gently to remove the surface solution, and measure its mass again. Calculate the percentage change in mass for each cylinder. Repeat for each concentration and calculate a mean, then plot a graph of percentage change in mass against concentration.

Level 3 (5 to 6 marks): a clear, logical method that would give valid results, including measuring mass before and after, a range of concentrations, control variables and percentage change.

Level 2 (3 to 4 marks): a method with most of the key steps, but some detail or control variables missing.

Level 1 (1 to 2 marks): some relevant steps, but the method would not give valid results.

Use results to estimate the concentration of cell contents

2 marks **Grade 7**

1. Find where the % change in mass goes from positive to negative.
2. Estimate (or read from a graph) the concentration at 0% change.
3. Explain: at 0% change there is no net movement of water, so the concentrations are equal.

Example. A student put potato cylinders in sugar solutions of different concentrations. The table shows the results.

Concentration of sugar solution in mol/dm^3	Percentage change in mass
0.0	+18
0.2	+7
0.4	−4
0.6	−14
0.8	−21

Estimate the concentration of the solution inside the potato cells. Explain your answer.

Model answer. About 0.33 mol/dm^3 (allow 0.3 to 0.35) (1). At this concentration there would be no change in mass, so no net movement of water: the solution and the cell contents have the same concentration (1).

Don’t lose marks

- Saying water moves 'from high concentration to low concentration' without saying of what. Say from a dilute solution to a concentrated solution.
- Saying sugar or salt moves by osmosis. Only water moves by osmosis.
- Dividing by the final mass instead of the starting mass in a percentage change.
- Leaving the minus sign off a loss in mass.
- Saying plant cells burst in water. The cell wall stops this.
- Not blotting the tissue before weighing, so surface liquid adds to the mass.

More tips

Memory tricks

- Water follows the solute: water moves towards the side with more dissolved substance.
- Positive % change = water moved in; negative = water moved out; zero = no net movement.
- Osmosis is just the diffusion of water, so it is also passive and a net movement.
- Sense check: potato in pure water should gain mass; in a strong sugar solution it should lose mass.

Exam technique

- Always give the full definition: diffusion of water, dilute to concentrated, partially permeable membrane.
- In the practical, say why each step is done: same size pieces for a fair test, blotting to remove surface solution, percentage change because starting masses differ.
- To find the concentration of the cell contents, draw a line of best fit and read where it crosses 0% change in mass.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3 — **Define osmosis**
The diffusion of water from a dilute solution to a concentrated solution through a partially permeable membrane.

Grade 4 — **Predict the direction of water movement**
Water moves from the more dilute solution into the more concentrated solution.

Grade 5 — **Describe the osmosis required practical**
Weigh pieces of plant tissue, leave them in a range of concentrations, then reweigh them.

Grade 5 — **Calculate percentage change in mass**
Change in mass ÷ starting mass × 100; a loss in mass gives a negative answer.

Grade 5 — **Explain gains and losses in mass**
Tissue gains mass when the solution is more dilute than the cell contents, and loses mass when it is more concentrated.

Grade 6 — **Calculate a rate of change in mass**
Change in mass ÷ time, e.g. in g per minute.

Grade 6 — **Explain osmosis in animal and plant cells**
Animal cells can burst in water or shrivel in concentrated solutions; a plant cell wall stops the cell bursting.

Grade 7 — **Estimate cell concentration from a graph**
Read the concentration where the line of best fit crosses 0% change in mass.

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