3 MOVEMENT IN & OUT OF CELLS

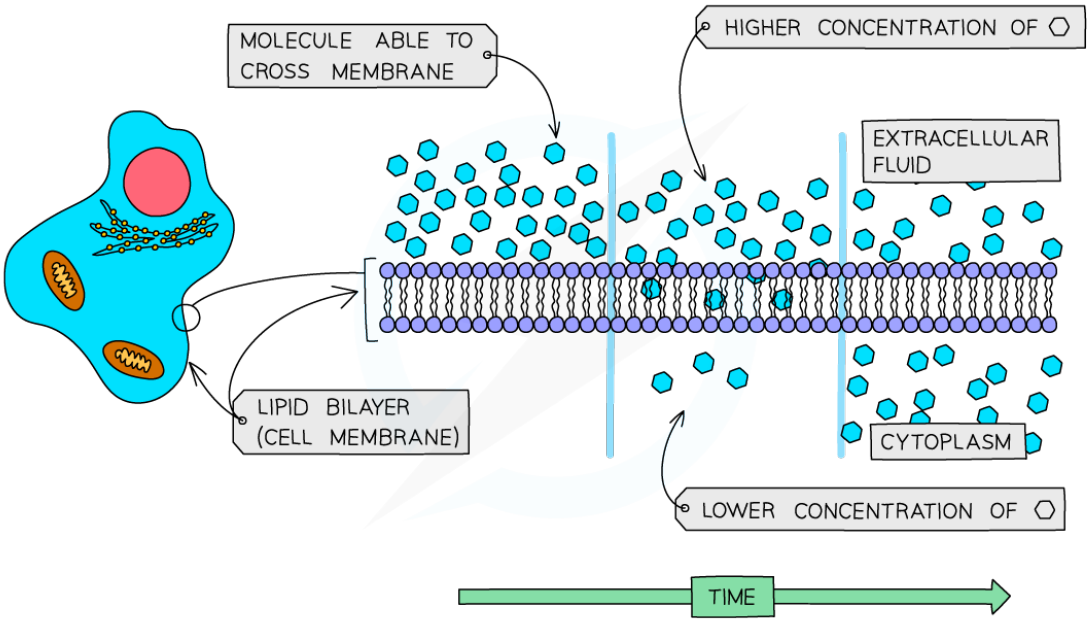
YOUR NOTES

CONTENTS:

3.1 DIFFUSION

Diffusion in Living Organisms

- **Diffusion** is the movement of molecules from a region of its **higher** concentration to a region of its **lower** concentration
- Molecules move **down** a **concentration gradient**, as a result of their **random movement**



Diffusion across the cell membrane

3 MOVEMENT IN & OUT OF CELLS

3.1 DIFFUSION cont...

YOUR NOTES

- For **living cells**, the principle of the movement down a concentration gradient is the same, but the cell is surrounded by a **cell membrane** which can restrict the free movement of the molecules
- The cell membrane is a **partially permeable membrane** – this means it allows some molecules to cross easily, but others with difficulty or not at all
- The simplest sort of selection is based on the **size** of the molecules
- Diffusion helps living organisms to:
  - obtain many of their **requirements**
  - get rid of many of their **waste products**
  - carry out **gas exchange** for **respiration**

Examples of diffusion in living organisms

You will need to learn examples of substances that organisms obtain by diffusion. Don't forget that plants require oxygen for respiration at all times, as well as carbon dioxide for photosynthesis when conditions for photosynthesis are right (e.g. enough light and a suitable temperature).

