Lecturer Dr. Ghaidaa S. Hameed

Nonelectrolyte cont…..

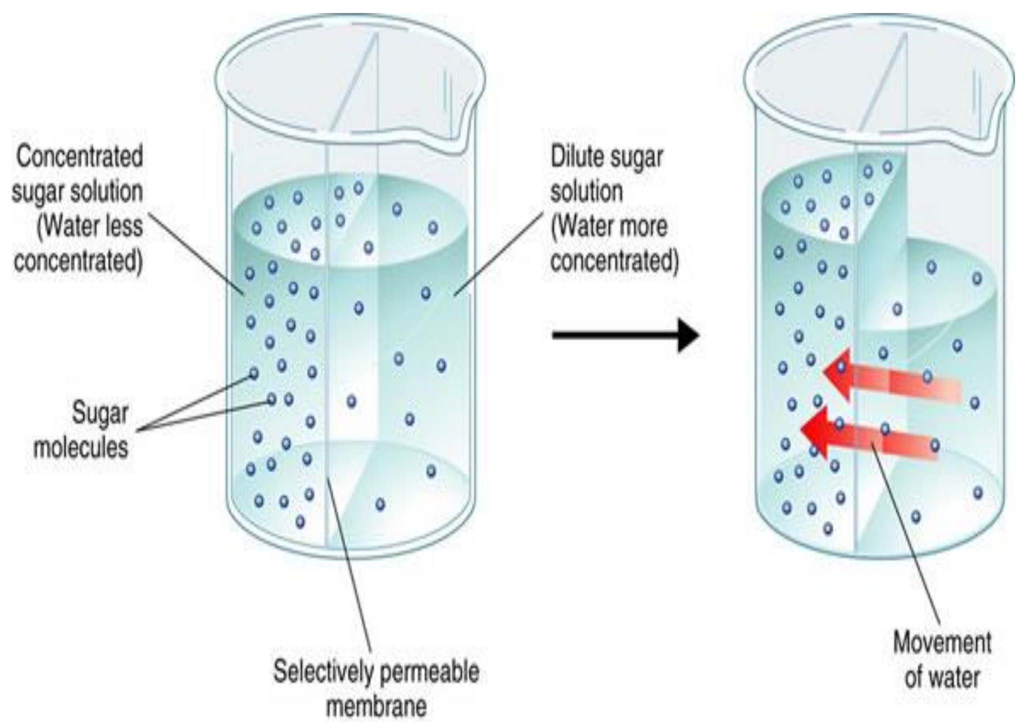
Osmotic Pressure π

- Escaping tendency can be measured in terms of vapor pressure or the closely related colligative property, osmotic pressure.
- If a solution is confined in a membrane only permeable to the solvent molecules (semipermeable), osmosis occurs.
- Osmosis is defined as the passage of the solvent into a solution through a semi-permeable membrane.

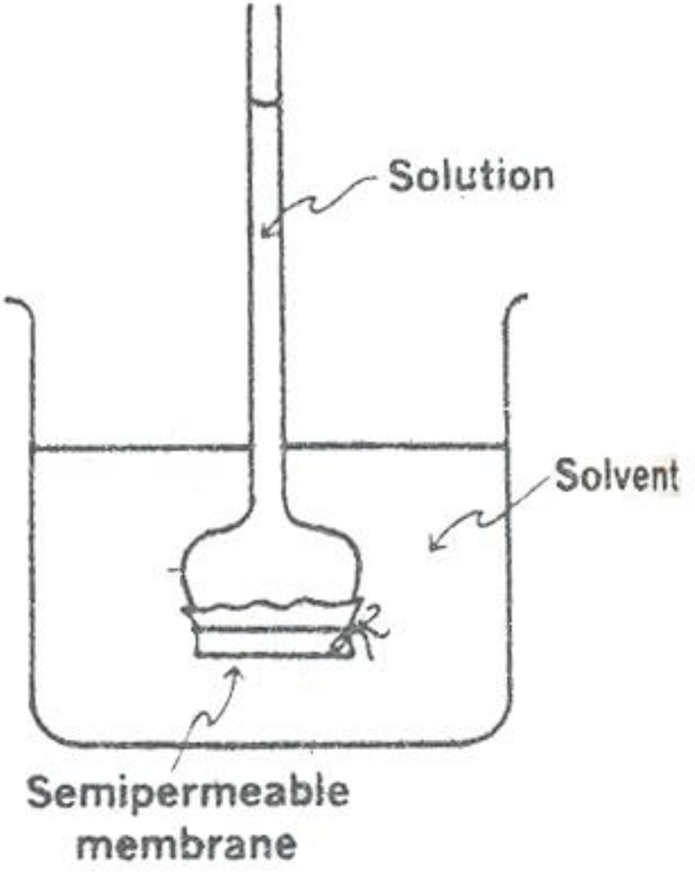
Osmotic Pressure

In the process of *diffusion*, both the solvent and the solute molecules migrate freely.

