

$$\Delta T_f = K_f \cdot m$$

$$\Delta T_b = K_b \cdot m$$

( $^{\circ}\text{C}$ ) ( $^{\circ}\text{C}/\text{m}$ ) ( $\frac{\text{mol}}{\text{kg}}$  or  $m$ )

$K_f$  = freezing-point depression constant  
(for a particular solvent)

$K_b$  = boiling-pt. elevation const

ex:  $\text{H}_2\text{O}(l)$   $K_f = 1.86^{\circ}\text{C}/m$   
 $K_b = 0.52^{\circ}\text{C}/m$

ex: Benzene(l)  
 $\text{C}_6\text{H}_6(l)$   $K_f = 5.12^{\circ}\text{C}/m$   
 $K_b = 2.53^{\circ}\text{C}/m$

$fp = 5.53^{\circ}\text{C}$

$bp = 80.1^{\circ}\text{C}$

5.0% (w/w) soln of  $\text{C}_2\text{H}_5\text{OH}$  in  $\text{C}_6\text{H}_6$ .  
solute solvent.

what's fp?

$fp(\text{benzene}) = 5.53^{\circ}\text{C}$  ,  $K_f = 5.12^{\circ}\text{C}/m$

$$\Delta T_f = K_f \cdot m$$

$\uparrow$  molar conc.

$$m = \frac{\# \text{mol solute } (\text{C}_2\text{H}_5\text{OH})}{\# \text{kg solvent } (\text{C}_6\text{H}_6)}$$

$\leftarrow 0.1085 \text{ mol}$   
 $\leftarrow 0.0950 \text{ kg}$

Start: 100g soln  $\rightarrow$  5.0g  $\text{C}_2\text{H}_5\text{OH}$   
 $\rightarrow$  95.0g  $\text{C}_6\text{H}_6$   
 $0.0950 \text{ kg}$

$$\frac{5.0 \text{ g } \text{C}_2\text{H}_5\text{OH}}{46.07 \text{ g } \text{C}_2\text{H}_5\text{OH}} \left| \frac{1 \text{ mol } \text{C}_2\text{H}_5\text{OH}}{46.07 \text{ g } \text{C}_2\text{H}_5\text{OH}} \right| = 0.1085 \text{ mol } \text{C}_2\text{H}_5\text{OH}$$

$$m = \frac{0.1085 \text{ mol}}{0.0950 \text{ kg}} = 1.142 \frac{\text{mol}}{\text{kg}} \text{ or } m$$

$$\Delta T_f = K_f \cdot m = 5.12^\circ\text{C}/m \times 1.142 m = 5.85^\circ\text{C}$$

fp?

pure  $\text{C}_6\text{H}_6$ :  $f_p = 5.53^\circ\text{C}$

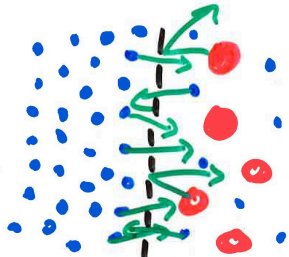
5% (w/w) soln:  $f_p = 5.53^\circ\text{C}$   
 $- 5.85^\circ\text{C}$   


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 $- 0.32^\circ\text{C}$

### Osmotic Pressure

high  $[\text{H}_2\text{O}]$



pure water

aq. soln

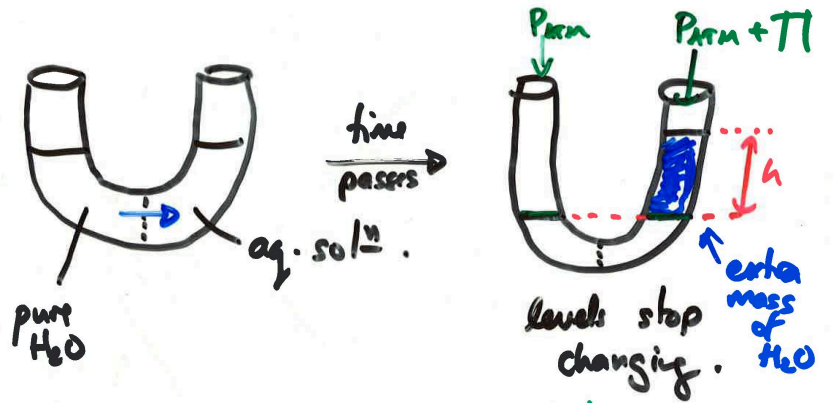
large solute  
(can't pass thru' membrane)

low  $[\text{H}_2\text{O}]$

**OSMOSIS**  
diffusion of  $\text{H}_2\text{O}$  but not solute.

semi-permeable membrane

→ net flow of small  $\text{H}_2\text{O}$  molecules



Hydrostatic pressure ( $\pi$ )

Osmotic pressure.

