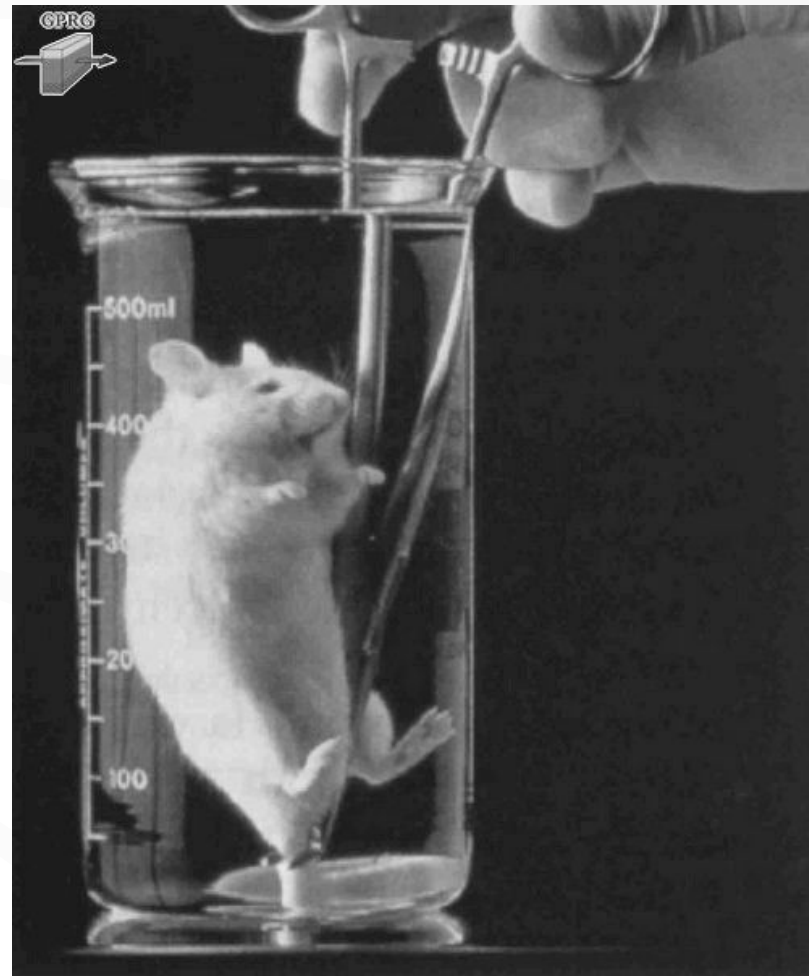


*Professor K*

Solutions

# *More on solutions*

- Earlier, we explored general terminology and reactions of solutions.
- We now return back to solutions to explain some physical phenomena, such as why impure water (a solution of ethylene glycol, aka antifreeze) is used as a car coolant instead of just pure water.
- Solutions can be of several types: gas-gas, gas-liquid, liquid-liquid, solid-liquid, gas-solid, solid-solid (and, for completeness, one would suppose, combinations with the other 2 phases of matter as well)
- How can the compound the mouse is breathing be fluorine-containing when F is a highly toxic cumulative bone-marrow attacker?

