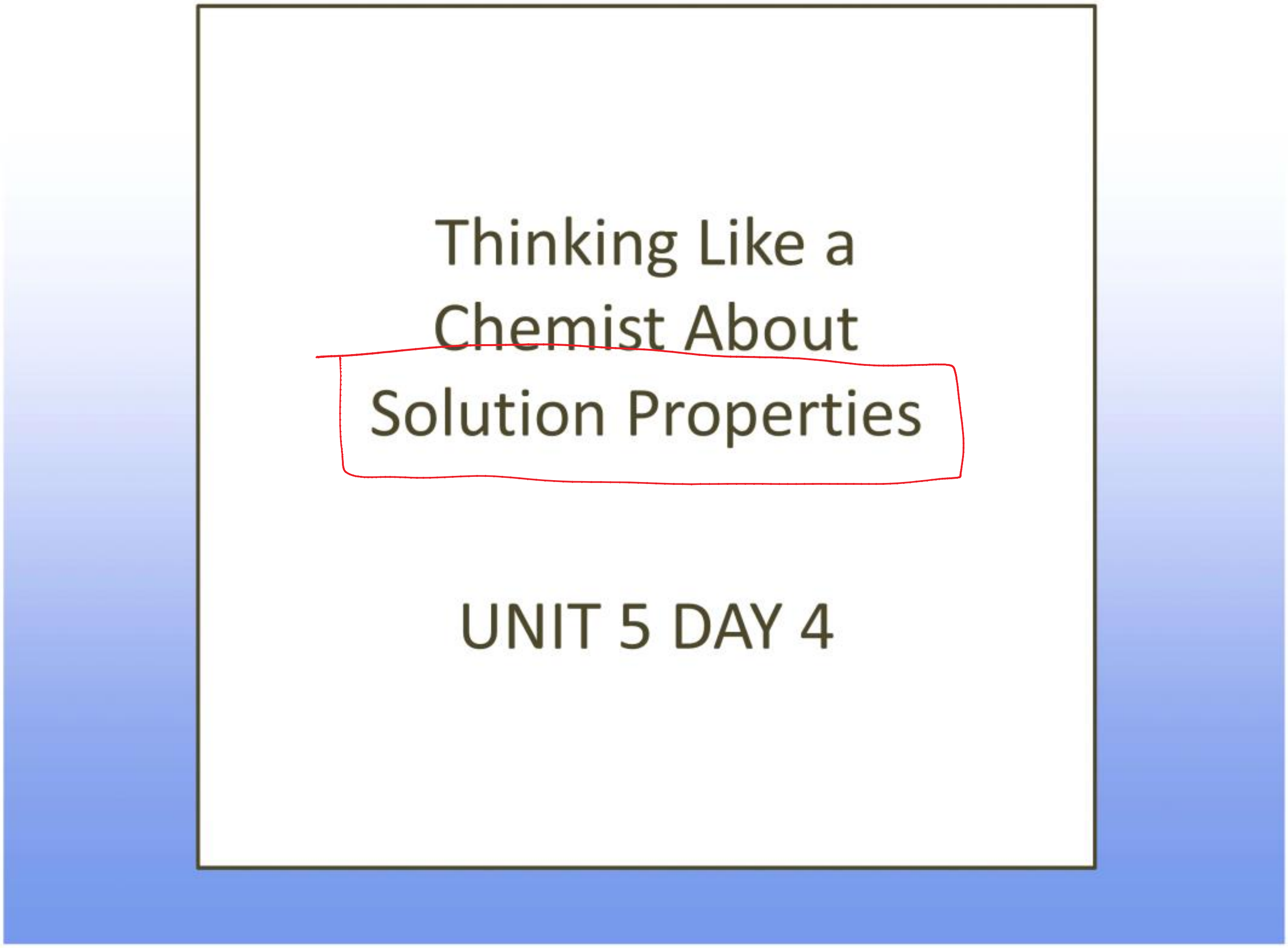
Unit5-Day4-LaB

Wednesday, January 22, 2014
9:11 AM



What are we going to learn today?

Thinking Like a Chemist in the Context of the Solutions.

- Thermodynamics of Solutions
  - Effects of P and T
- Colligative Properties
  - Boiling Point Elevation (VP lowering)
  - Freezing Point Depression
  - Osmosis

IMPORTANT INFORMATION

HW2 due Tue 9 AM

LM09 – Colligative Properties due Tue 9AM

EXTRA WORKSHEETS – AVAILABLE ON WEBSITE

LEARNING STRATEGIES – AVAILABLE ON WEBSITE

Henry's Law states that:

A. $P_{solvent} = X_{solvent}P_{solute}$

B. $P_{solute} = X_{solute}P_{solvent}$

C. $P_{solute}=k_H X_{solute}$

D. $P_{solvent}=k_H X_{solute}P_{solute}$

$$P_{N_2} = k X_{N_2}$$

Independent Quiz: Clicker Question

"Like dissolves like" means that two substances that have similar __________ are likely to form a solution.

