# Helpful lessons for today

Why do they salt the roads when it is icy?

Why do you put salt in pasta water?

What do fish need dirty water?

Different ways to describe concentration

All of them are essentially

$$\frac{\text{Amount of solute}}{\text{Amount of everything (solvent)}}$$

Mole Fraction

$$\chi_i = \frac{\text{moles of i}}{\text{total moles}}$$

Molality

$$m = \frac{\text{moles of solute}}{\text{kg of solvent}}$$

Molarity

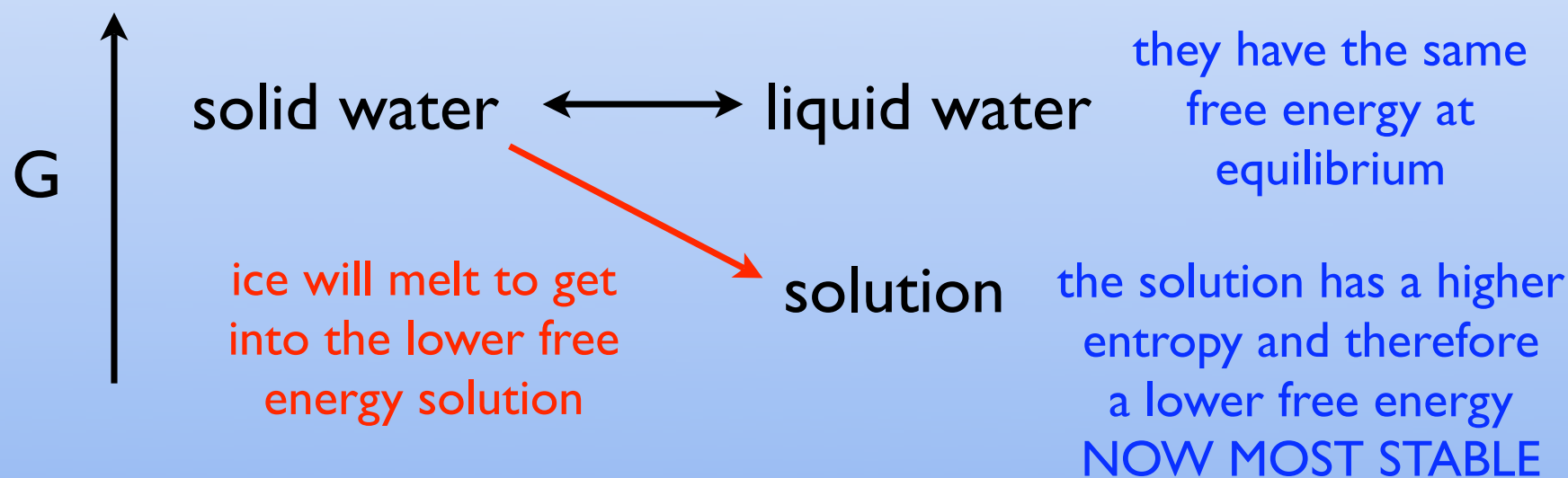$$M = \frac{\text{moles of solute}}{\text{L of solution}}$$

# Demo

# Why does the temperature drop?

A. the salt dissolving requires energy (endothermic)

B. the salt dissolving releases energy (exothermic)

C. the ice melting releases energy (exothermic)

D. the ice melting requires energy (endothermic)

# Solutions

The main effect of making a solution is that the entropy of the solution is higher than the separate solvent and solute

T = 0°C and P = 1 atm

G

solid water ←——→ liquid water

they have the same free energy at equilibrium

ice will melt to get into the lower free energy solution

solution

the solution has a higher entropy and therefore a lower free energy
NOW MOST STABLE

This effect depends on the entropy of the
solution which depends on how much "stuff"
is dissolved but not what the "stuff" is

Colligative Properties
depend on the concentration of the solution
but not what is actually dissolved
(note: this is approximate as it assumes and
ideal solution)

The only thing that matters is the number of
moles of "stuff"

Somethings dissolve into ions making more moles

1 M sugar solution = 1 moles of sugar in 1 L solution

1 M NaCl solution = 1 moles of $Na^+$ in 1 L solution
1 mole of $Cl^-$ in 1 L solution

2 moles of "stuff"

# Van't Hoff Number

$$i = \frac{\text{moles of "particles" in solution}}{\text{moles of solute dissovled}}$$

**TABLE 17.6** Expected and Observed Values of the van't Hoff Factor for 0.05 $m$ Solutions of Several Electrolytes

| Electrolyte | $i$ (expected) | $i$ (observed) |
|---|---|---|
| NaCl | 2.0 | 1.9 |
| $MgCl_2$ | 3.0 | 2.7 |
| $MgSO_4$ | 2.0 | 1.3 |
| $FeCl_3$ | 4.0 | 3.4 |
| HCl | 2.0 | 1.9 |
| Glucose* | 1.0 | 1.0 |

*A nonelectrolyte shown for comparison.