SITE	MOLECULES MOVING	FROM	TO
SMALL INTESTINE	DIGESTED FOOD PRODUCTS – GLUCOSE, AMINO ACIDS, FATTY ACIDS AND GLYCEROL ETC.	LUMEN OF SMALL INTESTINE	BLOOD / LYMPH IN VILLI FOUND COVERING SMALL INTESTINE WALLS
LEAF	OXYGEN	AIR SPACES BETWEEN MESOPHYLL CELLS	MITOCHONDRIA IN ALL CELLS
LEAF	CARBON DIOXIDE	AIR SPACES BETWEEN MESOPHYLL CELLS	CHLOROPLASTS IN MESOPHYLL CELLS
LEAF	WATER VAPOUR	STOMATAL PORES	AIR OUTSIDE STOMATA
LUNGS	OXYGEN	ALVEOLAR AIR SPACE	BLOOD IN CAPILLARIES AROUND ALVEOLI
LUNGS	CARBON DIOXIDE	BLOOD IN CAPILLARIES AROUND ALVEOLI	ALVEOLAR AIR SPACE

Examples of diffusion in living organisms

3 MOVEMENT IN & OUT OF CELLS

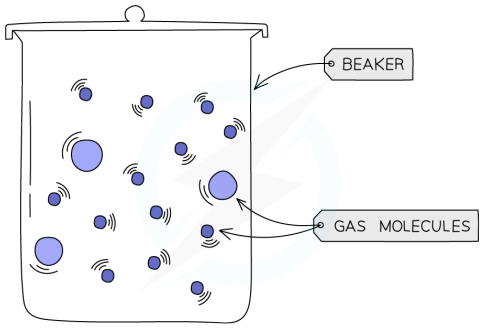
3.1 DIFFUSION cont...

YOUR NOTES

EXTENDED ONLY

Brownian Motion

- All particles move randomly at all times
- This is known as Brownian motion
- The energy for diffusion comes from the kinetic energy of this random movement of molecules and ions

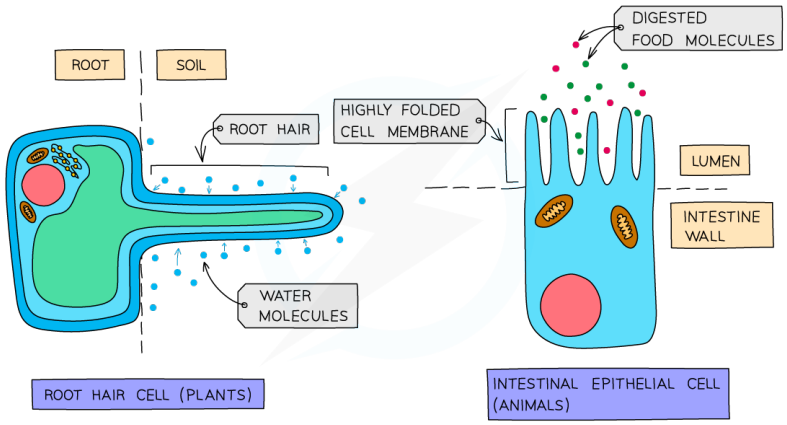


Brownian motion

Factors that Influence Diffusion

Surface area to volume ratio

- The **bigger** a cell or structure is, the **smaller its surface area to volume ratio** is, slowing down the rate at which substances can move across its surface
- Many cells which are adapted for diffusion have **increased surface area** in some way – eg root hair cells in plants (which absorb water and mineral ions) and cells lining the ileum in animals (which absorb the products of digestion)



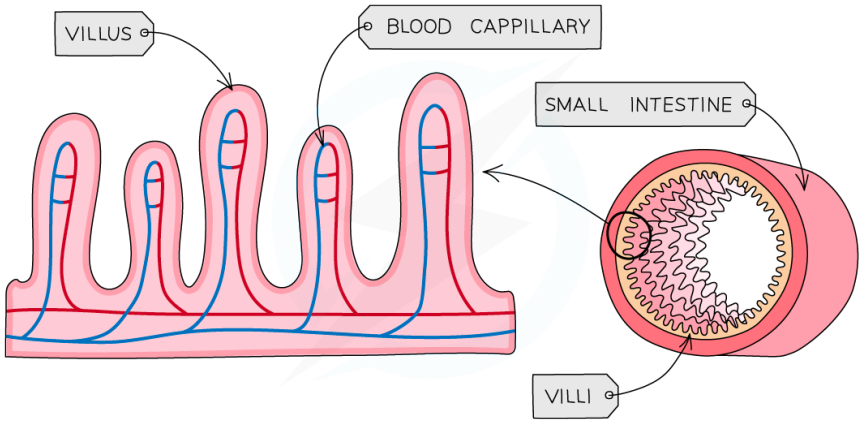
Cell adaptations for diffusion

3 MOVEMENT IN & OUT OF CELLS

3.1 DIFFUSION cont...

YOUR NOTES

EXTENDED ONLY cont...



