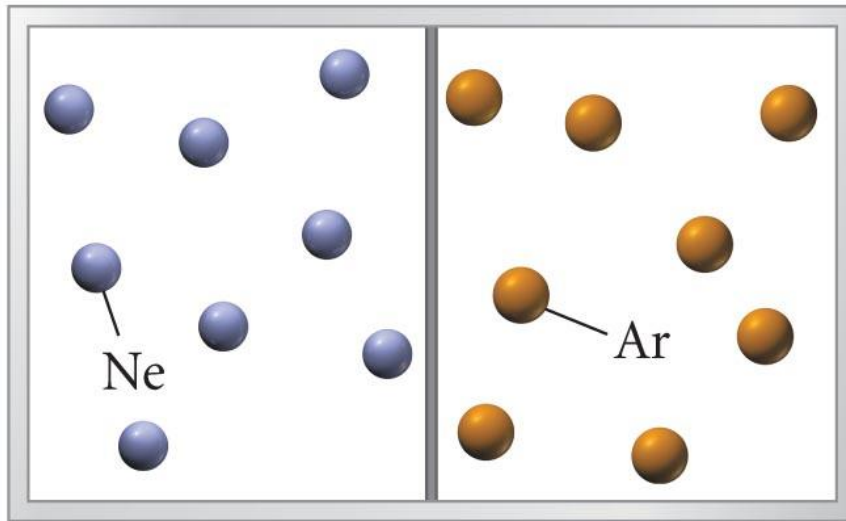
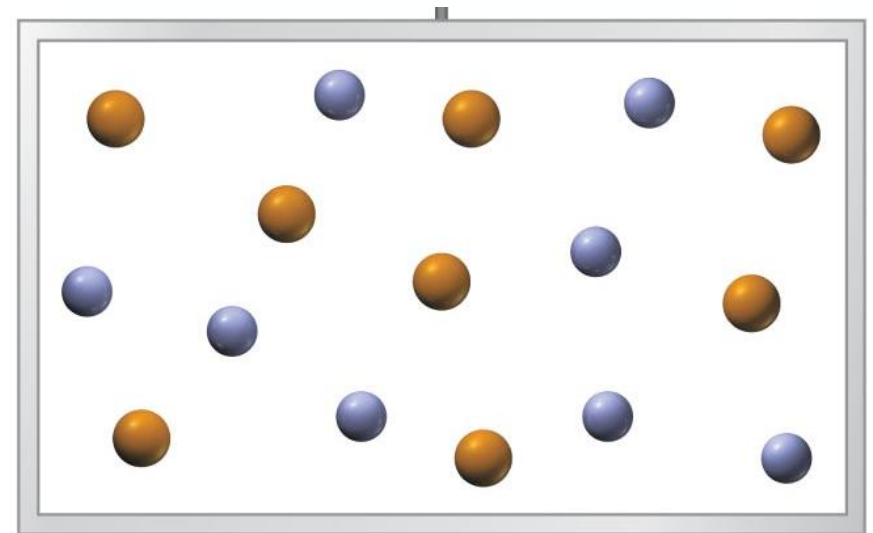


Chapter 12: Solutions

Part 1: Forces and Thermodynamics of Solution Formation



(a)



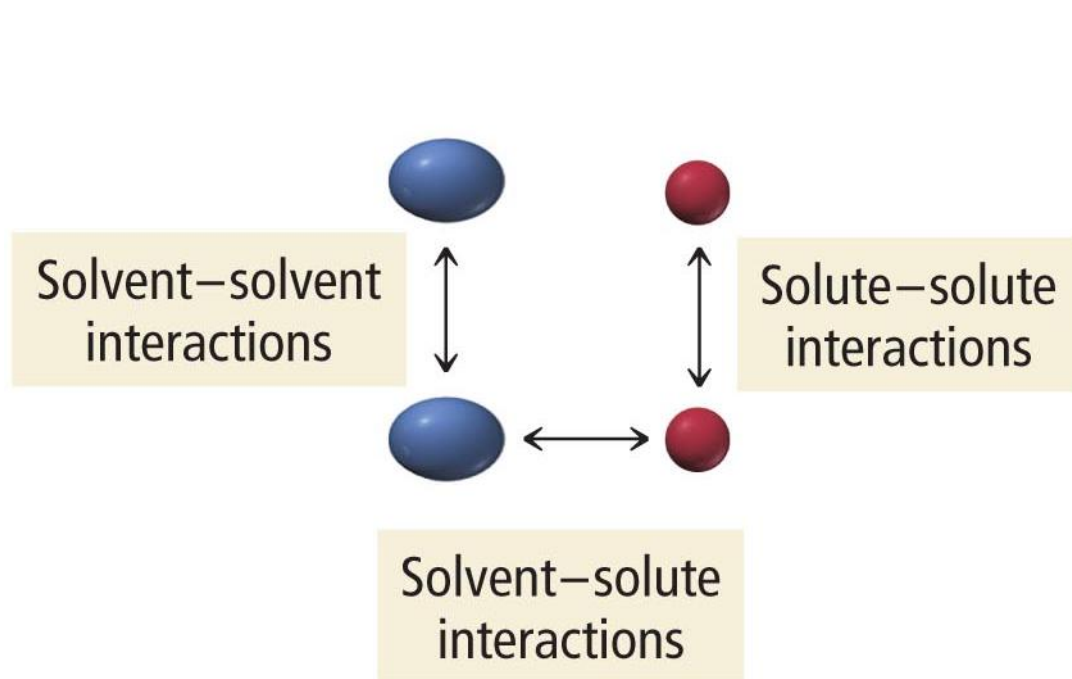
(b)