A. Molecular Weight
B. Shape
C. Number of Carbons
D. Temperature
E. Intermolecular Forces

Independent Quiz: Clicker Question

In general, when two compounds mix to form homogeneous a solution, $\Delta H_{solution}$ is

A. Large and positive

B. Small (near 0) and positive

C. Large and negative

D. Small (near 0) and negative

E. Follows no trend

pure ⟶ solution

$$\Delta G_{sol} = \Delta H_{sol} - T\Delta S_{sol} < 0$$

+

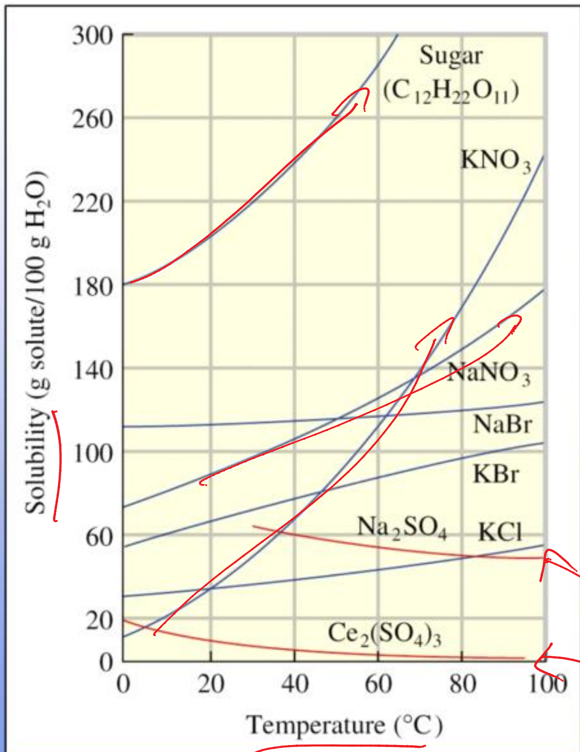
−

$\Delta H < 0$ RARE

$\Delta H > 0$ not "helpful"

Small as possible

Talk about T dependence of solvent dissolving..



Solubility – max solute get into solution

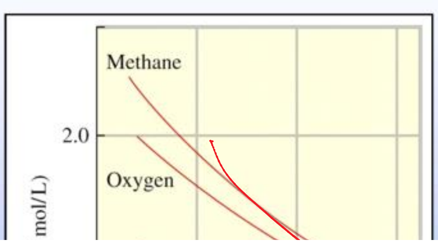
T ↑ solubility ↑

$\Delta H_{sol} < 0$ T↑ sol↓

Quiz: Clicker Question 4

Other types of solutions

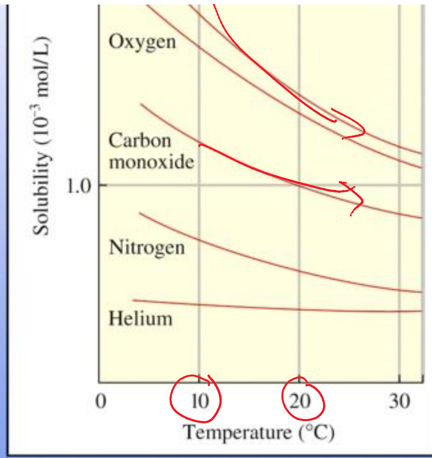
Gas as a solute!



Do you think $\Delta H_{solution}$ for a gas is

A. Positive

B. Negative



in H_2O

A. Positive

B. Negative

C. Zero

D. No way to know

$\Delta H < 0$ H_{gas} higher H_{sol} IMF

$\Delta G = \Delta H - T\Delta S$

Thinking about solubility we have been dealing with extremes – dissolves YES or NO

It happens or it doesn't

In reality, things always dissolve just a little tiny bit. The question is really the magnitude of ΔG. The bigger a negative number, the greater the solubility.

Poll: Clicker Question 5

Other types of solutions

Mixing Two liquids   Rather than soluble we say "miscible"

Miscible: capable of being mixed

Immiscible: incapable of being mixed

OIL + WATER

H-bond

hydrocarbon only dispersion

Which is most likely to be miscible with water?

A. methanol CH_3OH

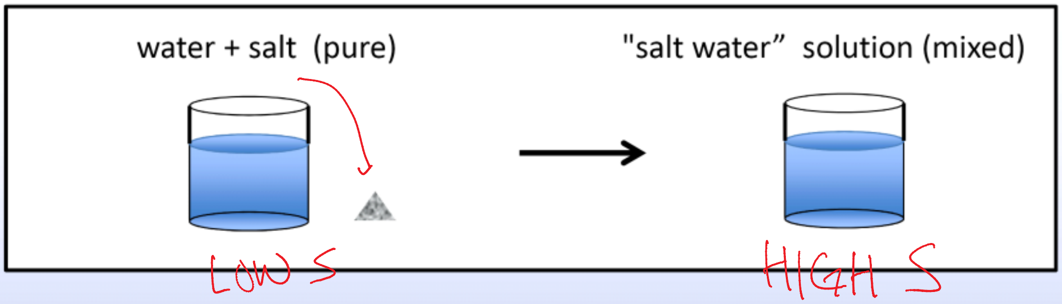
B. butanol C_4H_9OH

C. octanol $C_8H_{17}OH$

D. didodecanol $C_{12}H_{25}OH$

Poll: Clicker Question

Let's look at the following "reaction"



Which has the higher entropy?

A. The water + the solid salt

B. The solution

C. They are about the same

$\Delta S_{sol} > 0$

Poll: Clicker Question 7

Let's look at the following "reaction

Which has the higher enthalpy?

A. The water + the solid salt

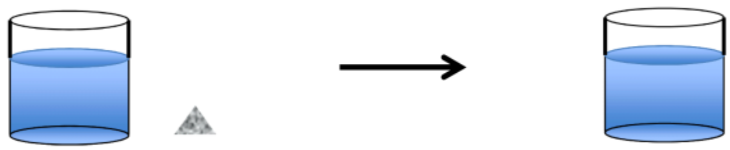
B. The solution

C. They are about the same

Poll: Clicker Question 8

Let's look at the following "reaction"

water + salt (pure) → "salt water" solution (mixed)



HIGH G → LOW G

$\Delta G = \Delta H - T\Delta S$

Which has the lower free energy?

