Ch 13 - Properties of Solutions

solute

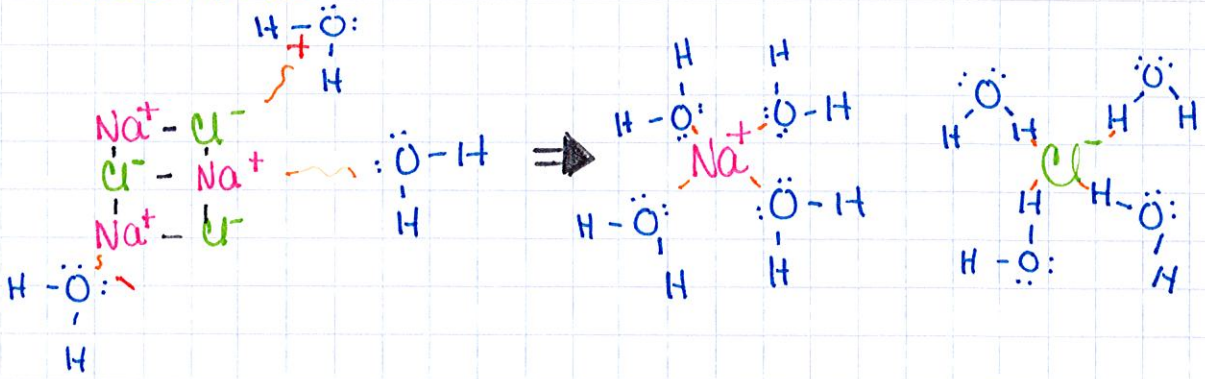
- **The Solution Process** - occurs when 1 substance disperses uniformly into another substance
  solvent

↳ 2 Factors affect the ability of a solute to dissolve & form a solution

(1) IMFs

Solutions form when the IMFs between the solute & the solvent are equal or greater than the IMFs between the solute particles or the solvent particles

NaCl in H_2O



solvation - interaction b/w solute & solvent
hydration - interaction b/w solute & H_2O

Ex (1) Why doesn't NaCl dissolve in nonpolar solvents like hexane, C_6H_{14}?

no attraction b/w solute ($NaCl$) & solvent (C_6H_{14})
ionic LDFs

(2) The natural tendency of substances to spread into larger volumes when not restrained.

↳ Energy changes when forming a Solution.

- 3 components
  (1) Separating solute particles
  (2) separating solvent particles
  (3) solute - solvent interactions

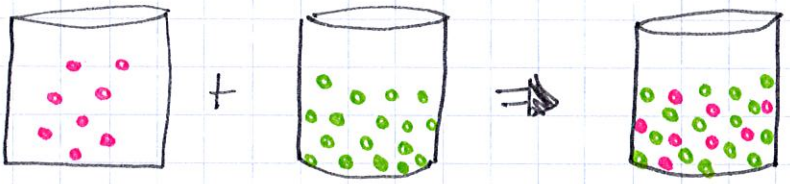
(1)

ΔH_1

(2)

ΔH_2

(3)



ΔH_3

$$\Delta H_{SOLN} = \Delta H_1 + \Delta H_2 + \Delta H_3$$

does NOT occur spontaneously (w/o intervention)

occur spontaneously

Exothermic

Na^+ OH^- breaking H bonds

separate solute + separate solvent

ΔH_2

Na^+ OH^-

Separate solute + solvent

ΔH_1

Solute + Solvent

NaOH H_2O

ΔH_{SOLN}

Solution

ΔH_3

ENTHALPY

Endothermic

NH_4 Cl^- breaking H Bonds

separate solute + separate solvent

ΔH_2

$NH_4^+ + Cl^-$

Separate solute + solvent

ΔH_1

Solute + Solvent

NH_4Cl H_2O

ΔH_3

Solution

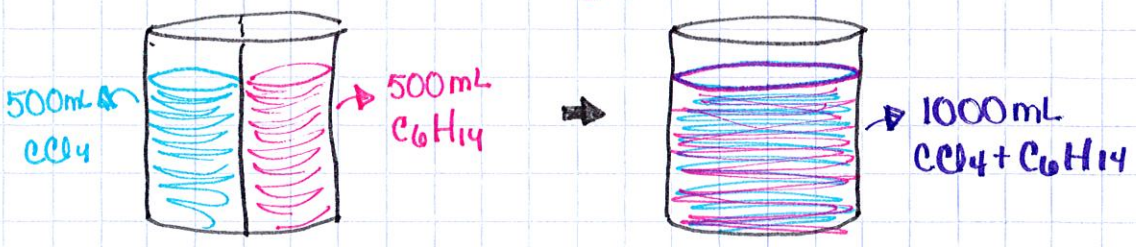
ΔH_{SOLN}

- But some endothermic processes do occur spontaneously.
  Ex) NH_4NO_3 dissolves in water & heat is absorbed.

