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Topic- Osmosis

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Osmosis

Definition of Osmosis

(i) Diffusion of water from its pure state or dilute solution into a solution or stronger solution when the two are separated by a semipermeable membrane is termed as osmosis.

(ii) The movement of water from its higher chemical potential (found in pure state or dilute solution) to its lower chemical potential (found in solution or stronger solution) without allowing the diffusion of solute by means of a semipermeable membrane is called osmosis. The chemical potential of water is also called water potential.

(iii) Osmosis is movement of solvent or water molecules from the region of their higher diffusion pressure or free energy to the region of their lower diffusion pressure or free energy across a semipermeable membrane.

The direction and rate of osmosis depend upon the sum of two forces, pressure gradient (gradient of Ψ_p) and concentration gradient (gradient of Ψ_s). The net force or gradient is determined by the difference in the water potentials of solutions separated by a semipermeable membrane.

A solution which can cause an osmotic entry of water into it is said to be osmotically active solution. It possesses a low water potential. Diffusion of water into it will continue across the separating membrane till an equilibrium is reached. At equilibrium water potential becomes equal on both sides of the membrane.

Osmosis is a special type of diffusion of water that occurs through a semipermeable membrane.

Explanation:

Solute particles decrease the chemical potential of water by decreasing the mole fraction of water. In osmosis, a semipermeable membrane separates (say) dilute solution A and concentrated solution B. Solute particles cannot pass through the semipermeable membrane. Water molecules are in random motion. They strike the semipermeable membrane on both the sides and pass through the same (Fig. 11.6).

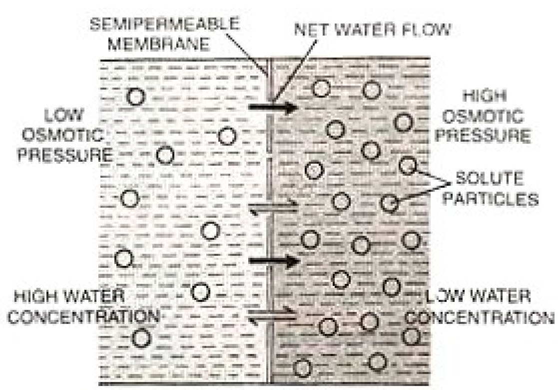

Fig. 11.6. Net movement of water from its higher chemical potential (dilute solution) to lower chemical potential (concentrated solution) when the two are separated by a semipermeable membrane.

Since more free water molecules are present on the side of dilute solution A, more of them pass through the membrane to enter the solution B as compared to the reverse flow. There is, therefore, a net diffusion of water from its higher chemical potential (dilute potential) to its lower chemical potential (concentrated solution).

Types of Osmosis:

Osmosis is of two types:

(i) Endosmosis:

The osmotic entry of water into a cell, organ or system

(ii) Exosmosis:

The osmotic withdrawal of water from a cell, organ or system.

Osmotic Pressure (O.P.):

It is maximum pressure which can develop in an osmotically active solution when it is separated from its pure solvent by a semipermeable membrane under ideal conditions of osmosis that do not allow dilution of solution. Osmotic pressure is also defined as the pressure required to completely stop the entry of water into an osmotically active solution across a semipermeable membrane (Fig. 11.10).

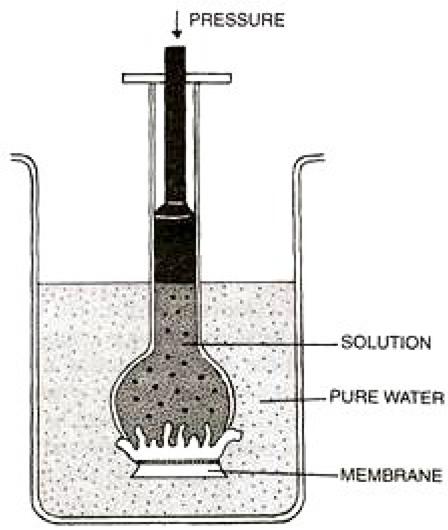

Fig. 11.10. Measurement of osmotic pressure of a solution.