A. The water + the solid salt

B. The solution

C. They are about the same

Ideal solutions
"Like dissolves Like"

$\Delta H = 0$

The solution forms, therefore $\Delta G_{solution} < 0$

In the ideal gas the IMF for the solute/solvent are the same

Therefore $\Delta H_{solution} \sim 0$

ITS ALL THE ENTROPY!!

Making a solution increases the entropy.
This lowers the free energy

Therefore the solution is "more stable"
It is lower in free energy than the pure unmixed compounds!

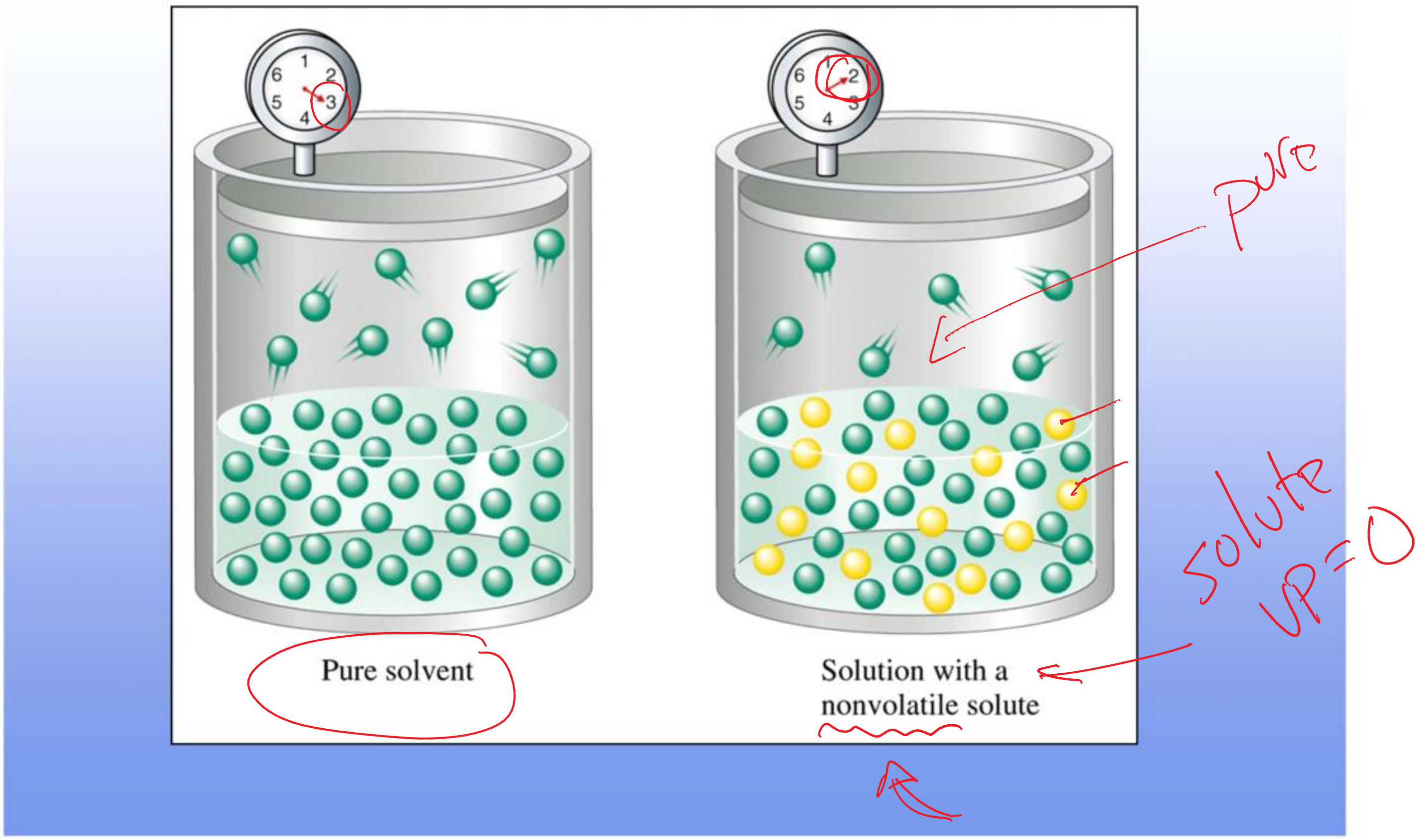
This is an approximation. But if we look at mixtures that are easily formed (like + like) then it isn't bad

Now we are going to talk about some properties of solutions.