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A. Entropy

- Entropy is the measure of energy dispersal throughout the system
- By each gas expanding to fill the container, it spreads its energy out and lowers its entropy

B. The Effect of Intermolecular Forces



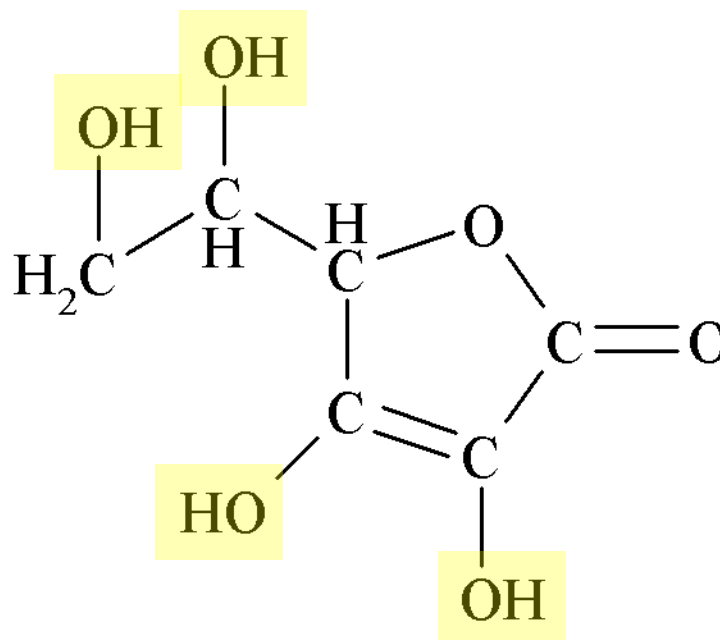
Solution

Example 12.1a: Predict whether the following vitamin is soluble in fat or water

Water is a polar solvent. Fat is mostly made of nonpolar molecules.

The four OH groups make the molecule highly polar and it will also H-bond to water.

Vitamin C is water soluble.



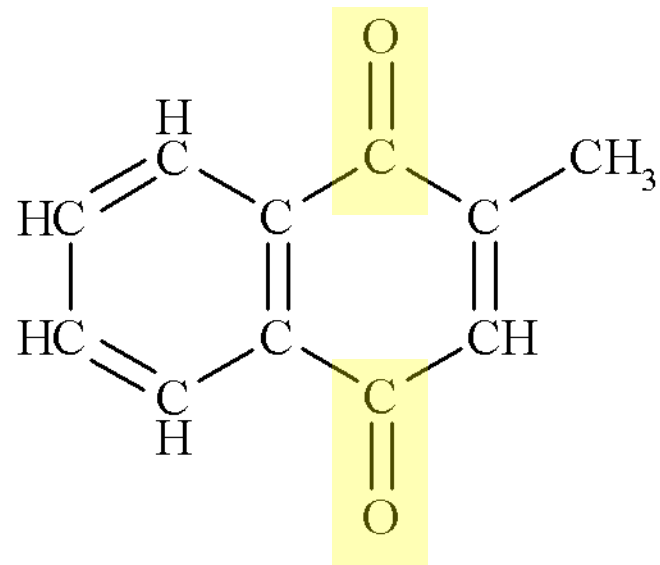
Vitamin C

Example 12.1b: Predict whether the following vitamin is soluble in fat or water

Water is a polar solvent. Fat is mostly made of nonpolar molecules.

The two C=O groups are polar, but their geometric symmetry suggests their pulls will cancel and the molecule will be nonpolar.

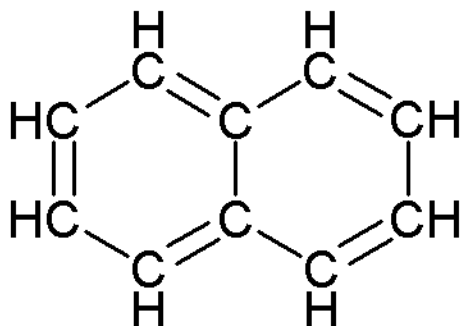
Vitamin K₃ is fat soluble.