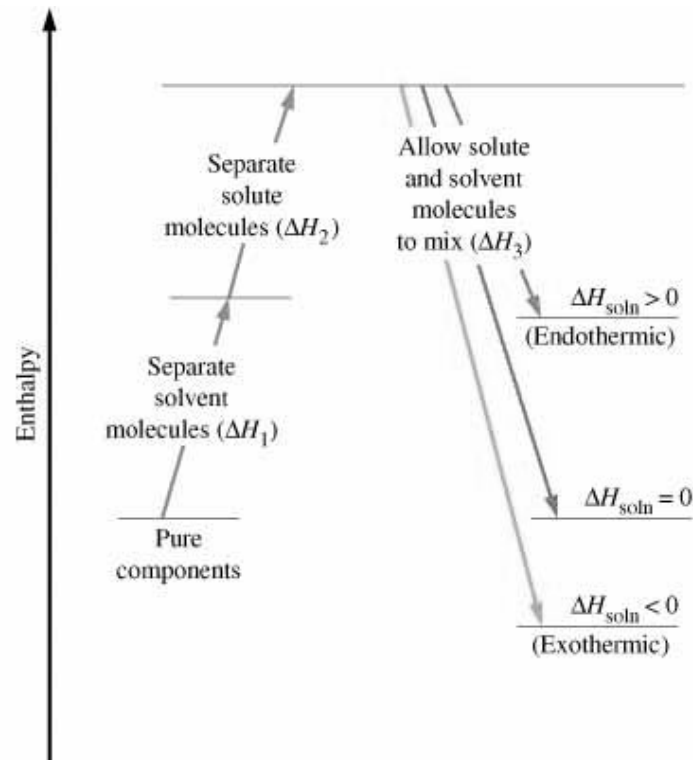


# *Molarity revisited*

- For mass percent, volume percent, mole percent or mole fraction, ppm and ppb calculations, **DON'T FORGET THE UNITS!**
- ppm = mg/L
- ppb = ug/L
- ppt = ng/L
- Analysis of low concentrations can be challenging...
- Femtomolar ( $10^{-15}$ ) analysis IS possible, luckily, since sometimes compounds are toxic at ppq levels!! (e.g.- dioxin)

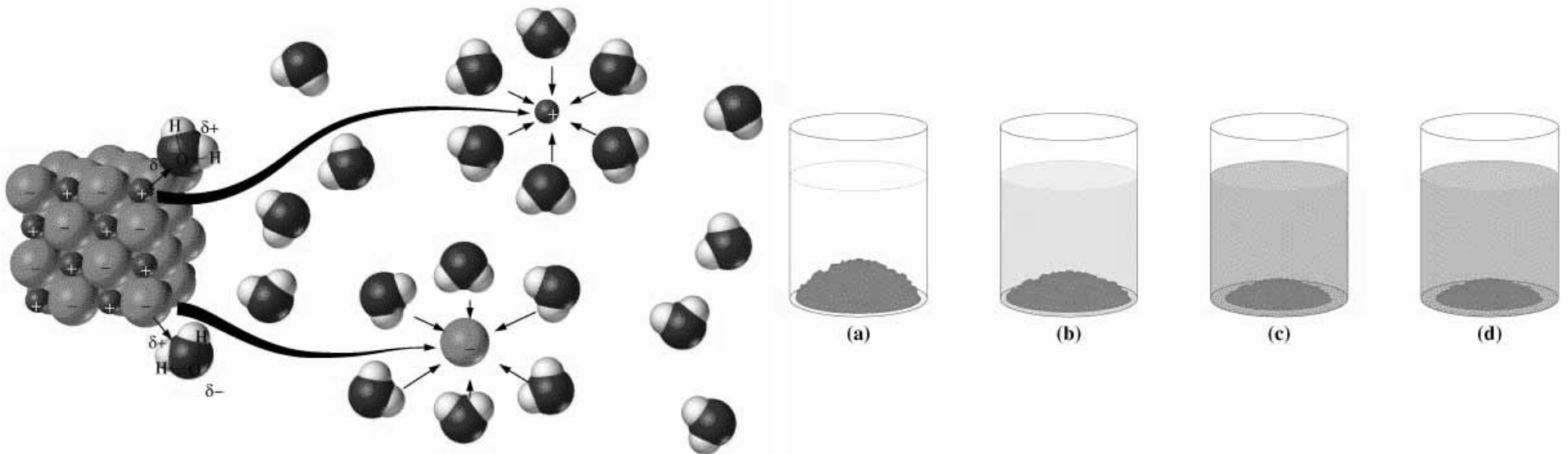
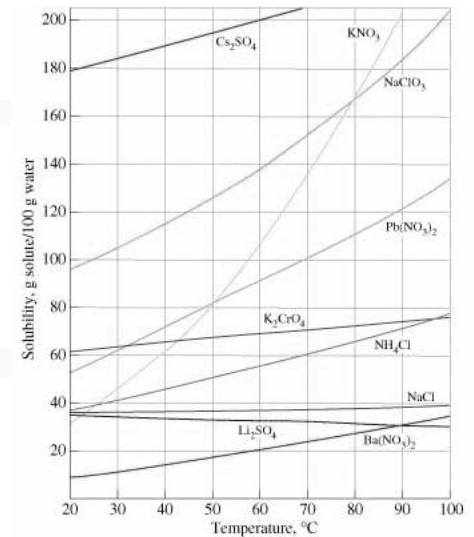
# Dissolution