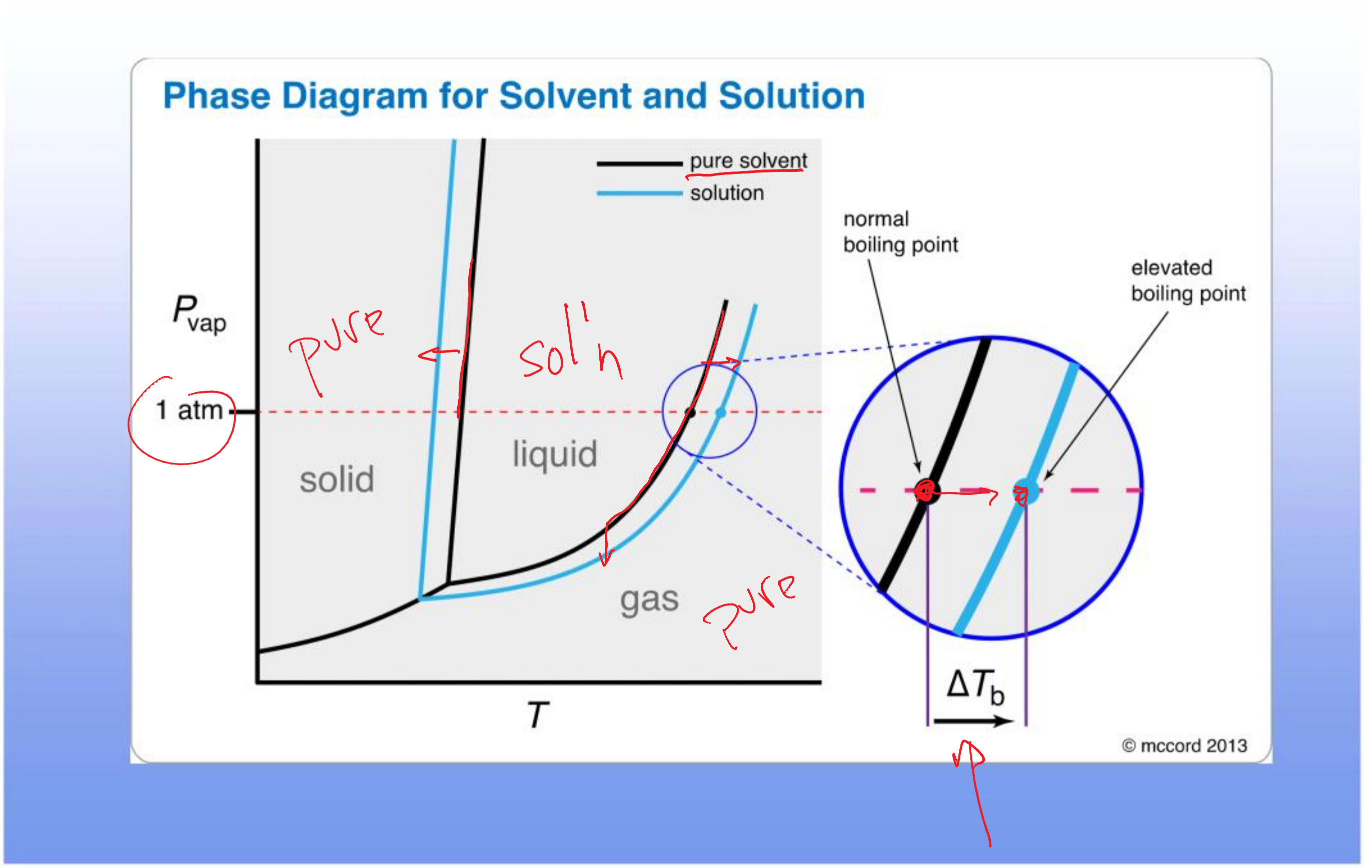
Will the freezing point of a solution be different that pure solvent?

Check it out with a demonstration.

Talk about VP of solutions..



Talk about BP of solutions..



Effect of making the solution

Boiling Point Elevation

Solution is now more stable.
Vapor pressure goes down.
Boiling point goes up.

Freezing Point Depression

Solution is now more stable.
Freezing point goes ~~does~~ down

The liquid phase of the solution now is stable over a larger temperature range

Poll: Clicker Question 9

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

E. all the same

$1\,M\ Mg^{2+}$

$+\ 2\,M\ Cl^-$

3M "stuff"

What matters is the total number of solute "particles" in the solution

Molecular solutes (generally molecular solids or liquids)

Since the molecules stay intact,
1 moles of solute added to the solution leads to 1 mole of "particles"

1 M sugar solution = 1 moles of sugar in 1 L of solution
Concentration of particles is 1M

Ionic solutes (generally ionic solids)

Since the solid breaks apart into individual ions,
1 moles of solute added to the solution leads to more than 1 mole of "particles"

1 M NaCl solution = 1 mole of Na^+ in 1 L of solution
1 mole of Cl^- in 1 L of solution
Concentration of particles is 2M

Van't Hoff Number (Factor)

$$i = \frac{\text{moles of “particles” in solution}}{\text{moles of solute dissolved}}$$