**Principles of Chemistry II**

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# Effect of making the solution

Boiling Point Elevation

Solution now more stable than vapor. Therefore the boiling point goes up

Freezing Point Depression

Solution now more stable than solid. Therefore the freezing point goes down

constant that depends on solvent

Boiling Point Elevation   $\Delta T = K_b m_{solute}$

molality solute

Remember the number of particles is what matters

$$\Delta T = i K_b m_{solute}$$

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constant that depends on solvent

Freezing Point Depression      $\Delta T = -K_f m_{solute}$

molality solute

Remember the number of particles is what matters

$$\Delta T = -iK_f m_{solute}$$

**TABLE 17.5** Molal Boiling-Point Elevation Constants ($K_b$) and Freezing-Point Depression Constants ($K_f$) for Several Solvents

| Solvent | Boiling Point (°C) | $K_b$ (°C kg/mol) | Freezing Point (°C) | $K_f$ (°C kg/mol) |
|---|---|---|---|---|
| Water ($H_2O$) | 100.0 | 0.51 | 0. | 1.86 |
| Carbon tetrachloride ($CCl_4$) | 76.5 | 5.03 | −22.99 | 30. |
| Chloroform ($CHCl_3$) | 61.2 | 3.63 | −63.5 | 4.70 |
| Benzene ($C_6H_6$) | 80.1 | 2.53 | 5.5 | 5.12 |
| Carbon disulfide ($CS_2$) | 46.2 | 2.34 | −111.5 | 3.83 |
| Ethyl ether ($C_4H_{10}O$) | 34.5 | 2.02 | −116.2 | 1.79 |
| Camphor ($C_{10}H_{16}O$) | 208.0 | 5.95 | 179.8 | 40. |