Vitamin K₃

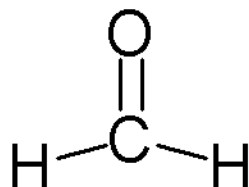
Practice – Decide if the following are more soluble in hexane, C_6H_{14} , or water

naphthalene



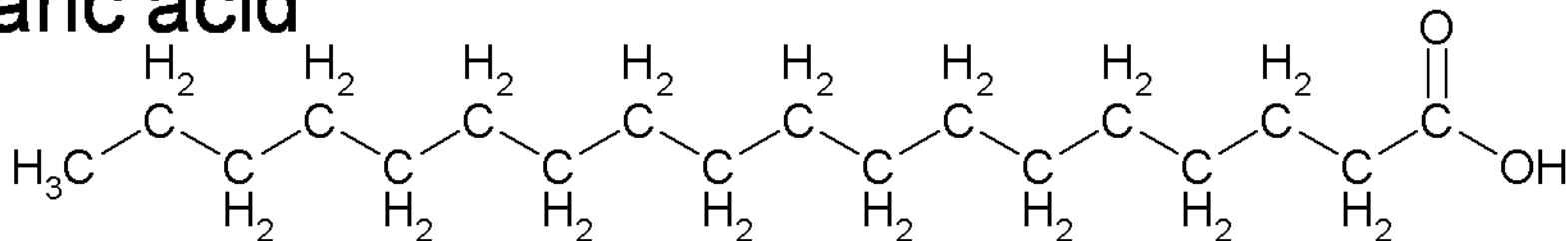
nonpolar molecule
more soluble in C_6H_{14}

formaldehyde




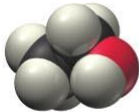


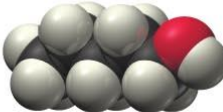
polar molecule
more soluble in H_2O

stearic acid



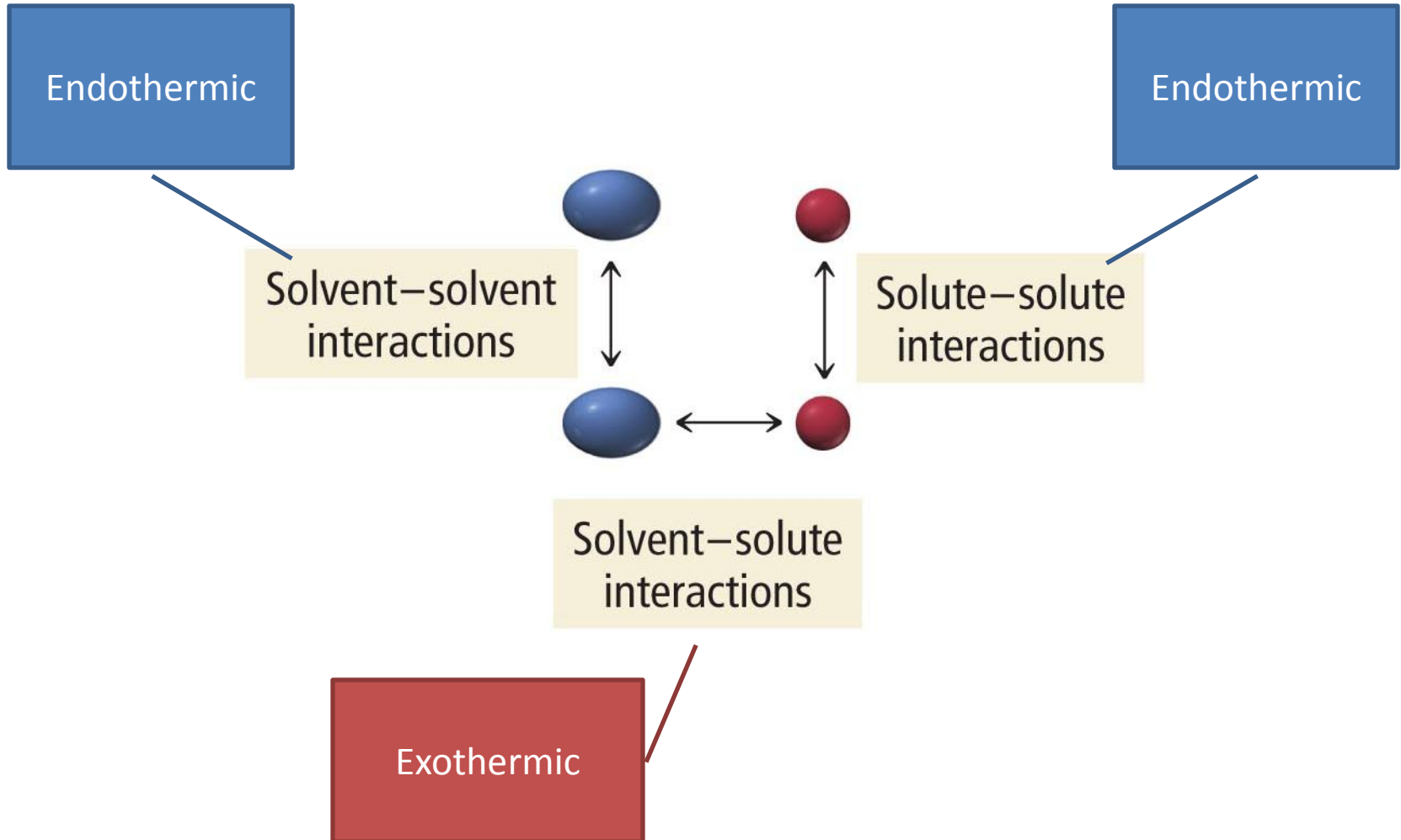
nonpolar part dominant
more soluble in C_6H_{14}

