**Chapter 13 part 3: Solubility**

*Read:* BLB 13.1 - 13.3  
*HW:* BLB 13:7,15, 21, 23, 33;  
Sup 13:1-7  

**Know:** Factors that affect solubility  
- thermodynamics of solution process  
- intermolecular interactions (like dissolves like)  
- temperature effects  
- pressure effects  

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**The Solution Process**

NaCl dissolves in water. What kind of IMF?
Dissolution requires 3 Steps:

1. break solute-solute interactions  
   \[ \Delta H_1 \]  
   \( \Rightarrow \) EXO OR ENDOTHERMIC?

2. break solvent-solvent interactions  
   \[ \Delta H_2 \]  
   \( \Rightarrow \) EXO OR ENDOTHERMIC?

3. form solute-solvent solvent interactions  
   \[ \Delta H_3 \]  
   \( \Rightarrow \) EXO OR ENDOTHERMIC?

Is Dissolution overall Exo or endothermic?  
Is Dissolution Spontaneous?  
Processes occur spontaneously when:
- energy is released (exothermic)
- disorder increases (increase in entropy)

- An endothermic process can be spontaneous if the increase in entropy (disorder) is large enough.

Enthalpy changes accompanying the solution process:

**L:** Net exothermic process \( (\Delta H_{\text{soln}}<0) \)  
Demo: \( \text{CuSO}_4 \)

**R:** Net endothermic process \( (\Delta H_{\text{soln}}>0) \)  
Demo: \( \text{NH}_4\text{NO}_3 \)
The Solution Process is a DYNAMIC EQUILIBRIUM

\[ \text{Solute} + \xrightarrow{\text{dissolve}} \text{solvent} \xrightarrow{\text{crystallize}} \text{solute} \]

Define **Saturated solution**: When a solution is saturated, no more solute can be dissolved without external changes.

Define **Supersaturated solution**: A supersaturated solution is a solution with more solute than it can normally hold.

Is the dissolution of CH₃COONa (sodium acetate) exothermic or endothermic?

1. exothermic
2. endothermic
SOLUBILITY IS:

FACTORS THAT AFFECT SOLUBILITY

1. Temperature
   - Effect of temperature on solubility of ionic solids
   - Effect of temperature on solubility of gases

2. IMF’s: Type and Strength

3. Pressure

Dependence of Solubility on Temperature

Effect of Temperature on solubility of ionic solids

Effect of temperature on solubility of gases
Effect of Intermolecular Forces on Solubility

In general: like dissolves like

- **Polar** solvents dissolve what kind of solutes?
- **Nonpolar** solvents dissolve what kind of solutes?

If the intermolecular forces broken and formed are approximately equal, dissolution is probable.

Which one of the following will be most soluble in benzene (C₆H₆(I))?

1. H₂O(I)
2. CH₃OH(I)
3. HCl(I)
4. CH₃CH₂OH(I)
5. heptane

**Like dissolves like**

What kind of molecule is CH₃CH₂OH?
What kind of IMF’s?
Is it an electrolyte?

Molecule | solubility in water at 25°C (g/100g of H₂O)
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CH₃OH | total
CH₃CH₂OH | total
CH₃CH₂CH₂OH | total
CH₃CH₂CH₂CH₂OH | 8.06
CH₃CH₂CH₂CH₂CH₂OH | 2.82
CH₃CH₂CH₂CH₂CH₂CH₂OH | 0.62

As the length of hydrocarbon chain increases, what happens to the solubility in water?
Effect of Pressure on Solubility
Does pressure affect solid, liquid or gas solubility?

What happens to solubility of a gas when:
Increase $P_g$?
Decrease $P_g$?

**HENRY’S Law**
Relationship between:

solubility and pressure
$C_g$ (note: text uses $S_g$) $P_g$

amount of gas dissolved ($C_g$)
is proportional to the partial pressure of that gas ($P_g$) above the solution.

Think soda pop!

Ammonia Fountain

$NH_3$ gas

$H_2O$ + phenolphthalein
(pink in basic solution)
To increase the solubility of \( \text{N}_2 \) in water:

1. increase \( T \)
2. decrease \( T \)
3. increase \( P \)
4. decrease \( P \)

How will the solubility of \( \text{KClO}_3 \) be effected by an increase in pressure?

1. increase solubility
2. decrease solubility
3. no effect on solubility

Which of the following aqueous solutions has the greatest total concentration of ions?

1. 0.2M \( \text{NH}_4\text{NO}_3 \)
2. 0.2M \( \text{Pb(NO}_3)_2 \)
3. 0.2M \( \text{Na}_2\text{SO}_4 \)
4. 0.2M \( \text{AlPO}_4 \)
5. 0.2M \( \text{AlBr}_3 \)
6. 0.5M \( \text{CH}_3\text{COOH} \) (acetic acid)