How?

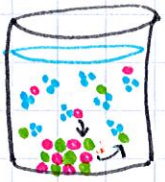
Entropy!

increasing the disorder (randomness) of a system tends to lower the energy of the system



- Types of Solutions

↳ Saturated
- the solvent holds as much solute as is possible at that temp.
- dissolved solute is in dynamic equilibrium w/ solid solute particles



↳ Unsaturated
- less solute than can dissolve in the solvent at that temp. is dissolved in the solvent

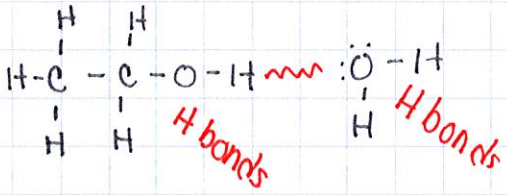
↳ Supersaturated
- the solvent holds more solute than is normally possible at that temp.
- unstable, crystallization can be caused by adding a "seed crystal" or scratching the side of the flask. (see p. 535)

- Factors that Affect Solubility (ability to dissolve)

↳ Solute - Solvent Interactions: "like dissolves like"

- polar substances dissolve in polar solvents
- nonpolar substances dissolve in nonpolar solvents

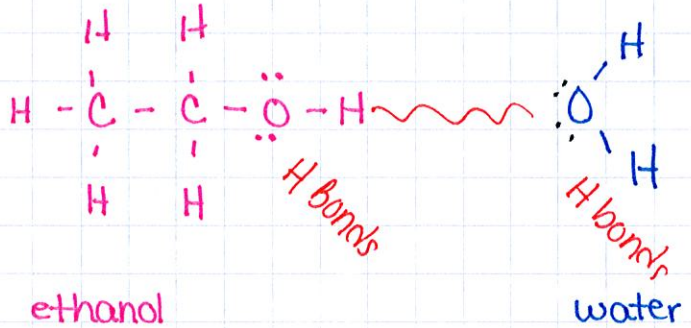
CH_3CH_2OH in H_2O
(alcohol)

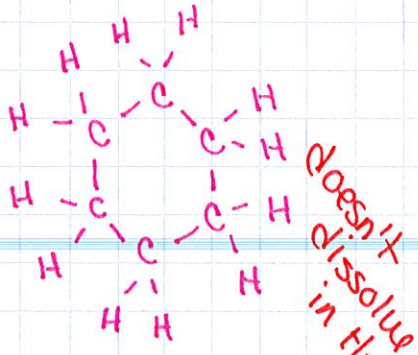


- The more carbons in the alcohol, the less soluble it is in polar solvents. The polar -OH part of the alcohol becomes less important as the molecule gets larger

Alcohol	solubility in H_2O	Solubility in C_6H_{14}
CH_3OH (methanol)	∞	.12
CH_3CH_2OH (ethanol)	∞	∞
$CH_3CH_2CH_2OH$ (propanol)	∞	∞
$CH_3CH_2CH_2CH_2OH$ (butanol)	.11	∞
$CH_3CH_2CH_2CH_2CH_2OH$ (pentanol)	.030	∞
$CH_3CH_2CH_2CH_2CH_2CH_2OH$ (hexanol)	.0058	∞

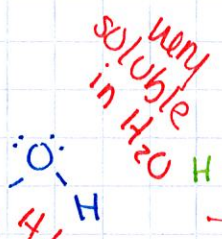
- The more similar the IMFs are in the solute & solvent, the more likely they are to be soluble in each other.





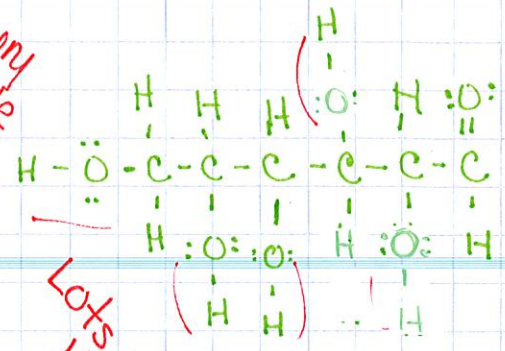
cyclohexane
C_6H_{12}
nonpolar

doesn't dissolve in H_2O



water

very soluble in H_2O



Lots of H bonds

glucose
$C_6H_{12}O_6$

↳ Gases in Solution
- Generally, the solubility of a gas increases w/ increasing mass.
  - larger molecules have stronger dispersion forces.