Practice – Explain the solubility trends seen in the table below

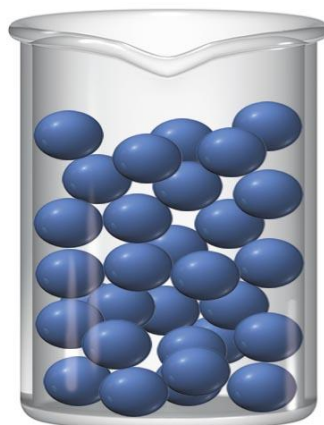
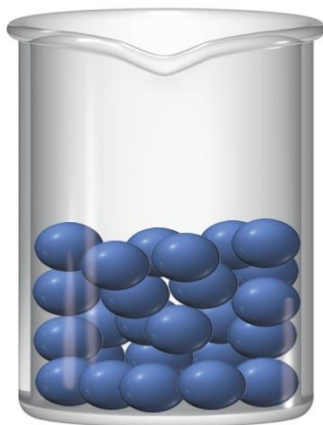
Alcohol	Space-Filling Model	Solubility in H ₂ O (mol alcohol/100 g H ₂ O)	Solubility in Hexane (C ₆ H ₁₄) (mol alcohol/100 g C ₆ H ₁₄)
Methanol (CH ₃ OH)		Miscible	0.12
Ethanol (CH ₃ CH ₂ OH)		Miscible	Miscible
Propanol (CH ₃ CH ₂ CH ₂ OH)		Miscible	Miscible
Butanol (CH ₃ CH ₂ CH ₂ CH ₂ OH)		0.11	Miscible
Pentanol (CH ₃ CH ₂ CH ₂ CH ₂ CH ₂ OH)		0.030	Miscible

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C. Energetics of Solution Formation



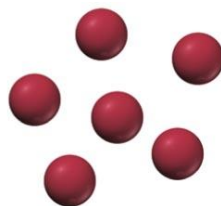
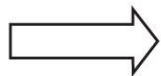
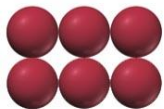
Step 1



$$\Delta H_{\text{solvent}} > 0$$

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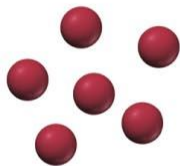
Step 2