Compound	i (expected)
NaCl	2
KNO_3	2
K_2SO_4	3
Sucrose	1

Same Effect. Different Manifestations

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

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

Change in Vapor Pressure: $\Delta P = -iX_{solute}\, P^{\circ}$

$P_{solution} = iX_{solvent} P^{\circ}$

conc molality

Depends Solvent

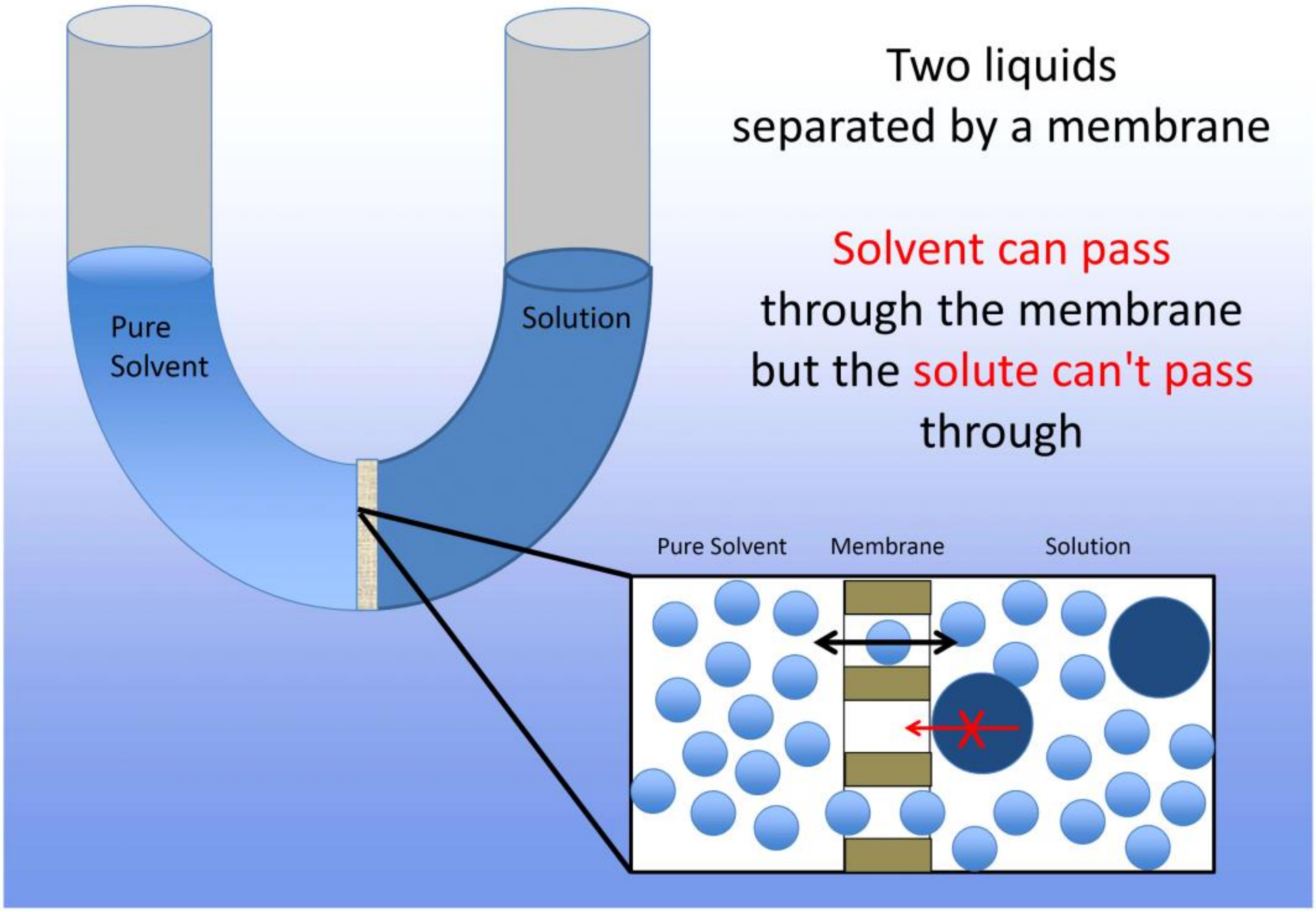
pure solvent

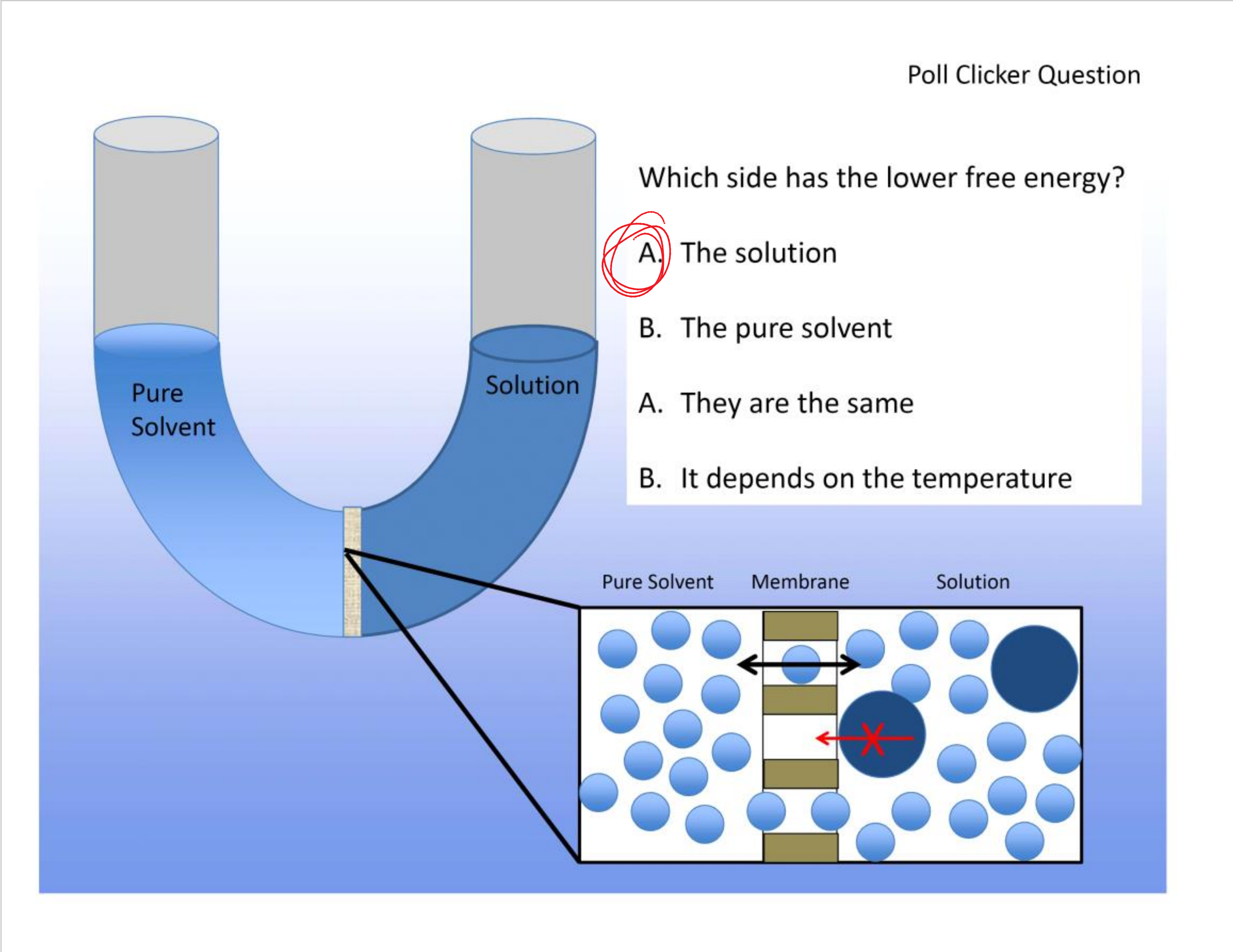
mole fraction

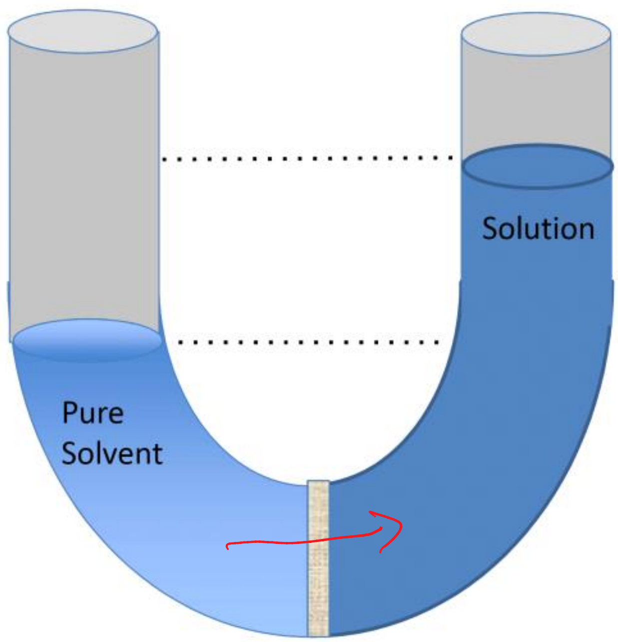
Example values for different compounds

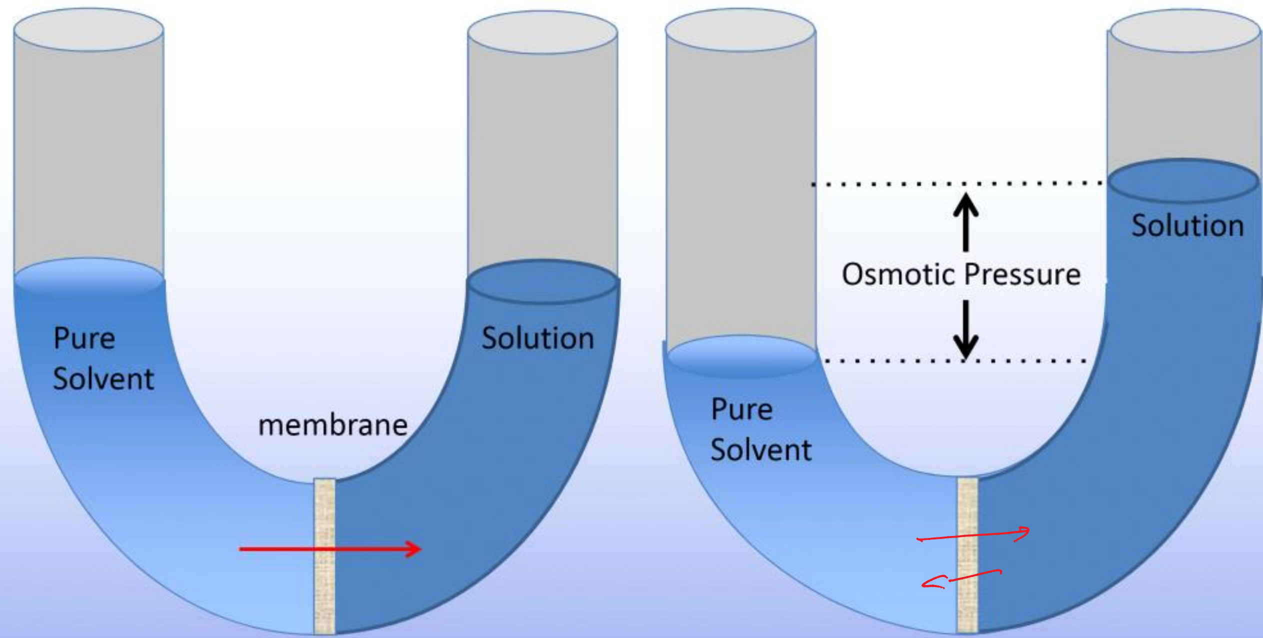
Colligative Property Constants

Compound	Boiling Point (°C)	K_b (°C m^{-1})	Freezing Points (°C)	K_f (°C m^{-1})
Benzene	80.1	2.53	5.5	4.9
Camphor	207.4	5.61	178.75	37.7
Carbon Tetrachloride	76.5	5.03	–23	30.0
Ethanol	78.5	1.22	–117.3	2.0
Water	100.0	0.512	0.0	1.86


Two liquids
separated by a membrane
Solvent can pass
through the membrane
but the solute can't pass
through
Pure
Solvent
Solution
Pure Solvent
Membrane
Solution


Poll Clicker Question
Which side has the lower free energy?
A. The solution
B. The pure solvent
A. They are the same
B. It depends on the temperature
Pure Solvent
Solution
Pure Solvent
Membrane
Solution

