UNIT5-DAY4-LaB1230

Wednesday, January 23, 2013
5:43 PM

Thinking Like a Chemist About Solution Properties

UNIT 5 DAY 4

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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

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IMPORTANT INFORMATION

HW2	due Tue 9 AM
LM09 – Colligative Properties	due Tue 9AM

↳ First before HW

EXTRA WORKSHEETS – AVAILABLE ON WEBSITE

LEARNING STRATEGIES – AVAILABLE ON WEBSITE

Quiz: Clicker Question 1

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

increase VP of gas solute above solution, increase gas in solution

Quiz: Clicker Question 2

"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

Quiz: Clicker Question 3

For most mixtures that form homogeneous solutions, $\Delta H_{solution}$ is

Does not dissolve no solution

A. Large and positive
B. Small (near 0) and positive
C. Large and negative
D. Small (near 0) and negative
E. Follows no trend

ant energy is ~ same

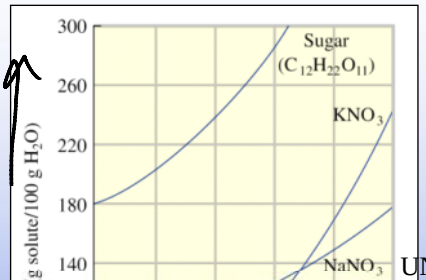
$\Delta H_{soln} = \Delta H_{lattice\ (solute)} + \Delta H_{solvation}$

slightly endothermic + —

ideal solution these would be the same

Reality, about the same

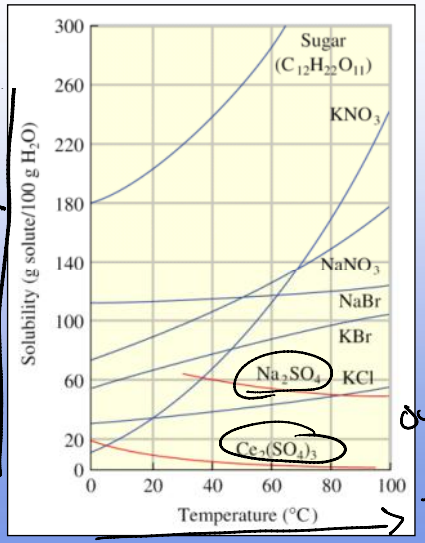
Talk about T dependence of ~~solvent~~ solute dissolving..



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

more "−" = ~ Ø

increase T



solubility

T

more "−" = ~ ∅

free energy of solution is lower

increase T increases TΔS term gets bigger drives to greater solubility

outlier weird experiment exothermic soln less soluble w/ inc T

Poll

Clicker Question 4

look at Data Other types of solutions

Temp inc, solubility goes down

Gas as a solute!

$\Delta H_{soln} = \Delta H_{lat} + \Delta H_{solvation}$

"−"

gas ∅ ≈ NO IMFs

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

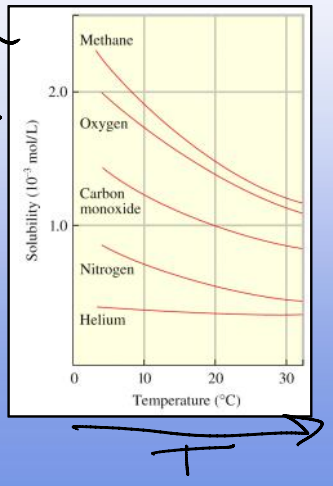
A. Positive

B. Negative exothermic

C. Zero

D. No way to know

$\Delta H_{soln} < 0$



solubility

T

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

It happens or it doesn't

better question: how much dissolves?

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.

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magnitude of ΔG is important

Big & negative ΔG → indicates obvious dissolving

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

Which is most likely to be miscible with water?

A. methanol CH_3OH (small nonpolar, polar)

B. butanol C_4H_9OH

C. octanol $C_8H_{17}OH$

D. didodecanol $C_{12}H_{25}OH$ (polar (hydrophilic), large nonpolar (hydrophobic))

Poll: Clicker Question 6

Let's look at the following "reaction"

water + salt ------> "salt water"

Which has the higher entropy?

