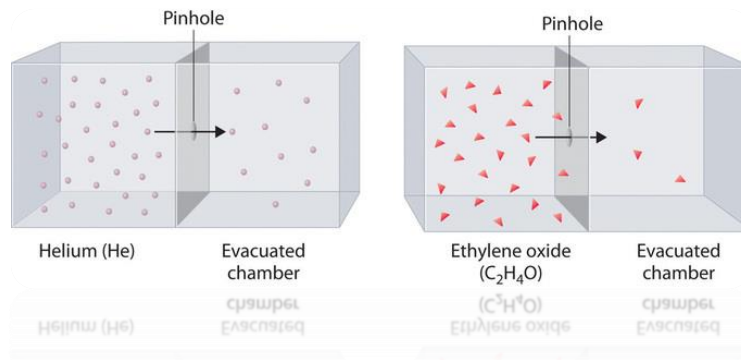


# Diffusion and Osmosis

## 1. Diffusion

Definition:

Diffusion is the net movement of particles (atoms, ions, or molecules) from a region of higher concentration to a region of lower concentration. It is a passive process that does not require energy, as it is driven by the kinetic energy of the particles themselves.



### Factors Affecting the Rate of Diffusion:

- **Temperature:** Higher temperatures increase the kinetic energy of particles, which speeds up the rate of diffusion.
- **Surface Area:** A larger surface area allows for a faster rate of diffusion, as there is more space for molecules to move.
- **Concentration Gradient:** A steeper concentration gradient (a greater difference between high and low concentration areas) results in a faster rate of diffusion.
- **Distance:** A shorter distance for the particles to travel results in a faster rate of diffusion.

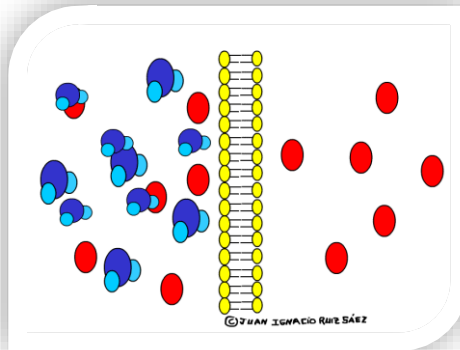
### Examples in Living Organisms:

- **Gas Exchange in Lungs:** Oxygen diffuses from the alveoli (high concentration) into the blood (low concentration), and carbon dioxide diffuses from the blood (high concentration) into the alveoli (low concentration) to be exhaled.
- **Nutrient Absorption in the Small Intestine:** Digested food molecules like glucose and amino acids diffuse from the small intestine lumen (high concentration) into the blood capillaries (low concentration).
- **Transpiration in Plants:** Water vapour diffuses out of the stomata of the leaves into the atmosphere.

## 2. Osmosis

Definition:

Osmosis is a special type of diffusion. It is the net movement of water molecules across a partially permeable membrane from a region of higher water concentration (more dilute solution) to a region of lower water concentration (more concentrated solution). This process is driven by the difference in water potential or solute concentration across the membrane.



### Effects of Osmosis on Cells:

- **Plant Cells:**
  - **In a dilute solution (higher water potential):** Water enters the plant cell by osmosis, causing the vacuole to swell and push the cytoplasm and cell membrane against the rigid cell wall. The cell becomes turgid. Turgor pressure provides support to herbaceous plants.
  - **In a concentrated solution (lower water potential):** Water leaves the plant cell by osmosis. The vacuole and cytoplasm shrink, and the cell membrane pulls away from the cell wall. The cell becomes flaccid and eventually plasmolysed, which can lead to the wilting and death of the plant.
  - **In an isotonic solution (same water potential):** There is no net movement of water, and the cell remains in its normal state.
- **Animal Cells (e.g., Red Blood Cells):**
  - **In a dilute solution (higher water potential):** Water enters the red blood cell by osmosis, causing it to swell and burst (haemolysis) because animal cells do not have a cell wall to prevent over-expansion.