The highly folded surface of the small intestine increases its surface area

Three factors that affect the rate of diffusion and therefore the movement of molecules through membranes:

Distance

- The **smaller the distance** molecules have to travel the **faster** transport will occur
- This is why blood capillaries and alveoli have walls which are only **one cell thick**, ensure the rate of diffusion across them is as fast as possible

Temperature

- The **higher the temperature**, the **faster** molecules move as they have more energy
- This results in **more collisions against the cell membrane** and therefore a faster rate of movement across them

Concentration Gradient

- The **greater the difference in concentration** either side of the membrane, the faster movement across it will occur
- This is because on the side with the higher concentration, **more random collisions against the membrane** will occur

3 MOVEMENT IN & OUT OF CELLS

YOUR NOTES

3.1 DIFFUSION cont...

EXAM TIP

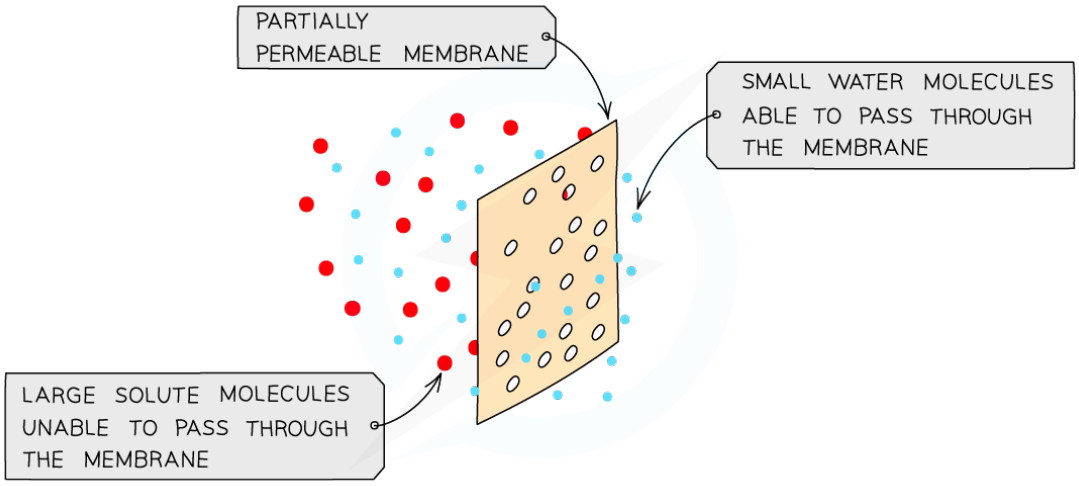
You should have carried out investigations into the factors that influence the rate of diffusion and so should:

- be able to use the information above to explain experimental results in an exam
- and plan and carry out an experiment which can investigate the effect of one of these factors.

3.2 OSMOSIS

Osmosis Theory: Basics

- All cells are surrounded by a cell membrane which is **partially permeable**
- **Water** can move in and out of cells by osmosis
- Osmosis is the diffusion of water molecules from a **dilute solution** (high concentration of water) to a **more concentrated** solution (low concentration of water) across a **partially permeable membrane**
- In doing this, water is moving down its **concentration gradient**
- The cell membrane is partially permeable which means it allows **small molecules** (like water) through but not larger molecules (like solute molecules)