This process tends to equalize the escaping tendency of the solvent on both sides of the membrane.



Osmotic Pressure π



Apparatus for demonstrating osmosis.

Osmotic Pressure π

- Van't Hoff suggested that there is an apparent analogy between solutions and gases **and that the osmotic pressure in a dilute solution is equal to the pressure that the solute would exert if it were a gas occupying the same volume**. The equation is

$$\pi V = nRT$$

In which π is the osmotic pressure in atm, V is the volume of the solution in liters, n is the number of moles of the solute, R is the gas constant equal to 0.082L atm mole^{-1} deg $^{-1}$, and T is the absolute temperature.

Osmotic Pressure π

- The van’t Hoff equation can be rewritten as

$$\pi = \frac{n}{V} RT = cRT$$

in which c is the concentration of the solute in moles per liter (molarity).

- Morse has shown that when the concentration is expressed in molality rather than molarity, the results compare more with the experimental findings. **The Morse equation is**

$$\pi = RTm$$

Osmotic Pressure π

- Thermodynamic osmotic pressure equation is a more exact expression for osmotic pressure. It applies to concentrated as well as dilute solutions, provided that the vapor follows the ideal gas law

$$\pi = \frac{RT}{V_1} \ln \frac{P^\circ}{P}$$

In which π is the osmotic pressure in atm, V_1 is the volume of 1 mole of solvent (partial molar volume) in liters, P^o is the vapor pressure of pure solvent in atm, and p is the vapor pressure of the solution in atm, R is the gas constant equal to 0.082L atm $mole^{-1}$ deg $^{-1}$, and T is the absolute temperature.

- *One gram of sucrose, molecular weight 342, is dissolved in 100 mL of solution at 25◦C. What is the osmotic pressure of the solution?*
- $Mole\ of\ sucrose = \frac{1}{342} = 0.0029$
- *π x 0.1 = 0.0029 × 0.082 × 298*
- π = 0.71 atm

MOLECULAR WEIGHT DETERMINATION

Lowering of the vapor pressure

the mole fraction of solvent, $n1 = w1/M1$

mole fraction of solute, $n2 = w2/M2$

$$\frac{p_1^\circ - p_1}{p_1^\circ} = \frac{n_2}{n_1 + n_2} = \frac{{w_2}/{\boldsymbol{M}_2}}{\left({w_1}/{M_1}\right) + \left({w_2}/{\boldsymbol{M}_2}\right)}$$

In dilute solutions in which w_2/M_2 is negligible compared with w_1/M_1, the former term may be omitted from the denominator, and the equation simplifies to

$$\frac{\Delta p}{p_1^\circ} = \frac{w_2/M_2}{w_1/M_1} \qquad (5\text{–}46)$$

MOLECULAR WEIGHT DETERMINATION

Boiling point elevation

$$m = \frac{w_2/\boldsymbol{M_2}}{w1} \, x \, 1000 = \frac{1000 \, w_2}{w_1 \boldsymbol{M_2}}$$

$$\Delta T_b = K_b m$$

$$\Delta T_b = K_b \frac{1000 \, w_2}{w_1 \boldsymbol{M}_2}$$

A solution containing 10.0 g of sucrose dissolved in 100 g of water has a boiling point of 100.149°C. What is the molecular weight of sucrose?(kb =0.51)

H.W

MOLECULAR WEIGHT DETERMINATION

Boiling point elevation

By rearranging equation

$$\Delta T_f = K_f \frac{1000\, w_2}{w_1 M_2}$$

The freezing point depression of a solution of 2.000 g of 1,3-dinitrobenzene in 100.0 g of benzene was determined by the equilibrium method and was found to be 0.6095◦C. Calculate the molecular weight of 1,3-dinitrobenzene.(kf = 5.12)

H.W

Determining Molecular Weight by Osmotic Pressure

Fifteen grams of a new drug dissolved in water to yield 1000 mL of solution at 25°C was found to produce an osmotic pressure of 0.6 atm. What is the molecular weight of the solute?

We write

$$\pi = cRT = \frac{c_g RT}{M_2} \qquad (5\text{–}53)$$

where c_g is in g/liter of solution. Thus,

$$\pi = \frac{15 \times 0.0821 \times 298}{M_2}$$

or

$$M_2 = \frac{15 \times 24.45}{0.6} = 612 \text{ g/mole}$$