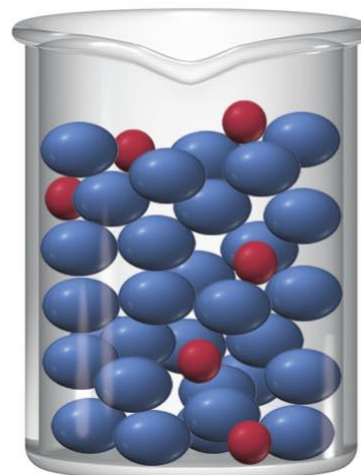
$$\Delta H_{\text{solute}} > 0$$

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Step 3



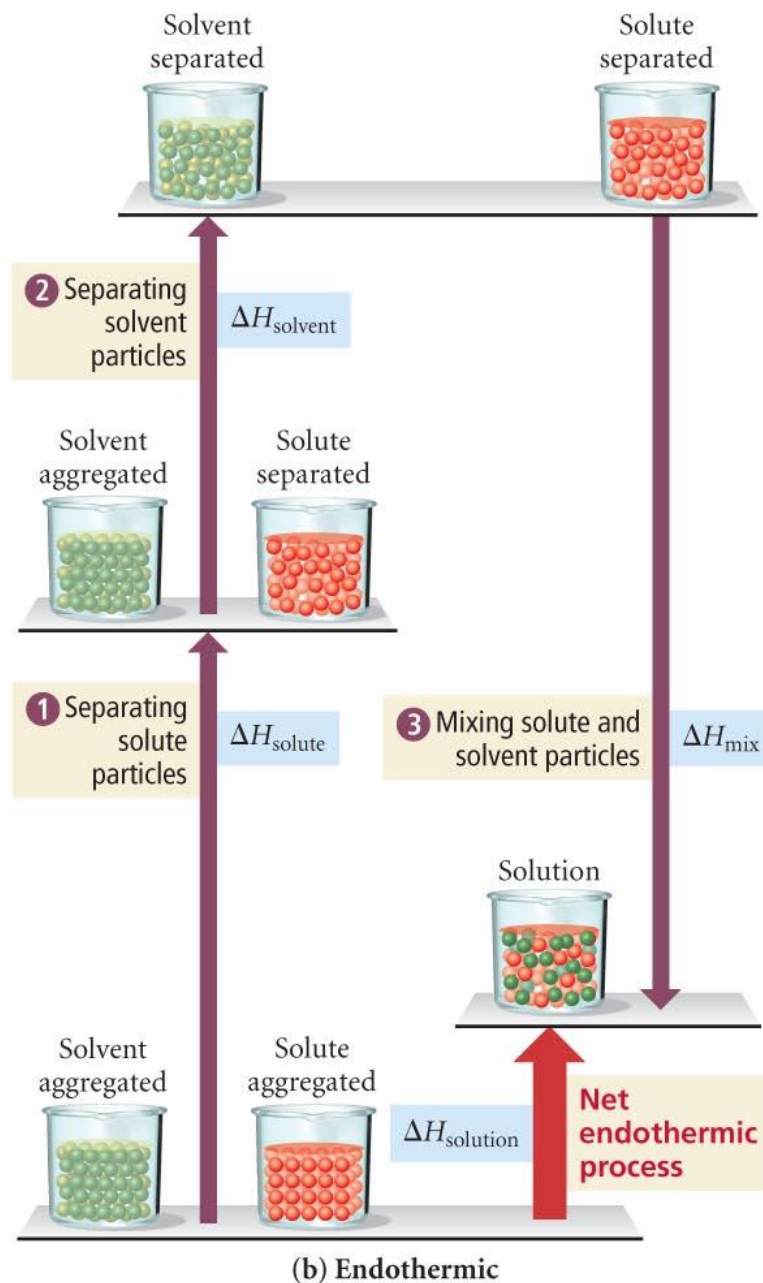
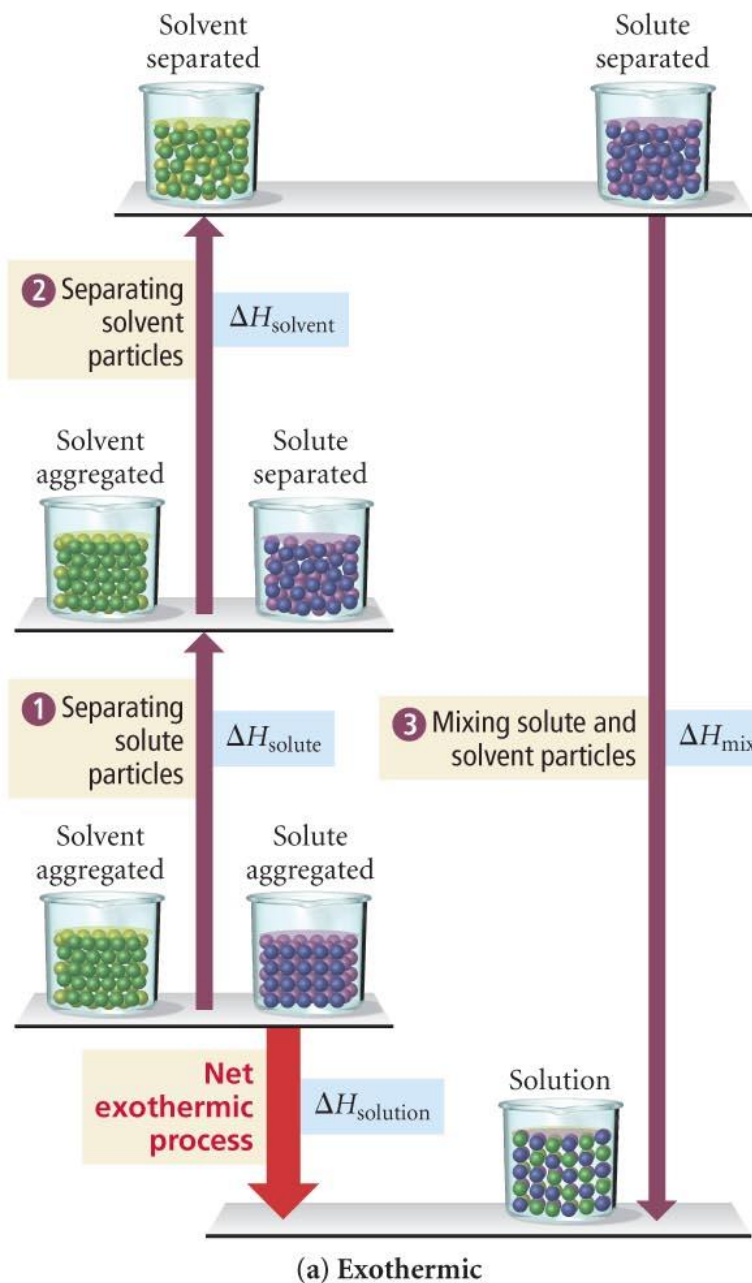
+