**Principles of Chemistry II**

# Which would you expect to have the lowest freezing point

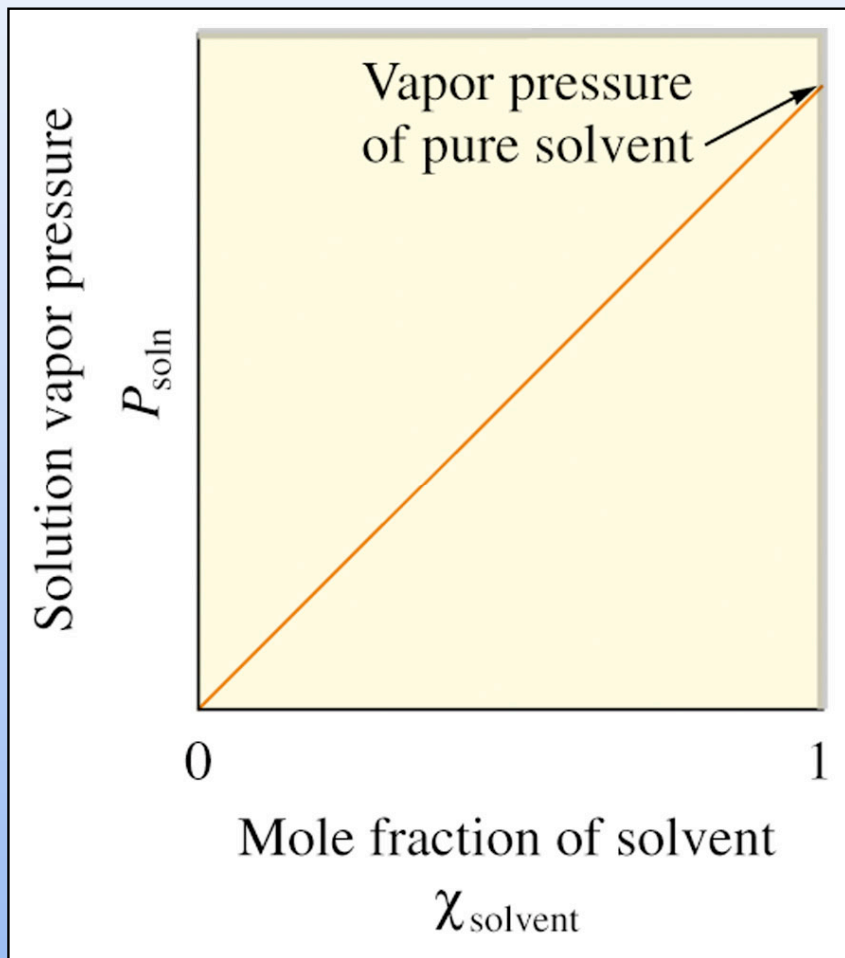A. 2 M sugar solution

B. 0.5 M NaCl solution

C. 1 M NaCl solution

D. 1 M MgCl$_2$ solution ⟵

# If the boiling point is higher, what is the vapor pressure of the solution?

A.  higher than the pure solvent

B.  lower than the pure solvent  ⟵

C.  the same as the pure solvent

# Raoult's Law



vapor pressure of pure solvent

$$P_{solvent} = X_{solvent}P°$$

mole fraction of solvent!
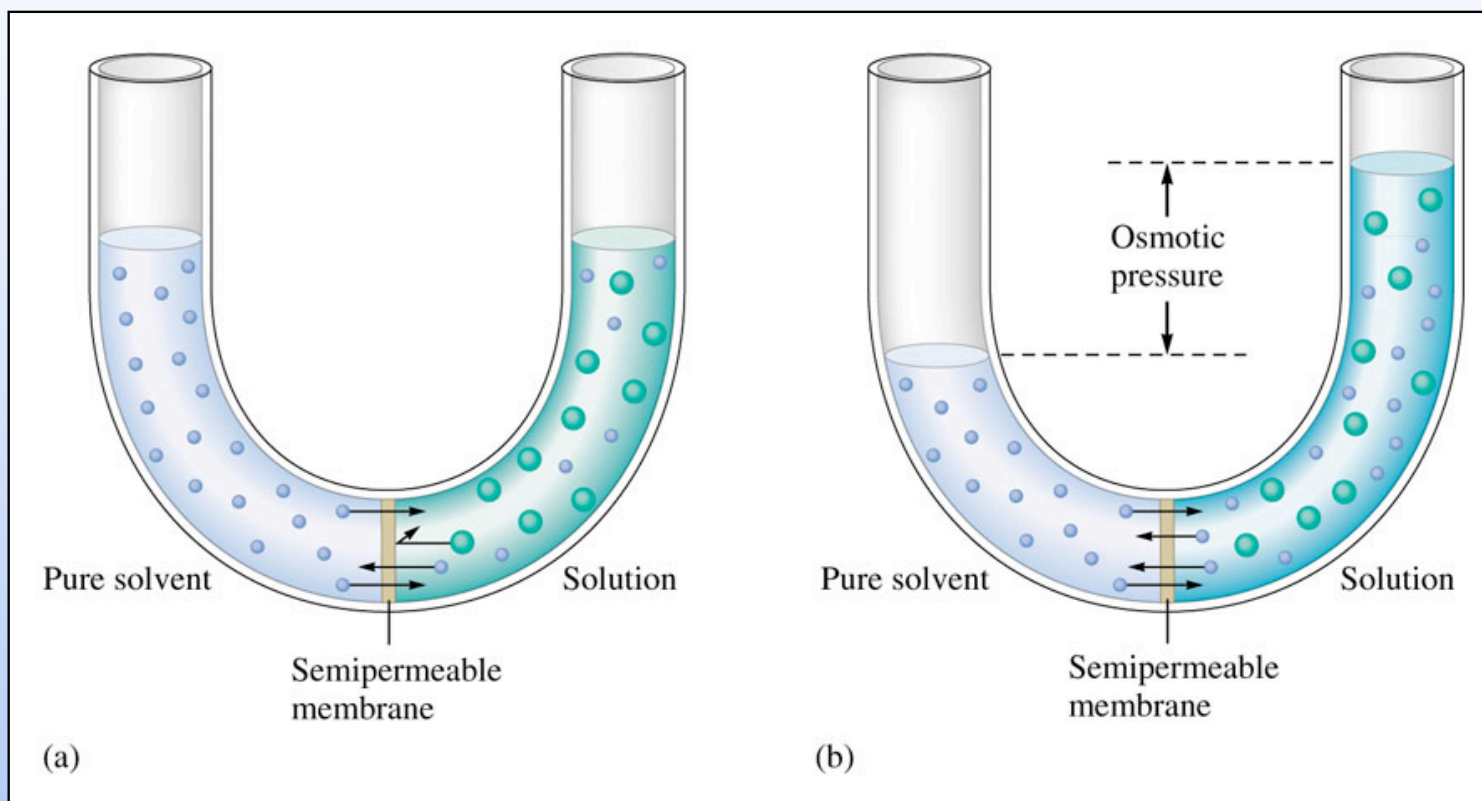
## new formula
## Change in pressure