- Can be endothermic or exothermic
  - "cold packs" ( $\text{NH}_4\text{NO}_3$ ) (what else is this used for?)
  - "hot packs" ( $\text{MgSO}_4$ )
- Enthalpy of solution (below)
- Nonideal solutions can expand or contract upon dissolution.....why??
- Thus, M is T dependent.



# Why do things dissolve?

- LIKE DISSOLVES LIKE
- Fully dissolving compounds are said to be MISCIBLE
- Saturated solution- dynamic equilibrium
- Solubility vs. temperature- supersaturation
- Purification by supersaturation



## *Solubility rules (again!)*

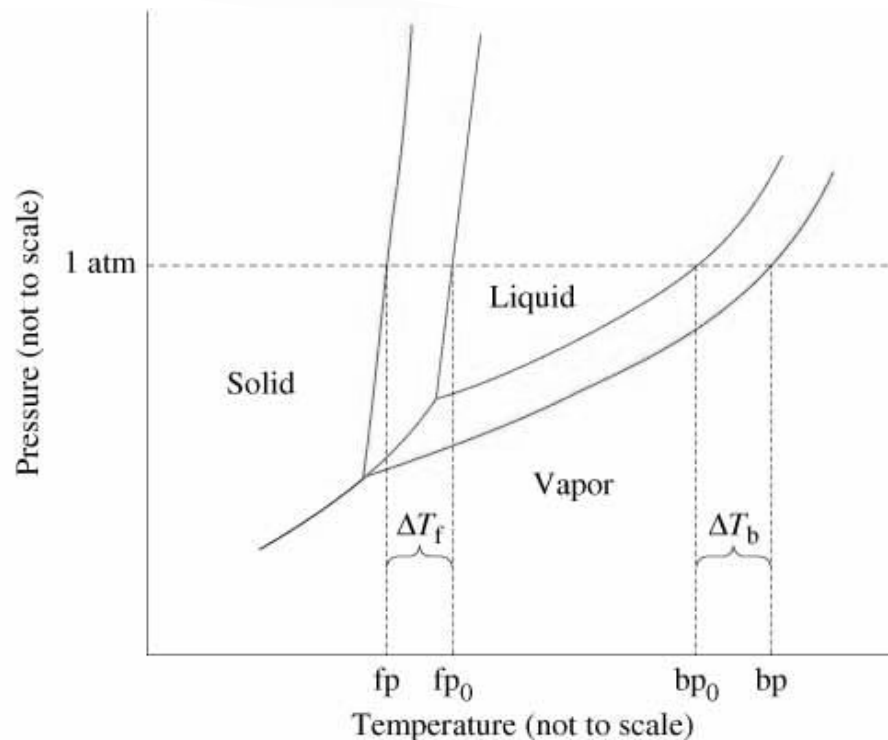
- Group I cation and  $\text{NH}_4^+$  salts are soluble (some  $\text{Li}^+$  exceptions)
- Nitrates, acetates, perchlorates are soluble
- Chlorides, bromides, iodides are soluble
- Sulfates are soluble except for Ca, Sr, Ba.
- Ag, Pb, Hg(I) salts are insoluble
- Carbonates, phosphates, sulfides, oxides, and hydroxides are insoluble (sulfides of Group II cations and hydroxides of  $\text{Ca}^{2+}$ ,  $\text{Sr}^{2+}$  and  $\text{Ba}^{2+}$  are slightly soluble)

# *Gas solubility*

- Temperature dependence
  - No general rule though most gases are less soluble in water at higher temperature
- Pressure dependence
  - Higher pressure = higher solubility due to equilibrium = Henry's Law (1803)... very common example?