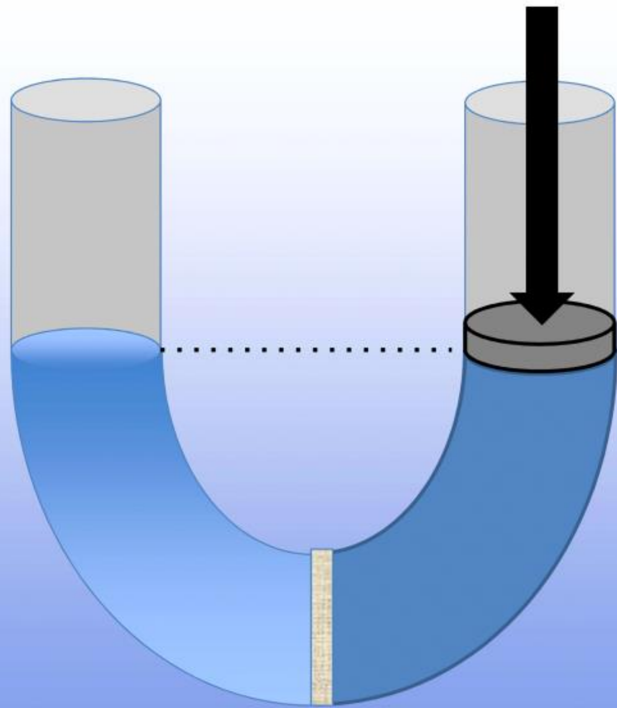

Solution
Pure
Solvent



The solvent will move to the solution side to lower its free energy!

at some point it will stop due to gravity
difference in height = difference in pressure
once it stops, they have the same free energy (that is why it stops)

Apply Pressure (Π)



The pressure needed to stop the flow of the solvent is the osmotic pressure,.