A. The water + the solid salt

B. The solution

C. They are about the same

Poll: Clicker Question 7 Let's look at the following "reaction"

$\Delta H_{soln} = \Delta H_{lattice} + \Delta H_{solvation}$

\+ −

The magnitude of these are very close

water + salt ------> "salt water"

Which has the higher enthalpy?

like dissolves like

A. The water + the solid salt

B. The solution

C. They are about the same

– b/c ΔH_{soln} is ~0 the 2 enthalpies must be nearly the same

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Poll: Clicker Question 8 Let's look at the following "reaction"

water + salt ------> "salt water"

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

$G_f - G_i =$ "−"

↑ smaller

Which has the lower free energy?

A. The water + the solid salt

B. The solution

C. They are about the same

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There will be a number of effects that are all the same

enthalpy is ~0 IMFs are about the same

When we make a solution

↓

its entropy increases

↓

When we make a solution

↓

its entropy increases ← Driving force!!

↓

therefore its free energy decreases

↓

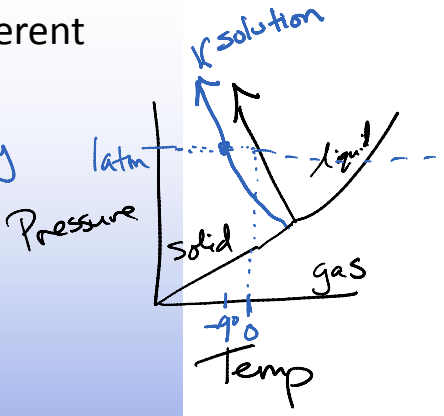
therefore it is more STABLE than the pure liquid

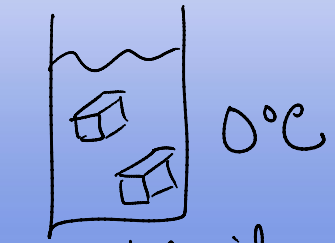
mixture

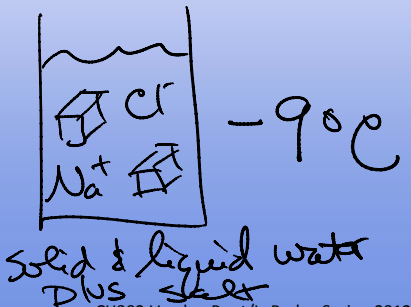
Will the freezing point of a solution be different that pure solvent?

expand region of stability

Check it out with a demonstration.





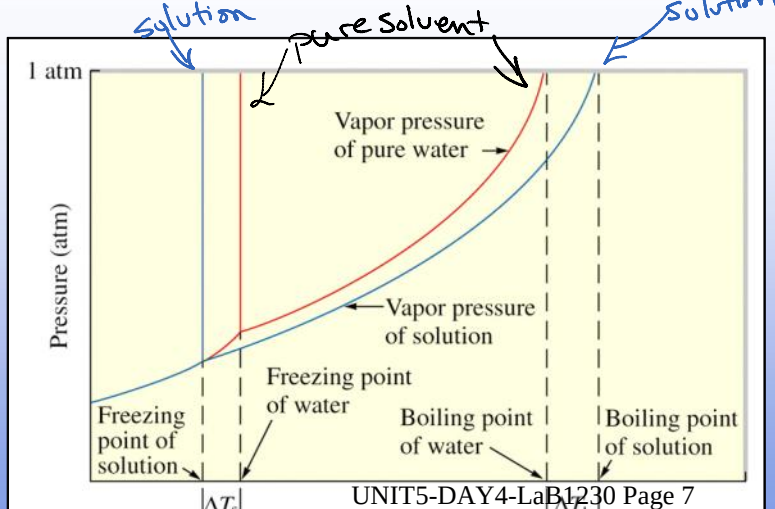


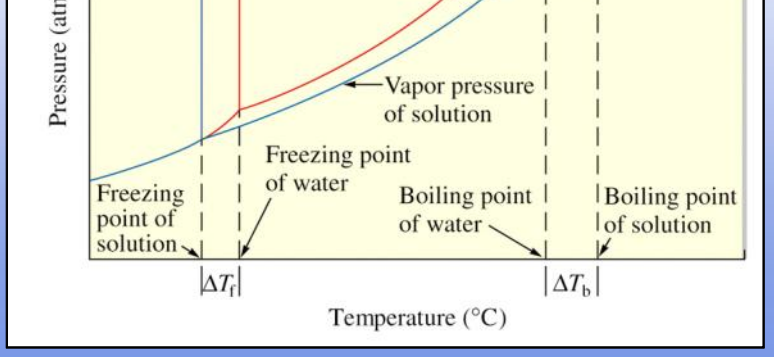
at specific temp & pressure a phase is most stable or has lowest free energy

Talk about BP of solutions..

