Information: Date:

Diffusion—Osmosis

Diffusion

If you open a bottle of perfume in a room, it is not long before molecules of scent spread to all parts of the room (and are detected when they fit into membrane receptors in your nose). This will happen, even in still air, by the process of diffusion. Diffusion can be defined as the movement of molecules (or ions) from a region of their higher concentration to a region of their lower concentration. It happens because of the natural kinetic energy (energy of movement) possessed by molecules or ions, which makes them move about at random. As a result of diffusion, molecules tend to reach an equilibrium situation where they are evenly spread within a given volume of space.

The respiratory gases, oxygen and carbon dioxide, cross membranes by diffusion.

Osmosis

Osmosis is best regarded as a special type of diffusion involving water molecules only. It is defined as the movement of water molecules from a region of their higher concentration to a region of their lower concentration through a partially permeable membrane. The latter is a membrane which allows only certain molecules through.

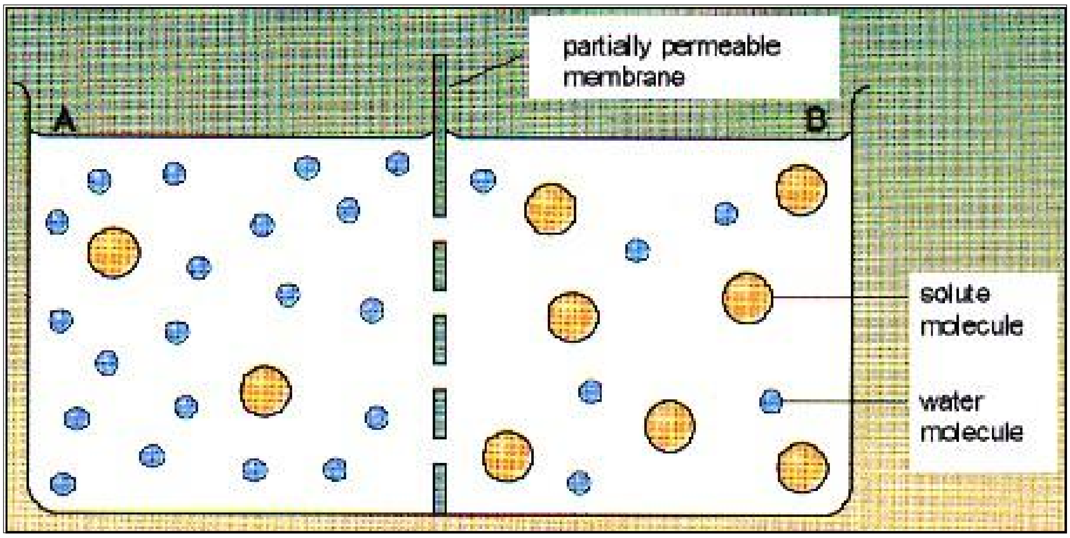
In explanations that follow, remember that solute + solvent = solution. In a sugar solution, for example, the solute is sugar and the solvent is water.

Look at the following figure.

a Which solution is more dilute and which is more concentrated?

b Which solution has the higher concentration of water molecules?

c In which direction will water molecules move by osmosis?



Since the solute molecules cannot cross the membrane, the two solutions A and B cannot come into equilibrium by the diffusion of both solute and water molecules, as would happen if there were no membrane. Instead, only water molecules can pass through the membrane. They will show a net movement from A to B because there is a higher concentration of water molecules in A than in B.

The tendency for water molecules to move from one place to another is measured as the water potential. Water moves from a place of higher water potential to a region of lower water potential.

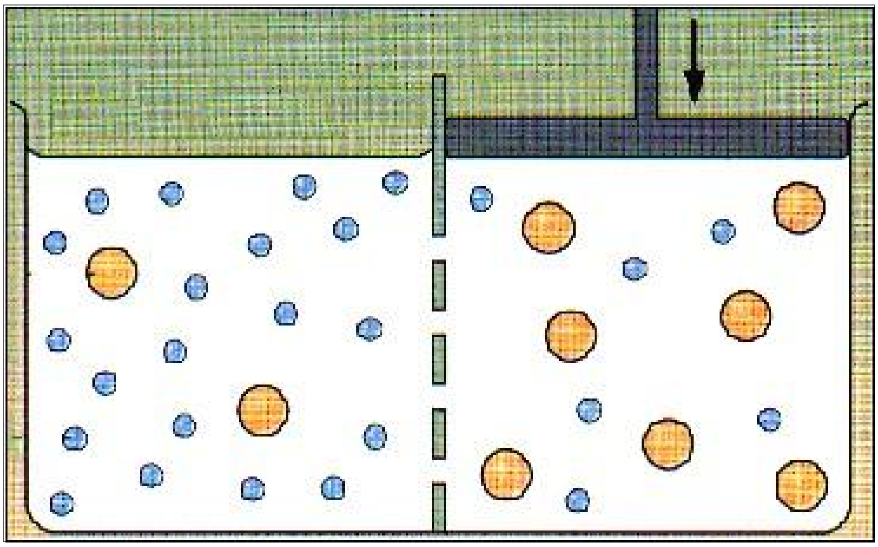
Solution A therefore has a higher water potential than solution B. Solute molecules reduce water potential. The extent of this lowering is called the solute potential. Pure water has the highest possible water potential. By convention, this is set at zero.

Since solutes make water potential lower, they make water potential less than zero, that is negative. The more solute, the more negative (lower) the solute potential and the water potential become.

In the figure (see above), which solution has the higher solute potential?

The symbol for water potential is Ψ (the Greek letter psi). The symbol for solute potential is ΨS. In the experiment with red blood cells you could see the effect of osmosis on an animal cell. The experiment shows how important it is to maintain a constant Ψ inside the bodies of animals.

For a solution or for an animal cell, water potential equals solute potential. However, in plant cells another factor comes into play. If a plant cell is placed in pure water or in a very dilute solution, it does not swell until it bursts like an animal cell would. It is prevented from bursting by its cell wall which is very strong and inelastic. As water enters the cell, pressure builds up which is soon so great that it stops further water entering the cell.
This figure shows a simplified model of this:



Pressure increases tendency of water molecules to move from right to left, and so increases water potential on the right. The amount of this increase is the pressure potential and can balance the effect of solute potential.

In fact, pressure builds up so quickly that very little dilution of the cell contents takes place (almost no change in ΨS). At this point, equilibrium is reached and water potential inside the cell equals that outside (water always moves from higher to lower Ψ, so at equilibrium there can be no difference in water potentials).
The pressure that develops inside the cell is called the pressure potential (Ψp) or turgor pressure and, like solute potential, it contributes to water potential. As pressure builds up, there is a greater tendency for water to leave the cell; in other words water potential increases inside the cell as pressure potential increases. For plant cells then, Ψ = ΨS + ΨP. Solute potential is negative, pressure potential is positive.

Possible osmotic changes in a plant cell can be examined in different solutions. These can easily be observed with a light microscope using strips of epidermis peeled from rhubarb petioles or tissue from beet root in sucrose or salt solutions of varying concentration.