Osmosis and the partially permeable membrane

3 MOVEMENT IN & OUT OF CELLS

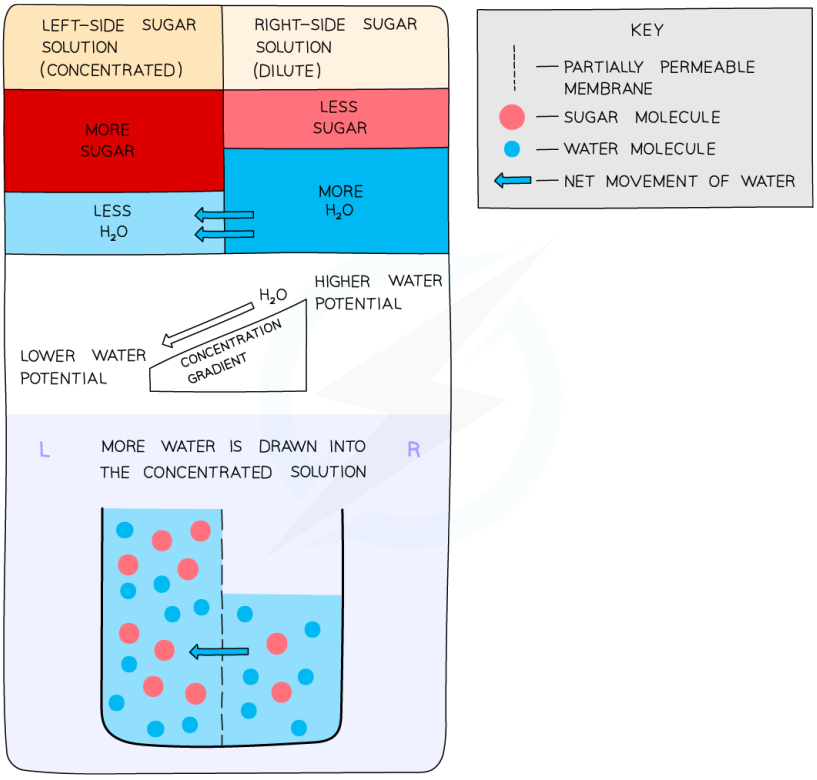
3.2 OSMOSIS cont...

YOUR NOTES

EXTENDED ONLY

Osmosis Theory

- Osmosis is the net movement of water molecules from a region of **higher water potential** (dilute solution) to a region of **lower water potential** (concentrated solution), through a **partially permeable membrane**.
- It can get a little confusing to talk about the 'concentration of water' when we also talk about solutions being 'concentrated' (having a lot of solute in them), so instead we can say that a **dilute solution** has a **high water potential** (the right hand side of the diagram below) and a **concentrated solution** has a **low water potential** (the left-hand side of the diagram below)



How osmosis works

EXAM TIP

The best explanations to do with osmosis will refer to water potential, so if you are aiming for a 7, 8 or 9 you will need to understand the concept and use it in your explanations.

3 MOVEMENT IN & OUT OF CELLS

3.2 OSMOSIS cont...

YOUR NOTES

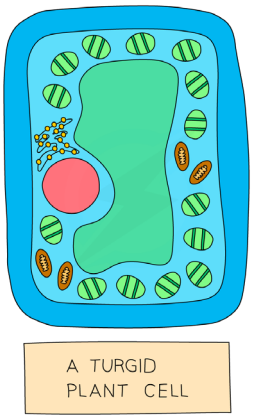
Osmosis Experiments: Basics

- The most common osmosis practical involves cutting **cylinders of potato** and placing them into **distilled water** and **sucrose solutions** of increasing concentration
- The potato cylinders are weighed before placing into the solutions
- They are left in the solutions for 20 – 30 minutes and then removed, dried to remove excess liquid and reweighed
- The potato cylinder in the distilled water will have **increased its mass the most**
- The potato cylinder in the strongest sucrose concentration will have **decreased its mass the most**
- If there is a potato cylinder that has not increased or decreased in mass, it means there was **no overall movement of water** into or out of the potato cells