- **In a concentrated solution (lower water potential):** Water leaves the red blood cell by osmosis, causing it to shrink and become crenated.
  - **In an isotonic solution (same water potential):** There is no net movement of water, and the cell maintains its biconcave shape.
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## IGCSE O Levels Biology Past Paper Questions

### Constructed-Response Questions

1. **Question:** Define osmosis and explain its importance in the uptake of water by plant roots.
  - **Constructed Answer:** 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) across a partially permeable membrane. The soil typically has a higher water potential than the cytoplasm of the root hair cells. This causes water to move from the soil into the root hair cells by osmosis, which is essential for transporting water to the rest of the plant.
  - **Examiner Report:** Candidates should clearly state that osmosis is a type of diffusion that involves water molecules and a partially permeable membrane. The term "water potential" is preferred over "water concentration" for a higher grade. Marks are awarded for explaining the concentration gradient and the directional movement of water.
2. **Question:** Describe an experiment to investigate osmosis using potato cylinders. Explain the expected results.
  - **Constructed Answer:** Cut several equal-sized potato cylinders and weigh them. Place each cylinder into a different concentration of a sugar solution (e.g., 0% pure water, 5%, 10%, 20%) for a fixed period of time, such as one hour. After one hour, remove the potato cylinders, dry them with a paper towel, and reweigh them. A potato cylinder in pure water will gain mass because water enters the cells by osmosis. A potato cylinder in a concentrated sugar solution will lose mass because water leaves the cells by osmosis.
  - **Examiner Report:** This is a common practical question. Marks are awarded for detailing each step: cutting equal-sized cylinders, using different concentrations of solution, and measuring mass change. A key point for a good answer is to

mention the drying of the cylinders before the final weighing to ensure that the mass change is due to osmosis and not just surface water.

3. **Question:** Describe and explain what happens when a red blood cell is placed in pure water.

- **Constructed Answer:** When a red blood cell is placed in pure water, water molecules move into the cell by osmosis because the concentration of water is higher outside the cell than inside. The cell swells and eventually bursts (haemolysis) because it does not have a cell wall to resist the pressure of the incoming water.
- **Examiner Report:** Candidates must mention the movement of water by osmosis and correctly identify that the cell will swell. Crucially, they must explain that the bursting of the cell is due to the lack of a cell wall, a key difference between animal and plant cells.

4. **Question:** State four factors that affect the rate of diffusion.

- **Constructed Answer:** The four factors are temperature, surface area, concentration gradient, and distance.
- **Examiner Report:** This is a straightforward recall question. Candidates should list all four factors for full marks. No explanation is required, but an incorrect explanation would be penalised.

5. **Question:** Explain how diffusion is important for gas exchange in the human lungs.

- **Constructed Answer:** Oxygen is at a higher concentration in the alveoli than in the blood capillaries. Therefore, oxygen molecules diffuse from the alveoli into the blood. At the same time, carbon dioxide, a waste product of respiration, is at a higher concentration in the blood than in the alveoli. It diffuses from the blood into the alveoli to be exhaled.
- **Examiner Report:** The answer must clearly state the concentration gradient for both oxygen and carbon dioxide and the direction of movement for each gas. Using terms like "high concentration" and "low concentration" for both gases is essential.

6. **Question:** Distinguish between diffusion and osmosis.

- **Constructed Answer:** Diffusion is the movement of any molecules from a high concentration to a low concentration. Osmosis is a specific type of diffusion that only involves the movement of water molecules. Furthermore, osmosis requires

a partially permeable membrane, whereas diffusion can occur in any medium (gas or liquid) without a membrane.

- **Examiner Report:** The distinction should be based on three key points: the type of molecule (any particle vs. water), the requirement of a partially permeable membrane, and the direction of movement (down a concentration gradient vs. down a water potential gradient).

7. **Question:** A plant cell is placed in a solution that has a lower water potential than its cell sap. Describe the process and the final state of the cell.

- **Constructed Answer:** Water will move out of the plant cell into the surrounding solution by osmosis because the solution has a lower water potential. The cell cytoplasm and vacuole will shrink, causing the cell membrane to pull away from the cell wall. The cell is now described as plasmolysed.
- **Examiner Report:** Candidates must use the term "plasmolysis" and correctly explain the movement of water out of the cell. The reason for the movement (lower water potential/more concentrated solution outside the cell) must be stated.

8. **Question:** Why is diffusion not sufficient to transport substances over long distances in large, multicellular organisms?