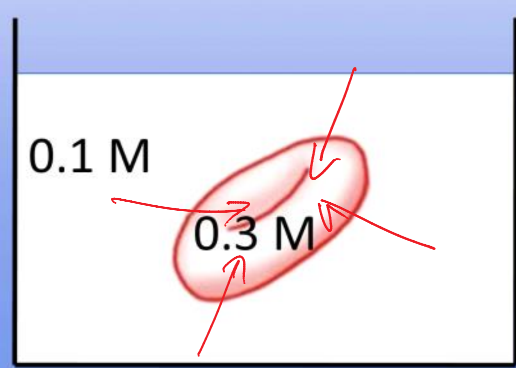
$$\Pi = iMRT$$

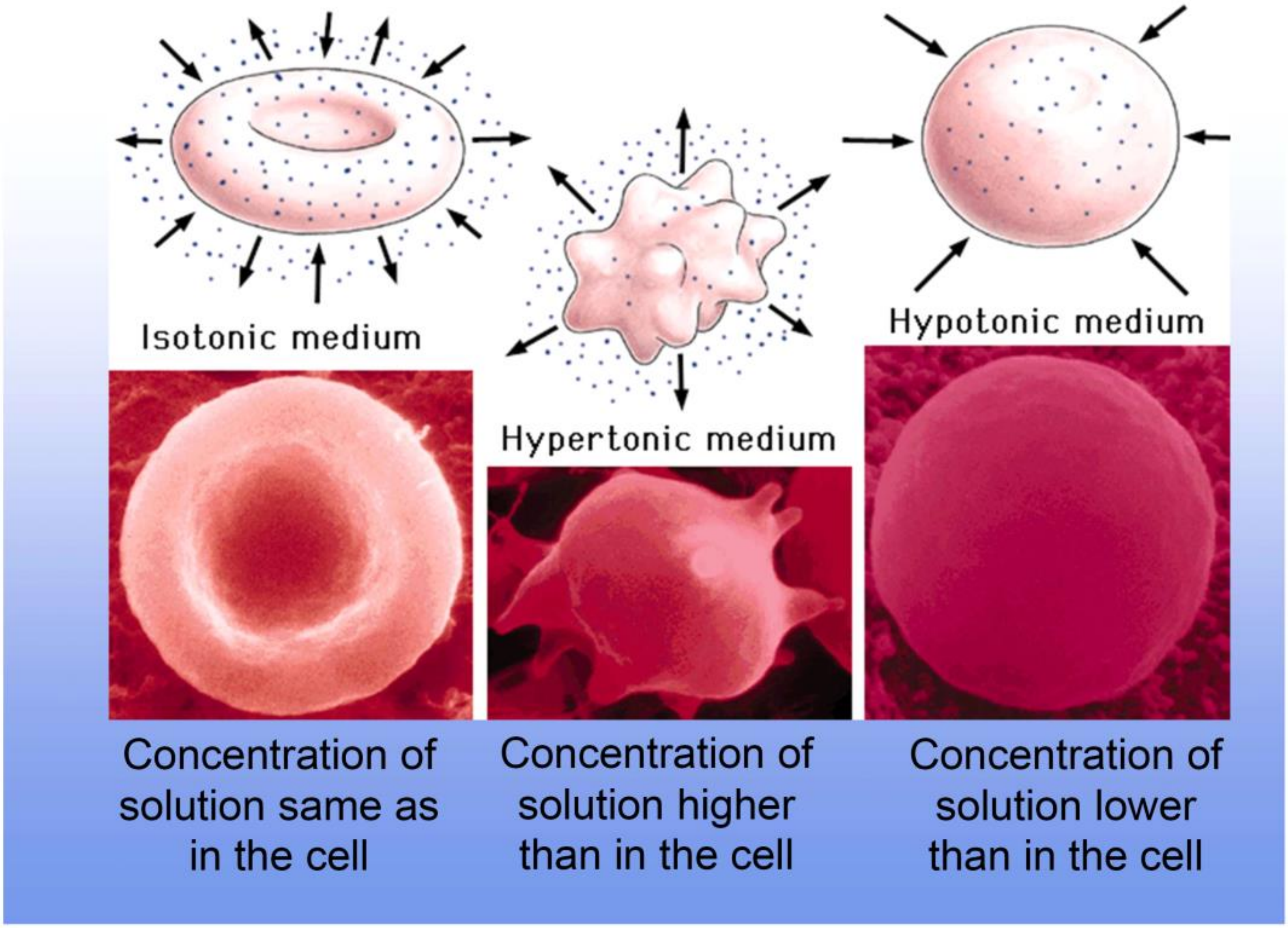
atm, atm-L, K, conc mol L^{-1}

Poll: Clicker Question

What will happen to the following cell when placed in the beaker?

a. The cell will not be affected
b. The cell will expand, swell
c. The cell will contract, shrink
d. Something will happen, but more information is needed



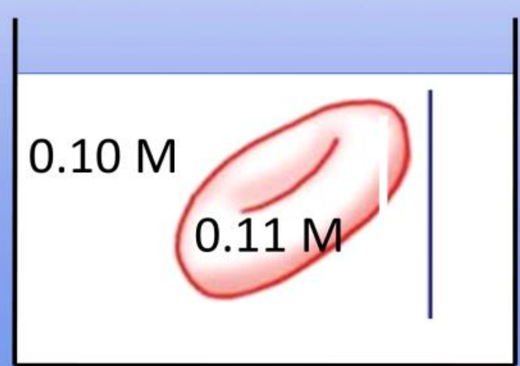

Isotonic medium
Hypertonic medium
Hypotonic medium
Concentration of solution same as in the cell
Concentration of solution higher than in the cell
Concentration of solution lower than in the cell

Poll: Clicker Question

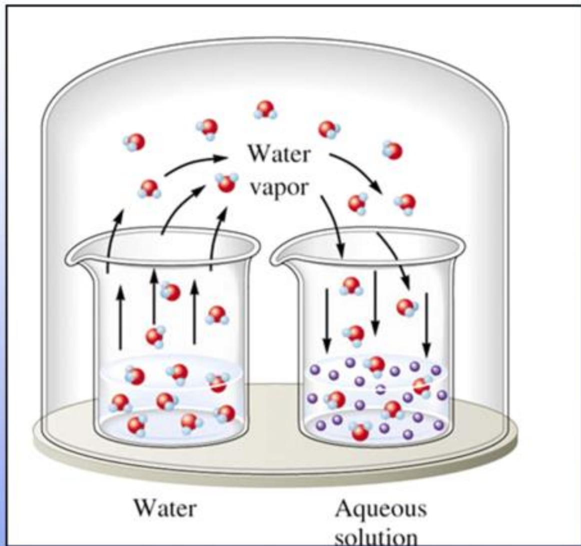
Will the osmosis stop?

a. No

b. Yes



Talk about VP of solutions.. – what will equilibrium look like?



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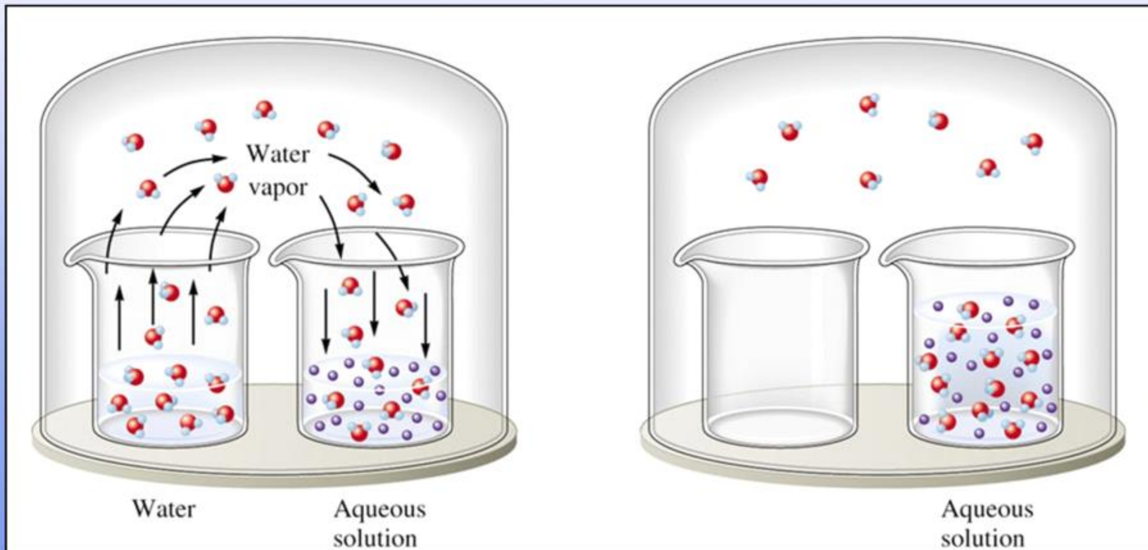
Free energy of water is lower in solution, so VP is lower …. To achieve lower VP, water must condense into solution!



What did we learn today?

Dependence of Colligative Properties on solvent and not solute type, but amount of solute present.

Free energy of solution is lower than pure solvent!

Learning Outcomes

Perform calculations and discuss the concept of the 4 colligative properties: Vapor Pressure lowering, Boiling Point elevation, Melting Point depression and Osmotic Pressure.

Describe the dissociation of ionic compounds in solution and the effects on colligative properties (van't Hoff factor, i)