EXTENDED ONLY

Osmosis Experiments

- The most common osmosis practical involves cutting **cylinders of potato** and placing them into **distilled water** and **sucrose solutions** of increasing concentration
- The potato cylinders are weighed before placing into the solutions
- They are left in the solutions for 20 – 30 minutes and then removed, dried to remove excess liquid and reweighed
- The potato cylinder in the distilled water will have **increased its mass the most** as there is a greater concentration gradient in this tube between the distilled water (high water potential) and the potato cells (lower water potential)
- This means more water molecules will move **into** the potato cells by **osmosis**, pushing the cell membrane against the cell wall and so increasing the **turgor pressure** in the cells which makes them **turgid** – the potato cylinders will feel hard



A turgid plant cell

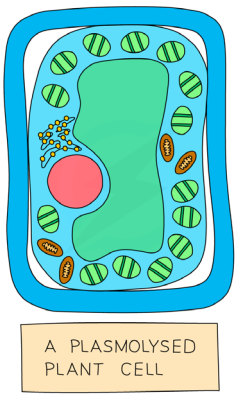
3 MOVEMENT IN & OUT OF CELLS

3.2 OSMOSIS cont...

YOUR NOTES

EXTENDED ONLY cont...

- The potato cylinder in the strongest sucrose concentration will have **decreased its mass** the most as there is a greater concentration gradient in this tube between the potato cells (higher water potential) and the sucrose solution (lower water potential)
- This means more water molecules will move **out of** the potato cells by **osmosis**, making them **flaccid** and decreasing the mass of the cylinder – the potato cylinders will feel floppy
- If looked at underneath the microscope, cells from this potato cylinder might be **plasmolysed**, meaning the cell membrane has pulled away from the cell wall



A plasmolysed plant cell

- If there is a potato cylinder that has not increased or decreased in mass, it means there was **no overall net movement of water** into or out of the potato cells
- This is because the solution that cylinder was in was the same concentration as the solution found in the cytoplasm of the potato cells, so there was **no concentration gradient**

EXAM TIP

Questions involving osmosis experiments are common and you should be able to use your knowledge of these processes to explain the results.

Don't worry if it is an experiment you haven't done – simply figure out where the higher concentration of water molecules is – this is the solution with the higher water potential – and explain which way the molecules move due to the differences in water potential.

3 MOVEMENT IN & OUT OF CELLS

YOUR NOTES

3.2 OSMOSIS cont...

Importance of Osmosis in Tissues

- When water moves into a plant cell, the vacuole gets bigger, **pushing the cell membrane against the cell wall**
- Water entering the cell by osmosis makes the cell **rigid and firm**
- This is important for plants as the effect of all the cells in a plant being firm is to **provide support and strength for the plant** – making the plant stand upright with its leaves held out to catch sunlight
- The pressure created by the **cell wall** stops too much water entering and **prevents the cell from bursting**
- If plants do not receive enough water the cells cannot remain rigid and firm (turgid) and the plant **wilts**

EXTENDED ONLY

Osmosis in Tissues

In plant tissues

- Plant cells that are **turgid** are full of water and contain a **high turgor pressure** (the pressure of the cytoplasm pushing against the cell wall)
- This pressure **prevents any more water entering** the cell by osmosis, even if it is in a solution that has a higher water potential than inside the cytoplasm of the cells
- This **prevents** the plant cells from taking in too much water and **bursting**
- Plant roots are surrounded by soil water and the cytoplasm of root cells has a **lower water potential** than the soil water
- This means water will move across the cell membrane of root hair cells **into the root** by **osmosis**
- The water moves across the root from cell to cell by osmosis until it reaches the xylem
- Once they enter the xylem they are transported away from the root by the transpiration stream, helping to maintain a concentration gradient between the root cells and the xylem vessels