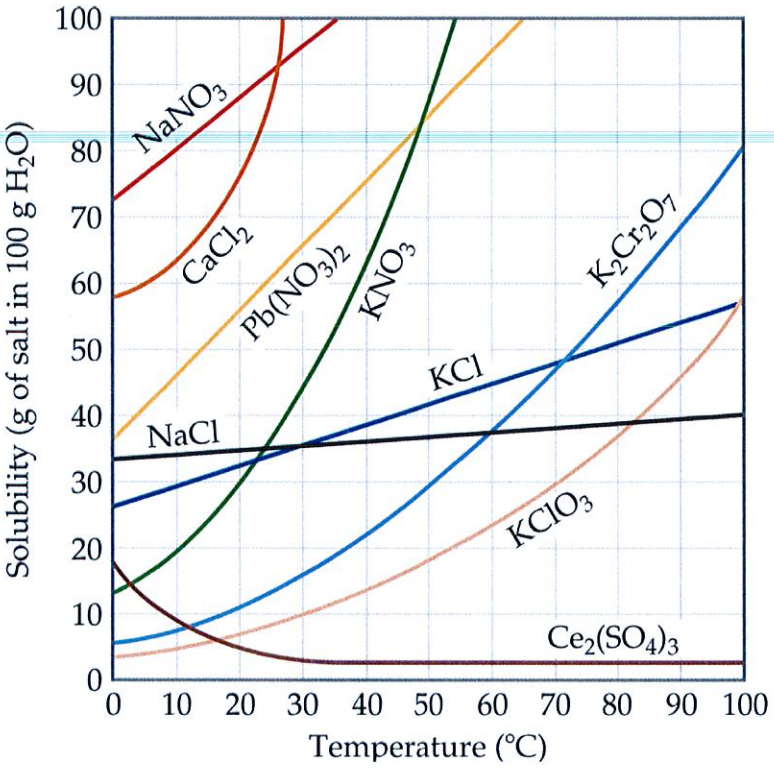
↳ Pressure Effects
- Liquids and solids
  - solubility does not change much w/ pressure
- Gases
  - solubility is directly proportional to pressure

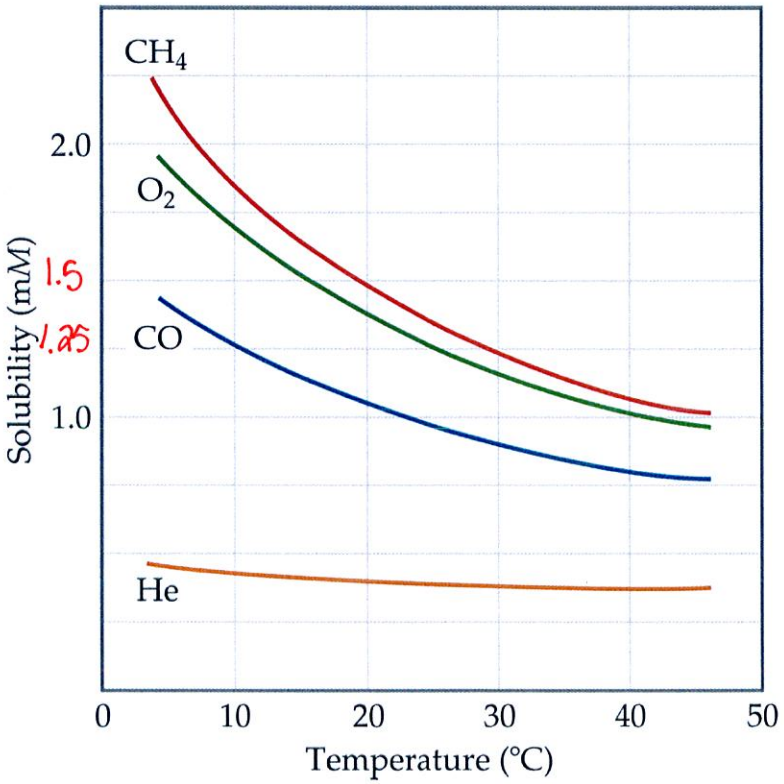
Henry's Law

$$S_g = kP_g$$

S_g = solubility
k = Henry's law constant
P_g = pressure (partial)

↳ Temperature Effects
- Liquids and Solids
  - solubility increases w/ increasing temperature
- Gases
  - solubility decreases w/ increasing temperature


Solubility (g of salt in 100 g H_2O)
100
90
80
70
60
50
40
30
20
10
0
0 10 20 30 40 50 60 70 80 90 100
Temperature (°C)
$NaNO_3$
$CaCl_2$
$Pb(NO_3)_2$
KNO_3
$K_2Cr_2O_7$
KCl
NaCl
$KClO_3$
$Ce_2(SO_4)_3$


Solubility (mM)
2.0
1.5
1.25
1.0
0 10 20 30 40 50
Temperature (°C)
CH_4
O_2
CO
He