BP
- temp at which VP equals the external pressure

lower free energy
lower VP
higher BP





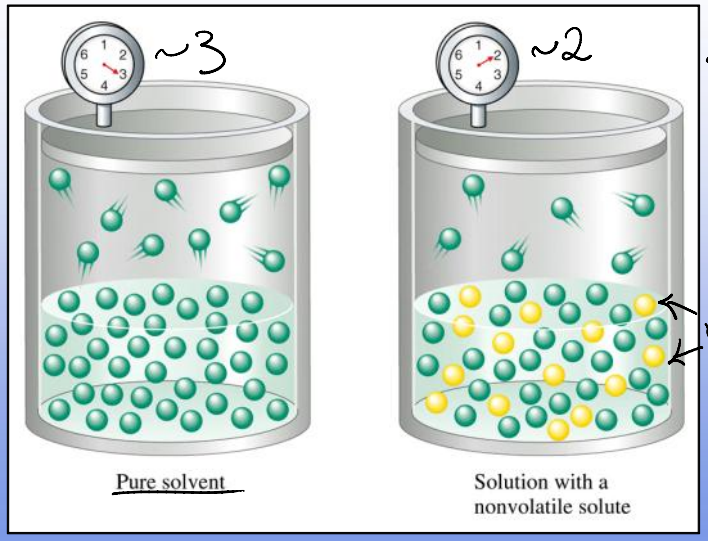
higher BP

larger stability range

The more you dissolve in, the Bigger the effect type does not matter, only amt to increase entropy

Talk about VP of solutions..

experimental evidence: solutions have lower VP



Effect of making the solution

VP = external pressure

Boiling Point Elevation

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

Freezing Point Depression

Colligative Properties

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

Poll: Clicker Question 9

Which would you expect to have the lowest freezing point

A. 2 M sugar solution

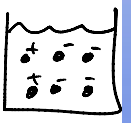
B. 0.5 M NaCl solution
0.5 M Na^+, 0.5 M Cl^-

1 M of ions or bits

C. 1 M NaCl solution

2 M

D. 1 M $MgCl_2$ solution
1 Mg^{2+}, 2 Cl^-



3 M must concentrated

Van't Hoff factor, i

COLLIGATIVE PROPERTIES DEPEND ON CONENTRATION OF SOLUTE, NOT TYPE OF SOLUTE.

Van't Hoff factor, i

COLLIGATIVE PROPERTIES DEPEND ON CONENTRATION OF SOLUTE, NOT TYPE OF SOLUTE.

BP elevation
FP depression

How many bits are floating around?

i = number of ions in formula unit

(for an ideal solution)

molecules $i = 1$

$NaCl$ $i = 2$

$MgCl_2$ $i = 3$

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Calculate the Properties

Boiling Point Elevation (positive change)

$\Delta T = iK_b m_{solute}$

Van't Hoff; BP constant for that solvent; molal = $\frac{\text{moles solute}}{\text{kg solvent}}$

Freezing Point Depression (negative change)

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

Change in Vapor Pressure

$\Delta P = -X_{solute} P^\circ$

change in VP of solvent; mole fraction = $\frac{\text{moles of solute}}{\text{moles solute} + \text{moles solvent}}$; P° = VP of Pure Solvent

Raoult's Law

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

VP of solution

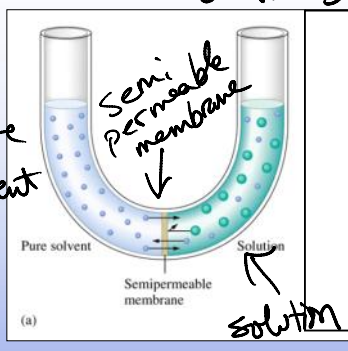
TABLE 17.5 Molal Boiling-Point Elevation Constants (K_b) and Freezing-Point Depression Constants (K_f) for Several Solvents

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.