- min. additional pressure required to stop

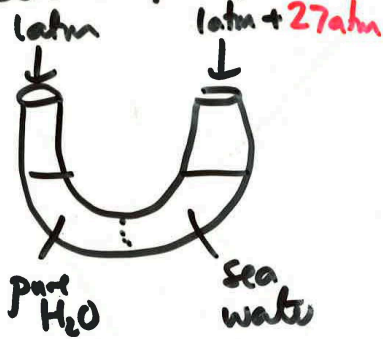
osmosis.

$$\pi = \rho \cdot g \cdot h$$

$\rho$  (density of soln)  
 $g$  acceleration due to gravity  $9.81 \text{ m/s}^2$   
 $h$  height.

For sea water,  $\pi \approx 27 \text{ atm}$

- about 30 ft of water  $\approx$  1 atm

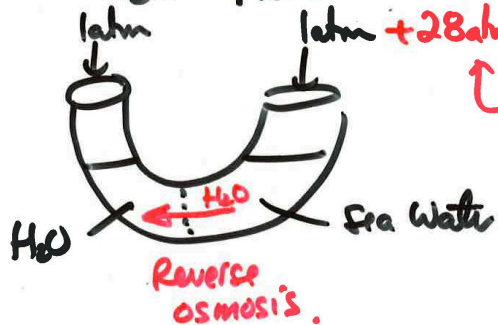


$$\pi = 27 \text{ atm}$$

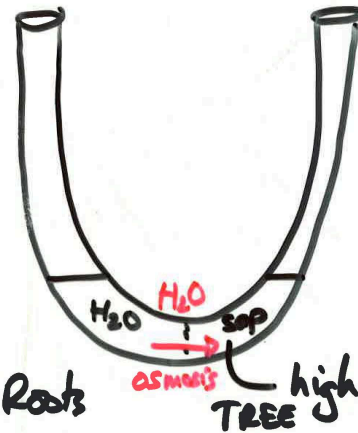
no net osmotic flow!

If we apply a pressure greater than  $\pi$ , we get  
**REVERSE OSMOSIS**

- H<sub>2</sub>O flows in other dir<sup>n</sup>!



$$P > \pi$$



for sap,  $\pi = \underline{\text{large}}$   
( $\sim 3M$  sucrose)  $h = 840m$

$$\pi = M \cdot R \cdot T$$

$P_i$   $\leftarrow$  Great "P"  
 $\uparrow$  molar conc.  
 $\uparrow$  gas constant.  
 Absolute temp (K)

$$\text{like: } P = \frac{n}{V} RT \quad \text{or} \quad pV = nRT$$

Using colligative props to find  $M$

↑  
 $\Delta T_f, \Delta T_b, \Pi$

ex: 0.150g of polyvinylalcohol (PVA)  
is dissolved in  $H_2O$  w/ a total vol of  
250.mL. The osmotic pressure of  
the sol<sup>n</sup> @ 25°C is 0.0676mmHg.

What's  $M$

$$\overset{\checkmark}{\Pi} = \overset{?}{M} \cdot \overset{\checkmark}{R} \cdot \overset{\checkmark}{T} \rightarrow M = \frac{\Pi}{RT}$$

$$\Pi = 0.0676 \text{ mmHg} \times \frac{1 \text{ atm}}{760 \text{ mmHg}} = 8.89 \times 10^{-5} \text{ atm}$$

$$\rightarrow M = \frac{8.89 \times 10^{-5} \text{ atm}}{0.0821 \frac{\text{atm} \cdot \text{L}}{\text{mol} \cdot \text{K}} \times 298 \text{ K}} = 3.637 \times 10^{-6} \frac{\text{mol}}{\text{L}}$$

$\frac{FT}{ML}$