$$\Delta P = X_{solute}P°$$

# Osmosis



(a)    Pure solvent    Solution
Semipermeable membrane

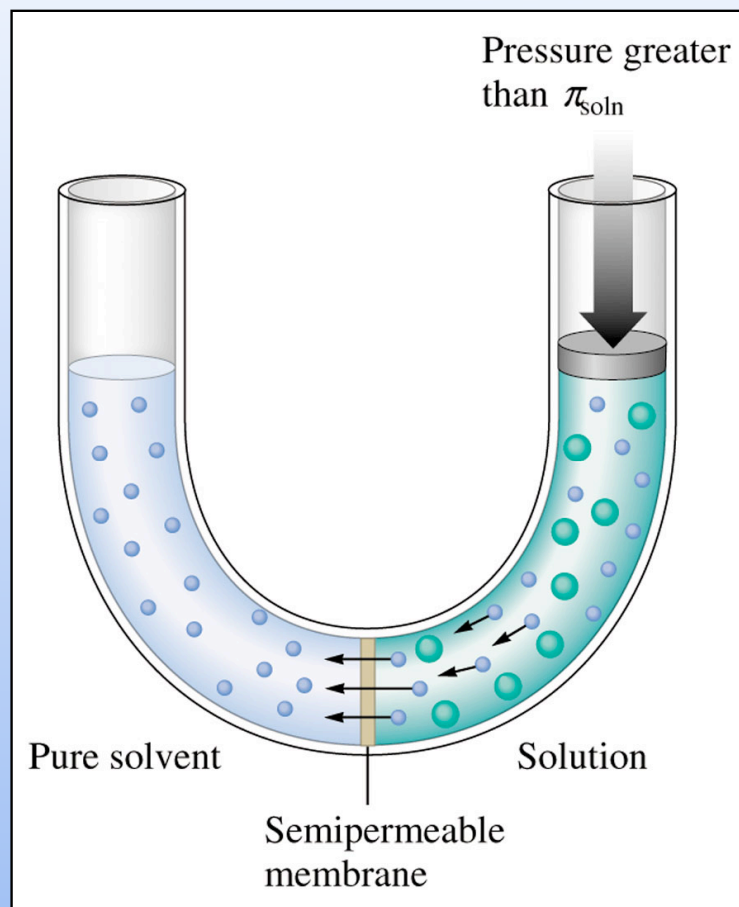(b)    Osmotic pressure    Pure solvent    Solution
Semipermeable membrane

Solvent can pass through the membrane
but the solute can't
Solution is lower in free energy so pure
solvent moves to the solution side

# Reverse Osmosis



Pressure greater than $\pi_{soln}$

Pure solvent

Solution

Semipermeable membrane

# Osmotic Pressure

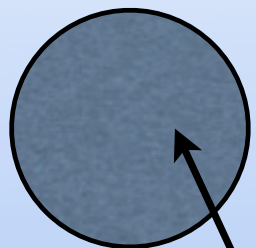$$\Pi = MRT$$

Osmotic pressure

Molarity of solution!
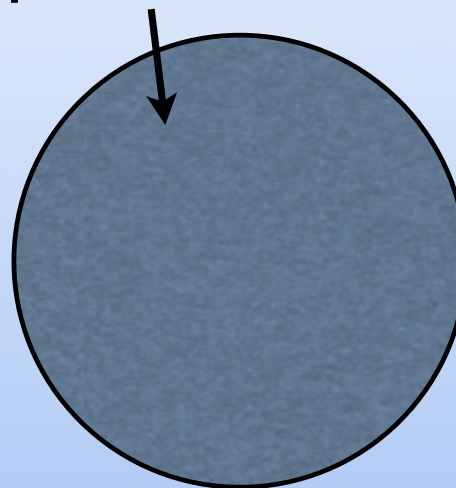
$$\Pi = iMRT$$

Cells

pure water

high conc "stuff"

pure water

# Helpful lessons for today

Why do they salt the roads when it is icy?
to melt the ice

Why do you put salt in pasta water?
to make the pasta tasty (very small change in boiling point)

What do fish need dirty water?
otherwise they "fill" up by osmosis

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