3 MOVEMENT IN & OUT OF CELLS

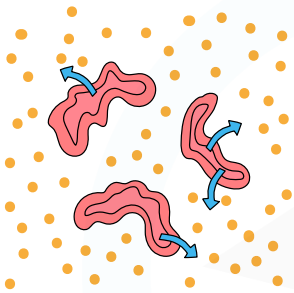
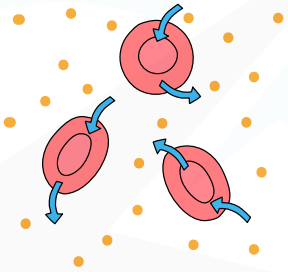
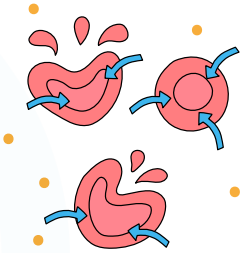
3.2 OSMOSIS cont...

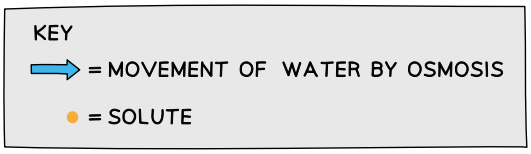
YOUR NOTES

EXTENDED ONLY cont...

In animal tissues

- **Animal cells** also lose and gain water as a result of osmosis
- As animal cells **do not have a supporting cell wall**, the results on the cell are more severe
- If an animal cell is placed into a **strong sugar solution** (with a lower water potential than the cell), it will lose water by osmosis and become **crenated** (shrivelled up)
- If an animal cell is placed into **distilled water** (with a higher water potential than the cell), it will gain water by osmosis and, as it **has no cell wall to create turgor pressure**, will continue to do so until the cell membrane is stretched too far and it **bursts**

HYPERTRONIC SOLUTION	ISOTONIC SOLUTION	HYPOTONIC SOLUTION
		
– RED BLOOD CELLS HAVE HIGHER WATER POTENTIAL THAN SOLUTION – NET MOVEMENT OF WATER OUT – SHRIVELLED CELLS	– WATER POTENTIAL EQUAL BETWEEN RED BLOOD CELL AND SOLUTION – NO NET MOVEMENT OF WATER – NORMAL CELLS	– RED BLOOD CELLS HAVE LOWER WATER POTENTIAL THAN SOLUTION – NET MOVEMENT OF WATER IN – CELLS SWELL. MAY LYSE (BURST)



Effect of osmosis on animal cells

3 MOVEMENT IN & OUT OF CELLS

3.3 ACTIVE TRANSPORT

YOUR NOTES

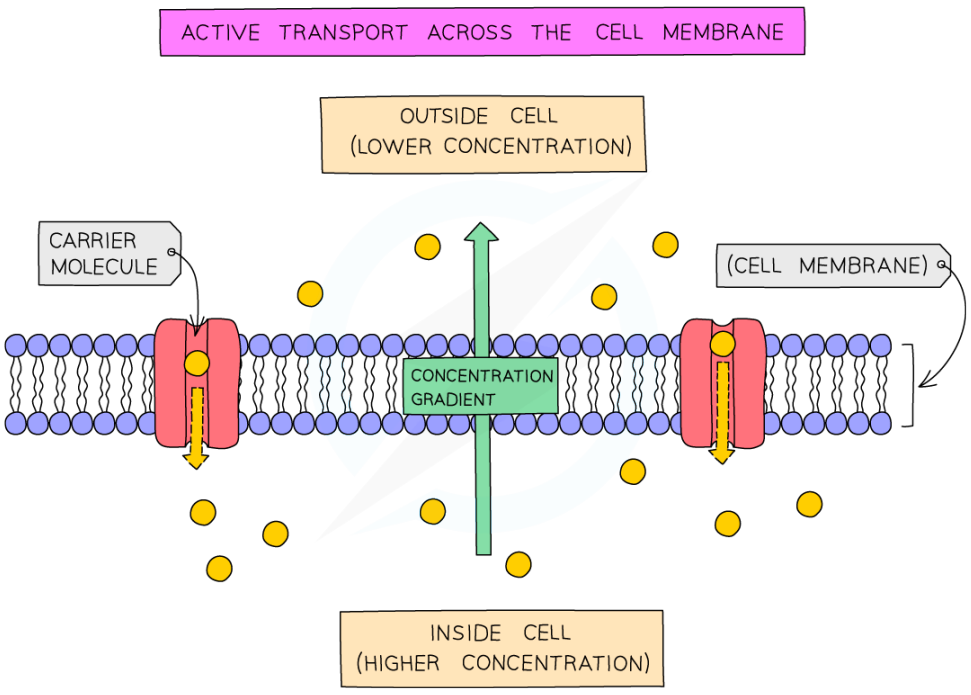
What is Active Transport?