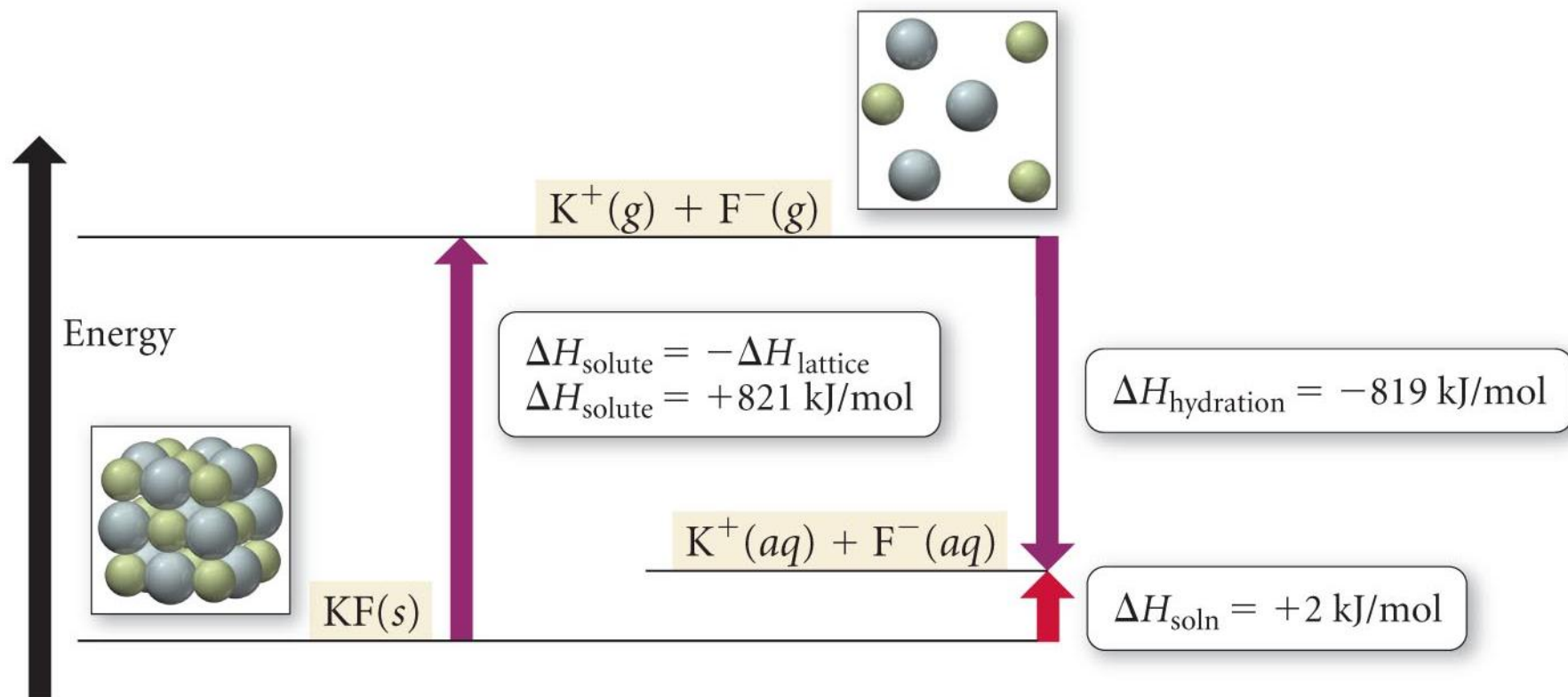
$$\Delta H_{\text{mix}} < 0$$

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Energetics of Solution Formation



Heat of Hydration



$$\Delta H_{\text{soln}} = \Delta H_{\text{solute}} + \underbrace{\Delta H_{\text{solvent}} + \Delta H_{\text{mix}}}_{\Delta H_{\text{hydration}}}$$

\uparrow
 $-\Delta H_{\text{Lattice}}$

Part 2: Factors that Affect Solubility

- Temperature

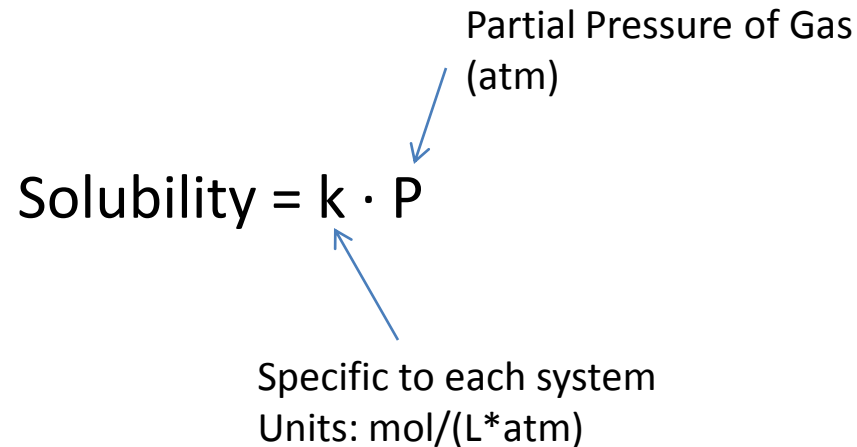
- Pressure

- Henry's Law for gas solubility

$$\text{Solubility} = k \cdot P$$

Partial Pressure of Gas
(atm)

Specific to each system
Units: mol/(L*atm)

The diagram features the equation $\text{Solubility} = k \cdot P$ centered on the page. A blue arrow points from the text 'Partial Pressure of Gas (atm)' to the variable 'P' in the equation. Another blue arrow points from the text 'Specific to each system Units: mol/(L*atm)' to the variable 'k' in the equation.