# *Colligative properties*

- Depend on the number of solute particles present, NOT their identity
- Vapor pressure- lowered by presence of solute
  - Raoult's Law-  $P_{\text{solv}} = x_{\text{solv}} P^{\circ}_{\text{solv}}$
  - Important application in fractional distillation.
  - Used in chemical purification, oil refining, ethanol production, etc.
- Freezing point depression  $\Delta T = K_f m$  ( $m = \text{moles solute} / \text{kg solvent}$ )
- Boiling point elevation  $\Delta T = K_b m$

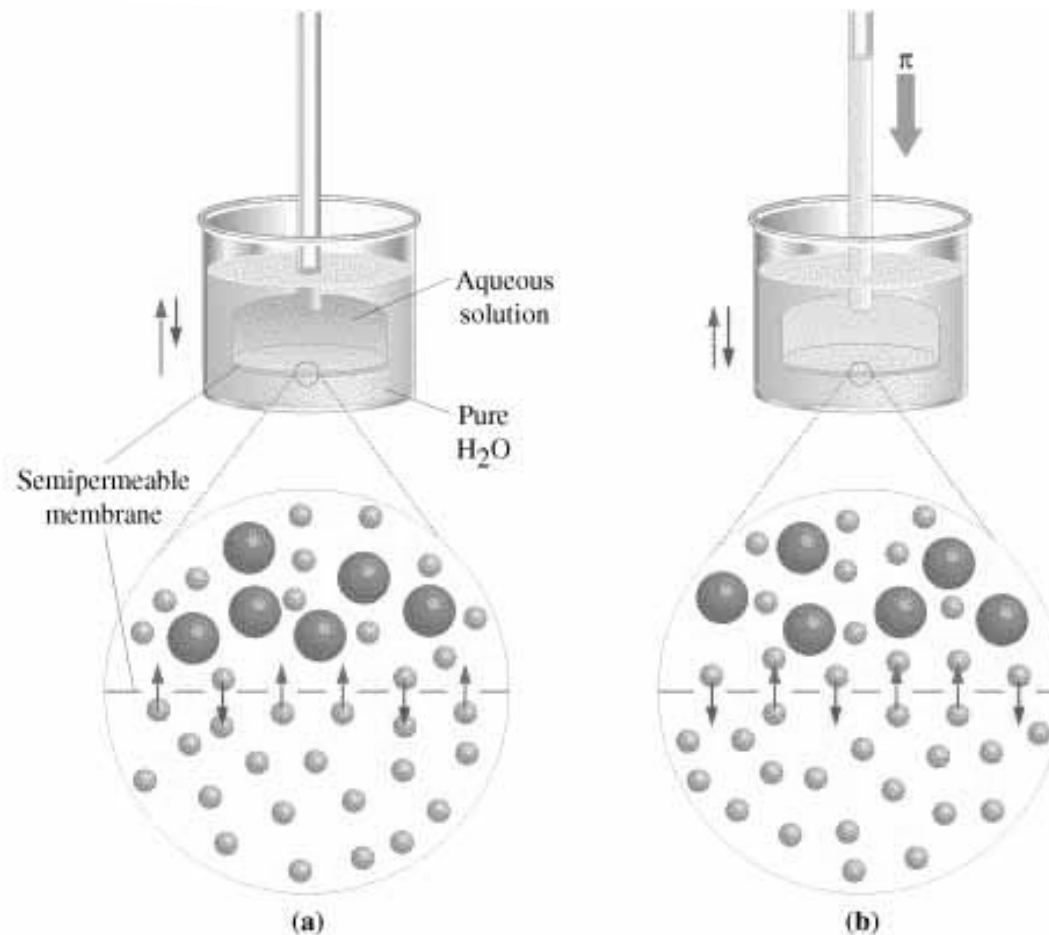


# *Osmotic pressure*

- OSMOSIS is the net flow of solvent molecules from pure solvent through a semi permeable membrane (small solvent molecules may pass through, but not large solute molecules) into a solution.
- For a 20% sucrose solution, osmosis can lift the solution 150m!
- ie- dilution of a solution by solvent through a barrier
- Can reduce solvent flow into solution by increasing flow of solvent out of the solution by applying pressure to it.
- At the OSMOTIC PRESSURE, osmosis ceases.
- (About 15 atm for the 20% sugar solution.)

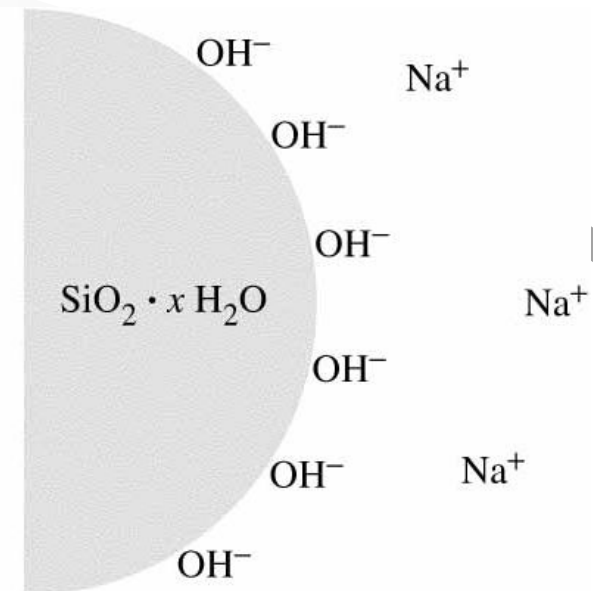
# *Osmotic pressure (cont'd)*

- $\pi = MRT$
- (yes, molarity even though it's a colligative property)



# *Colloids*

- Between a solution and a suspension
- Based on particle size (1-1000nm)
- Too small to see with regular microscope or settle out (can often COAGULATE-PRECIPITATE with an electrolyte)
- Large enough to diffract light (Tyndall effect)
- A SOL is a solid in a liquid