- Active transport is the movement of particles through a cell membrane from a region of **lower concentration** to a region of **higher concentration** using **energy** from **respiration**

EXTENDED ONLY

Examples of Active Transport

- Energy is needed because particles are being moved **against a concentration gradient**, in the opposite direction from which they would naturally move (by diffusion)
- Examples of active transport include:
  - **uptake of glucose** by epithelial cells in the villi of the small intestine and by kidney tubules in the nephron
  - **uptake of ions** from soil water by root hair cells in plants



Active transport across the cell membrane

3 MOVEMENT IN & OUT OF CELLS

3.3 ACTIVE TRANSPORT cont...

YOUR NOTES

EXTENDED ONLY cont...

How Protein Molecules Move Particles

- Active transport works by using **carrier proteins embedded in the cell membrane** to pick up specific molecules and take them through the cell membrane **against their concentration gradient**:

1. Substance combines with **carrier protein molecule** in the cell membrane
2. Carrier transports substances across membrane using **energy from respiration** to give them the kinetic energy needed to change shape and move the substance through the cell membrane
3. Substance released into cell

> NOW TRY SOME EXAM QUESTIONS

3 MOVEMENT IN & OUT OF CELLS

YOUR NOTES

EXAM QUESTIONS

QUESTION 1

Osmosis is:

A The active movement of molecules from a region of their lower concentration to a region of their higher concentration.

B The movement of water through a partially permeable membrane from a more concentrated to a more dilute solution

C Particles from a region of lower concentration to a region of higher concentration using energy from respiration.

D The movement of water through a partially permeable membrane from a more dilute to a more concentrated solution.

QUESTION 2

A group of students carried out an investigation into osmosis using cylinders of potato. The results from their experiment are shown below.

concentration of salt solution / mol dm^3	mass of potato cylinder at start / g	mass of potato cylinder after 24 hours / g
0.2	2.5	2.7

Which statement below correctly explains this change in length?

	movement of water	cause of this movement
A	out of the potato cells	The salt solution has a lower water potential than the potato cells.
B	out of the potato cells	The salt solution has a higher water potential than the potato cells.
C	into the potato cells	The salt solution has a lower water potential than the potato cells.
D	into the potato cells	The salt solution has a higher water potential than the potato cells.

3 MOVEMENT IN & OUT OF CELLS

EXAM QUESTIONS cont...

YOUR NOTES

QUESTION 3

How does a water vapour molecule move out of the air space of a leaf into the atmosphere on a dry day?

A Active transport

B Diffusion

C Evaporation

D Transpiration

QUESTION 4

Which of the following statements would be correct for both diffusion and osmosis?

	does not require energy from the cell	molecules must be separated by a partially permeable membrane	molecules more from a dilute to a more concentrated solution
A	✔	✔	✘
B	✘	✘	✔
C	✔	✘	✔
D	✔	✘	✔

3 MOVEMENT IN & OUT OF CELLS

EXAM QUESTIONS cont...

YOUR NOTES

QUESTION 5

A number of red blood cells were immersed in a pure solution of water before being observed under a microscope. There was a dramatic change in their appearance.

Which row of the table below correctly describes and explains what happened to the red blood cells?

	direction of water movement	from higher to lower concentration	from higher to lower water potential	effect
A	✔	✔	✘	cells burst
B	✘	✘	✔	cells burst
C	✔	✘	✔	cells shrink
D	✔	✘	✔	cells shrink

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