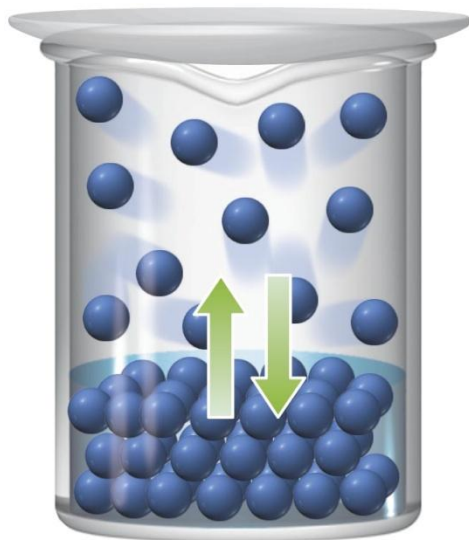
Part 3: Units of Concentration

- Molarity (M)
 - Molality (m)
 - Mole Fraction (X)
 - Mass %
-
- Be able to tell how to make a solution in the Lab.
 - Be able to convert between any of these units.
 - Remember that you always need a density to go to or from Molarity.

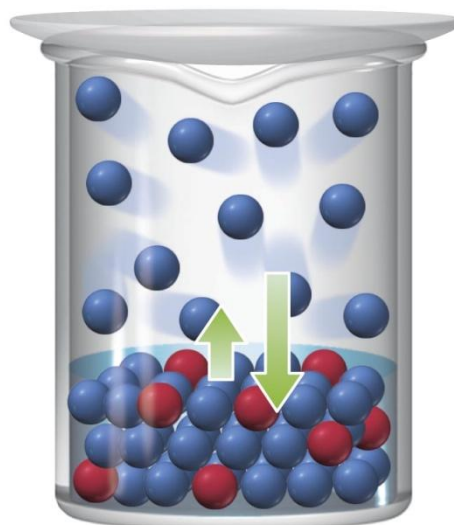
Part 4: Colligative Properties

- Vapor Pressure Change
 - Nonvolatile (always lower)
 - Volatile (raise or lower)
- Boiling Point Elevation
- Freezing Point Depression
- Osmotic Pressure

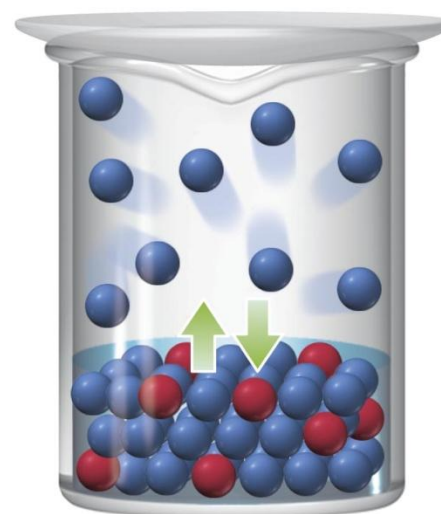
Vapor Pressure Lowering



Dynamic
equilibrium



Rate of vaporization
reduced by solute



Equilibrium reestablished
but with fewer molecules
in gas phase

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Rate of condensation
is still the same

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Rault's Law shows that the lowering of the vapor pressure is directly proportional to the mole fraction solute. (Be aware of electrolytes!)

Van't Hoff Factor

- This is a consequence of living in the real world...
- Ionic compounds rarely are 100% dissociated in solution.
- The Van't Hoff factor is an experimentally determined factor that corrects the ideal number of solute particles in a solution.

$$i = \frac{\textit{moles _ of _ particles}}{\textit{moles _ of _ solute _ dissolved}}$$