Use these constants for HW

Poll: Clicker Question 10

Osmosis



Pure Solvent

semi permeable membrane

solution

Which side has the lower free energy?

A. The solution

B. The pure solvent

C. They are the same

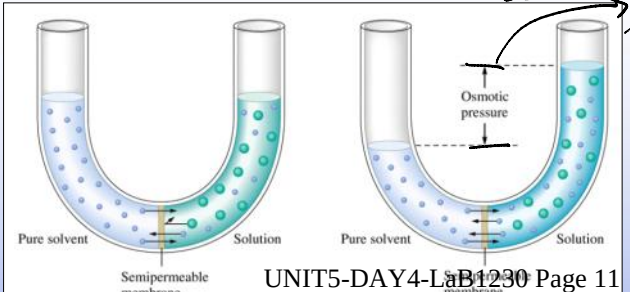
D. It depends on T

Two liquids separated by a membrane

Solvent can pass through the membrane but the solute can't pass through

initial

final

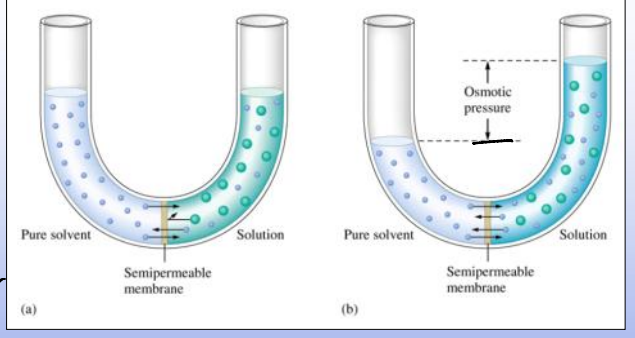


only solvent in more

osmotic pressure

Pressure difference will depend on concentration

Solvent can move compass through membrane

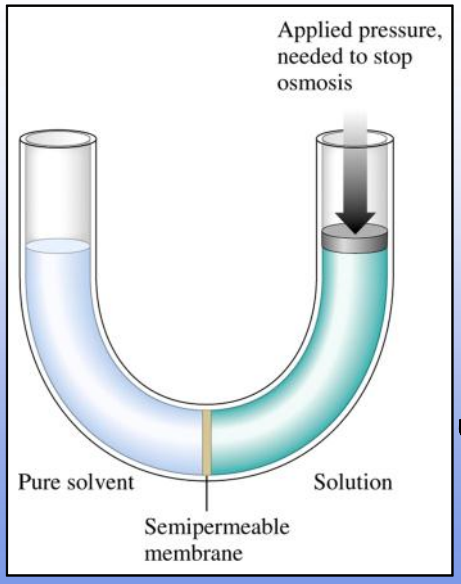


it will depend on concentration of solution

Water moves back & forth

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)



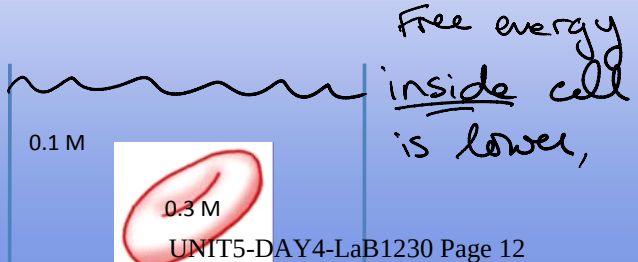
- The pressure needed to stop the flow of the solvent is the osmotic pressure, Π.
- $\Pi = iMRT$

van't Hoff factor
gas constant $\frac{L \cdot atm}{mol \cdot K}$
temp in KELVIN
Molar concentration
Π osmotic pressure

Poll: Clicker Question 11

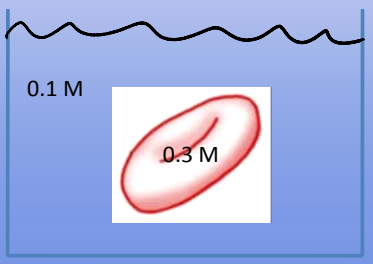
What will happen to the following cell when placed in the beaker?