- **Constructed Answer:** Diffusion is a very slow process. In large organisms, the distance between the source of a substance and the cells that need it is too great for diffusion to be effective. Specialized transport systems, such as the circulatory system in animals, are needed to move substances quickly.
- **Examiner Report:** The core idea is the slowness of diffusion over long distances. Candidates should link the large size of the organism to the need for a more efficient transport system.

9. **Question:** Explain why a fresh vegetable becomes soft or wilts when left in a hypertonic salt solution.

- **Constructed Answer:** A hypertonic salt solution has a lower water potential than the vegetable cells. Water will move out of the vegetable cells into the salt solution by osmosis. The loss of water from the cells causes them to become flaccid, and the turgor pressure decreases, which makes the vegetable soft and wilted.

- **Examiner Report:** Candidates need to correctly identify the solution as hypertonic (or more concentrated) and explain the osmotic movement of water. Mentioning the loss of turgor pressure and the resulting flaccidity and wilting is essential for a full answer.

10. **Question:** A drop of ink is placed in a beaker of cold water and another drop is placed in a beaker of hot water. Describe the difference in what is observed and explain why.

- **Constructed Answer:** The ink diffuses much faster in the hot water than in the cold water. This is because the molecules in the hot water have more kinetic energy due to the higher temperature. This increased kinetic energy causes the water and ink molecules to move and collide more frequently, leading to a faster rate of diffusion.
- **Examiner Report:** This question tests the understanding of factors affecting diffusion. The key points are to correctly state that the rate of diffusion is faster at higher temperatures and to provide the correct reason: increased kinetic energy of molecules.

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### Multiple-Choice Questions

1. Which of the following processes requires a partially permeable membrane?

- A. Diffusion
- B. Osmosis
- C. Active transport
- D. Facilitated diffusion

- **Answer:** B. Osmosis

2. Which of the following is a feature of both diffusion and osmosis?

- A. They require energy from respiration.
- B. They involve the movement of water molecules only.
- C. They occur down a concentration gradient.
- D. They are used to absorb mineral ions by root hair cells.

- **Answer:** C. They occur down a concentration gradient.

3. What happens to a plant cell when it is placed in a concentrated sugar solution?

- A. It becomes turgid.
- B. It bursts.
- C. It becomes plasmolysed.
- D. It undergoes haemolysis.

○ **Answer:** C. It becomes plasmolysed.

4. A student places a potato strip in a solution. After one hour, the mass of the potato strip decreases. What can be concluded about the solution?

- A. It is pure water.
- B. It has a higher water potential than the potato cells.
- C. It has a lower water potential than the potato cells.
- D. It has the same water potential as the potato cells.

○ **Answer:** C. It has a lower water potential than the potato cells.

5. What is the main driving force behind diffusion?

- A. Kinetic energy of particles
- B. Cellular respiration
- C. Turgor pressure
- D. Osmotic pressure

○ **Answer:** A. Kinetic energy of particles.

6. Which of the following is an example of diffusion in a living organism?

- A. Uptake of water by roots.
- B. Absorption of mineral salts by root hair cells.
- C. The movement of sucrose in phloem.
- D. Gas exchange in the gills of a fish.

○ **Answer:** D. Gas exchange in the gills of a fish.

7. A cell is placed in an isotonic solution. What is the net movement of water?

- A. Water moves into the cell.
- B. Water moves out of the cell.
- C. There is no net movement of water.
- D. Water moves in and out equally, but only at the beginning.

- **Answer:** C. There is no net movement of water.

8. Why does a plant cell not burst when it becomes turgid?

- A. Because of the presence of a cell wall.
- B. Because it has a large sap vacuole.
- C. Because the cell membrane is selectively permeable.
- D. Because the nucleus controls water movement.

- **Answer:** A. Because of the presence of a cell wall.

9. The rate of diffusion is fastest when the concentration gradient is:

- A. The steepest
- B. The flattest
- C. Non-existent
- D. Decreasing

- **Answer:** A. The steepest.

10. What is the correct definition of a partially permeable membrane?

- A. A membrane that allows all substances to pass through freely.
- B. A membrane that allows no substances to pass through.
- C. A membrane that allows some substances to pass through but restricts others.
- D. A membrane that only allows water to pass through.

- **Answer:** C. A membrane that allows some substances to pass through but restricts others.