It is measured in atmospheres, bars or Pascal's. Osmotic pressure is numerically equal to osmotic potential (= solute, potential, Ψ_s) but while osmotic potential has a negative value, osmotic pressure (n, pi) has a positive value, ($\Psi_s = -\pi$). The instrument used for measuring osmotic pressure is called osmometer, e.g., Berkeley and Hartley's osmometer, Pfeffer s osmometer.

Aquatic plants have an osmotic pressure of 1-3 atm, mesophytes 5—15 atm while in xerophytes it lies between 10-30 atm but goes up to 60 atm under drought conditions. Upper leaves have more osmotic pressure than the lower leaves. Seeds may develop an osmotic pressure of 100 atm. Halophytes have the maximum osmotic pressure with Atriplex confertifolia showing an O.P. of 202. 4 atm.

Reverse Osmosis:

It is the expulsion of pure water from a solution through a semipermeable membrane under the influence of pressure higher than the O.R of the solution. Reverse osmosis is used in removing salts from saline water as well as extra-purification of water.

Factors Controlling Osmosis:

Presence of a perfectly semipermeable membrane is a must for the operation of osmosis.

Osmosis is driven by two other factors:

(i) Concentration of dissolved solute on the two sides of semipermeable membrane,
(ii) Difference in pressure.

In thistle funnel experiment there is no indefinite passage of water from beaker into the funnel despite the fact that osmotic potential of the solution continues to be negative as compared to the chemical potential of pure water. It is because after some distance the raised column of solution exerts sufficient pressure over the semipermeable membrane as to balance the chemical potential of pure water.

Osmotic Concentrations:

A solution having low osmotic concentration (hence low osmotic pressure but less negative solute potential) as compared to another solution is known as hypotonic solution. A solution having high osmotic concentration (hence high osmotic pressure but more negative solute potential) as compared to another solution is termed as hypertonic solution.

The two solutions with the same concentration or pressure or potential are named as isotonic solutions. External hypotonic solution will cause endosmosis while hypertonic solution results in exosmosis. There is no change if the external solution is isotonic (Fig. 11.11). Such a flaccid cell will allow movement of water in both the directions.

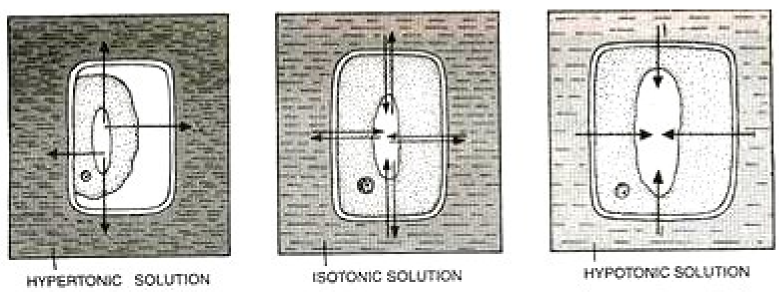

Fig. 11.11. Behaviour of a living cell placed in solutions of different concentrations.

Importance of Osmosis:

(1) Entry of soil water into root is carried out by osmosis.
(2) Osmosis performs cell to cell movement of water.
(3) Living cells remain distended or turgid only by the osmotic entry of water into them.
(4) Various cell organelles like mitochondria and chloroplasts will collapse if they are not able to maintain a proper osmotic concentration.
(5) 70% of cell water is held in vacuoles. It has come from outside through endosmosis and is kept in its place due to osmotic concentration of solutes dissolved in it.
(6) The soft organs like leaves, flowers, fruits and young stems are able to keep themselves stretched and swollen due to turgidity of their cells which is dependent upon osmosis.
(7) Osmosis plays a key role in the growth of radicle and plumule during the germination of seeds.
(8) Many plant movements like the folding and drooping of leaves in Mimosa are brought about by osmosis.
(9) The stomata open and close only in response to increase or decrease of the osmotic pressure of the guard cells in relation to nearby epidermal cells.
(10) A high osmotic pressure has been found to protect the plants against drought and frost injury. Seeds and spores are similarly able to pass through the unfavourable periods due to high osmotic pressure (or low solute potential).