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

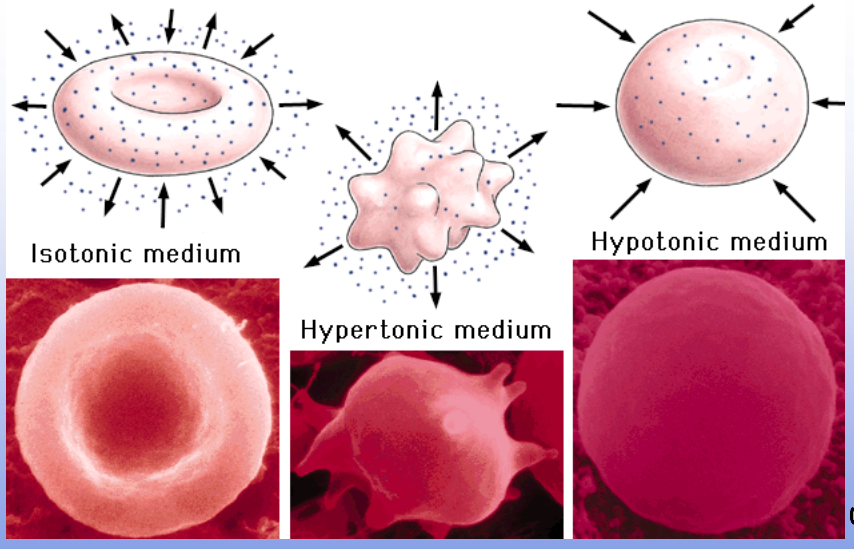


Free energy inside cell is lower,

d. Something will happen, but more information is needed



inside cell is lower, water flows in



Red Blood Cell

flows in & out is same

Concentration of solution same as in the cell

Concentration of solution higher than in the cell

water flows out

Concentration of solution lower than in the cell

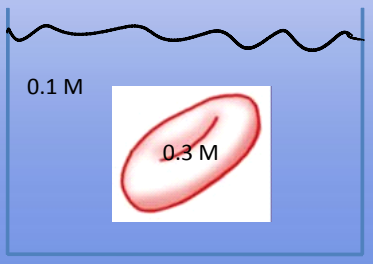
water flows in

Poll: Clicker Question 12

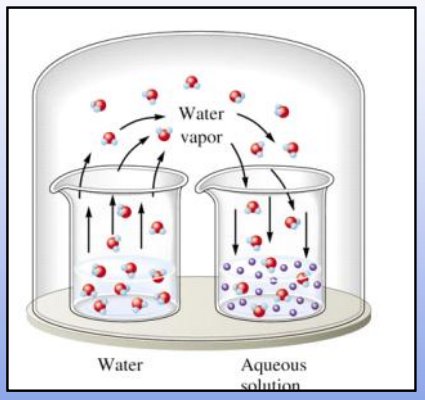
Will the osmosis stop?

a. No
b. Yes

Concentrations will equal out
Osmosis is water flow
water flow continues
dynamic equilibrium



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



?

Choices:

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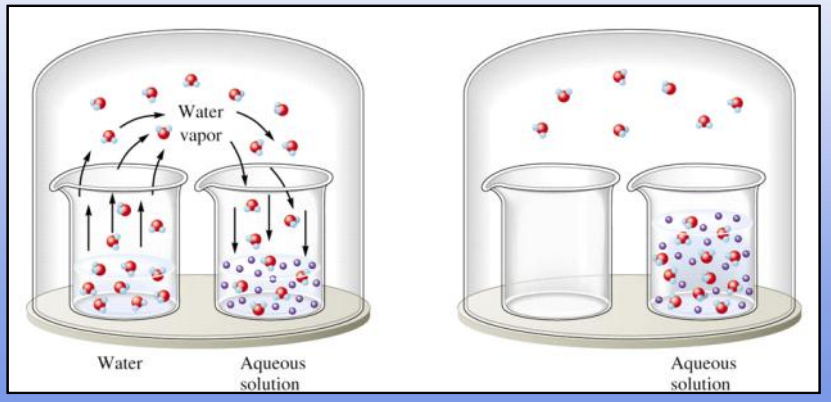
Free energy of water is lower in solution, so VP is lower …. To achieve lower VP, water must condense into solution!



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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)