- An EMULSION is a liquid in a liquid
- An AEROSOL is a solid or liquid in a gas



# *What I want you to know about solutions and kinetics (preview)*

- Solutions can incorporate the various states of matter.
- Definitions of, calculations with molarity and molality, including ppm, ppb, ppt.
- Solutions can expand or contract upon dissolution, thus M is T dependent.
- Dissolution can be exo- or endothermic.
- Like dissolves like.
- Colligative properties- specifically boiling point elevation and freezing point depression.

# *What I want you to know about solutions and kinetics (cont'd)*

- Rate constants (little  $k$ ) will be discussed in P.Chem and are experimentally determined.
- Reaction rate is how fast a reaction occurs.
- At eq., forward and reverse rates are equal.
- Reactant and product concentrations are constant at equilibrium, even though it is DYNAMIC.
- Product concentrations divided by reactant concentrations gives the eq. constant expression or equation (big  $K$ ), with exponents equal to the stoichiometric coefficients from the balanced equation (pure solids and liquids do not appear).
- Size of  $K$  (either in terms of concentration or pressure) gives the extent of reaction (“how far to the left or right the reaction lies”).
- The reaction quotient  $Q$  starts at zero and goes to  $K$ .
- Use LeChatelier to predict effects of changing  $P$ ,  $V$  or  $T$
- Catalysts (enzymes, biologically) lower activation energy and speed up reactions... they do not effect eq.