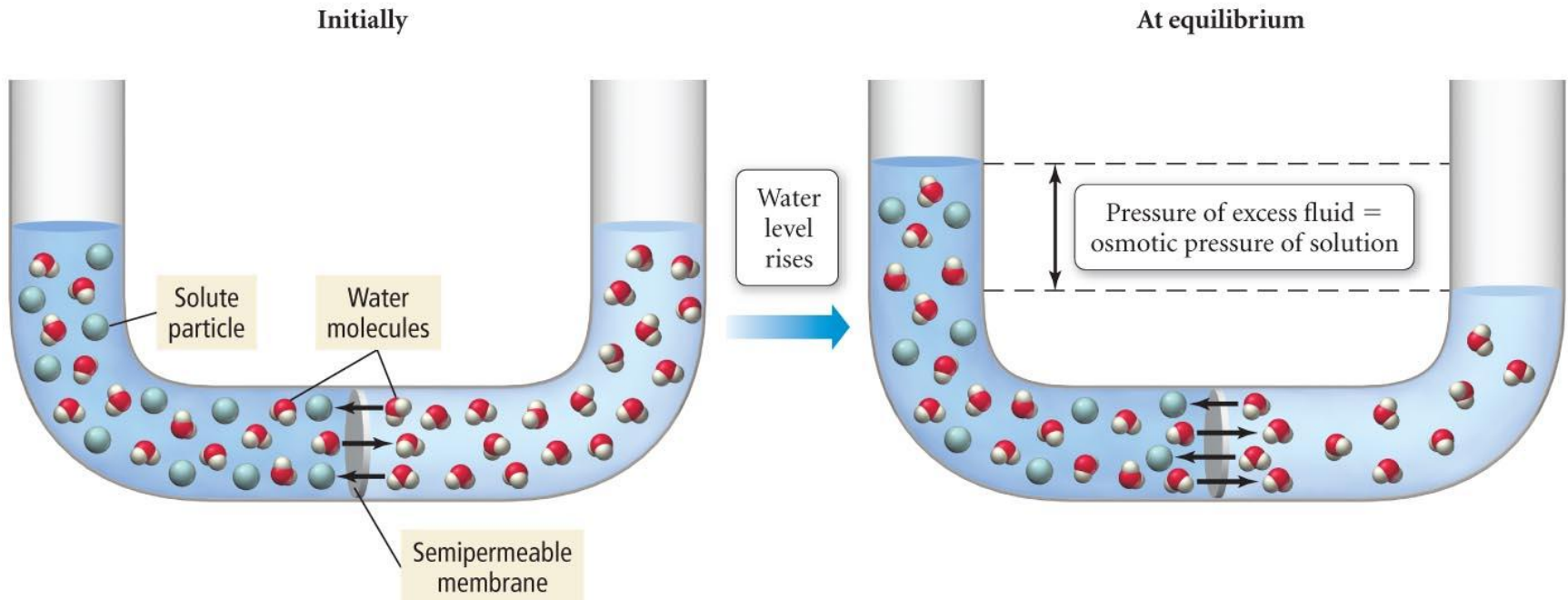
Vapor Pressure Change due to addition of Volatile Solute

Boiling Point Elevation and Freezing Point Depression

Osmotic Pressure

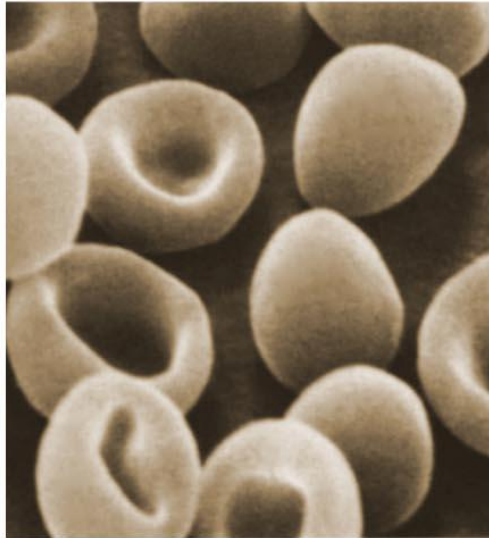
$$\Pi = M \cdot R \cdot T$$

Osmosis and Osmotic Pressure



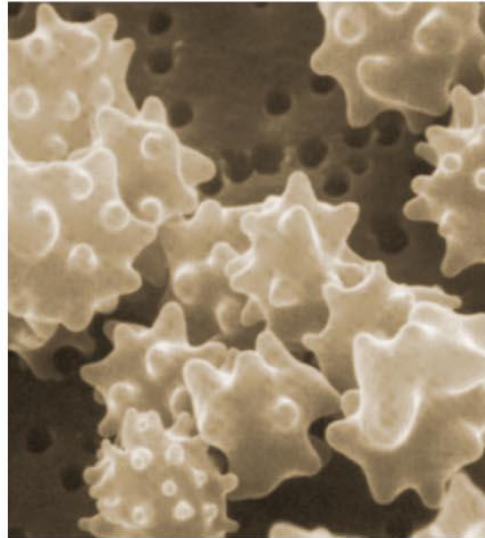
Why I care about Osmosis...

Isosmotic
solution



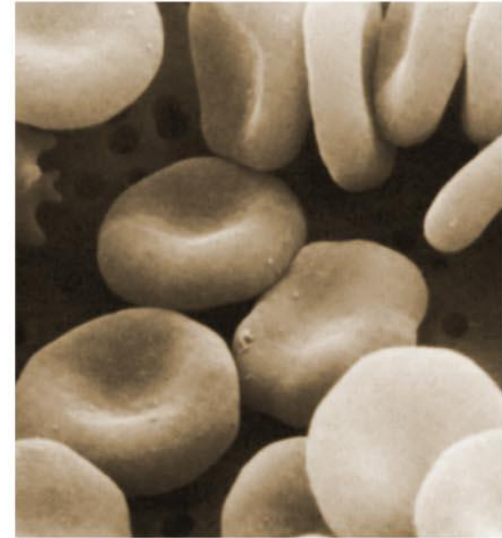
(a) Normal red blood cells

Hyperosmotic
solution



(b) Shriveled red blood cells

Hyposmotic
solution



(c) Swollen red blood cells