Inovace bakalářského studijního oboru Aplikovaná chemie

Reg. č.: CZ.1.07/2.2.00/15.0247

Lecture vocabulary:

solution	roztok
colligative phenomena	koligativní jevy
solute	solut, tj. rozpuštěná látka
dissolve	rozpouštět
solvent	rozpouštědlo
extent	rozsah, rozmezí
specific solvent	určité rozpouštědlo
saturation	nasycenost
partial pressure	parciální tlak
double	zdvojnásobit
solubility	rozpustnost
sparsely soluble	obtížně rozpustný
amount	množství
number of particles	množství částic
lowering	snížení
vapour	pára
elevation	zvýšení
depression	snížení, propad
freezing point	bod tuhnutí
mole fraction	molární zlomek
non-volatile	netěkavý
rearrangement	přeskupení
pure solvent	čisté rozpouštědlo
molecular weight	molekulová hmotnost
dilution	zředění
thermometer	teploměr
permeable	propustný
power plant	elektrárna
membrane	membrána
hope	doufat
output	výstup
reach	dosahovat

esf
evropský sociální fond v ČR
EVROPSKÁ UNIE
MŠMT
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Introduction to Physical Chemistry

Lecture 3

- Solutions
- Solubility of gases
- Solubility of solids
- Colligative phenomena
  - Raoult's law
  - Osmotic pressure

Solutions

Solubility is the property of a solid, liquid, or gaseous chemical substance called solute to dissolve in a solid, liquid, or gaseous solvent to form a homogeneous solution of the solute in the solvent.

The solubility of a substance fundamentally depends on the used solvent as well as on temperature and pressure.

The extent of the solubility of a substance in a specific solvent is measured as the <u>saturation concentration</u> where adding more solute does not increase the concentration of the solution.

Solubility of gases

The solubility of a gas in a liquid depends on temperature, the partial pressure of the gas over the liquid, the nature of the solvent and the nature of the gas.

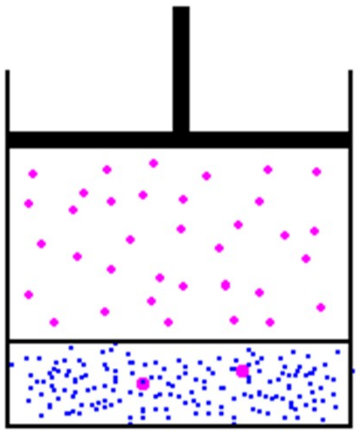
Ideal gas solubility follows Henry's law $x = K_H p$

For diluted solutions, c can be used instead of χ $c = K_H^{'} p$

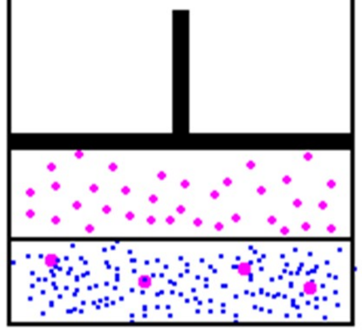
Sometimes, Ostwald's formulation of Henry's law is useful

$$\frac{V_g}{V_l} = K_H^{'} RT = \alpha$$

α … Ostwald absorption coefficient
V_l .. volume at which 1mole of gas is dissolved

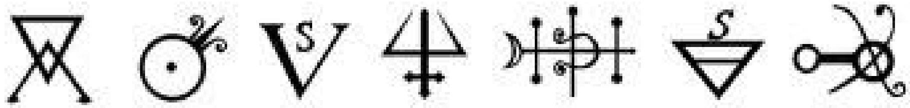


Double the pressure – double the concentration

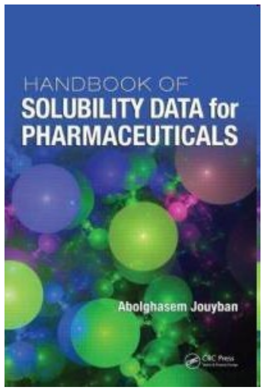


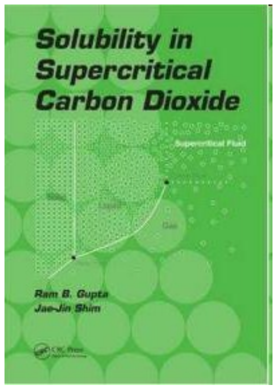
Solubility of solids

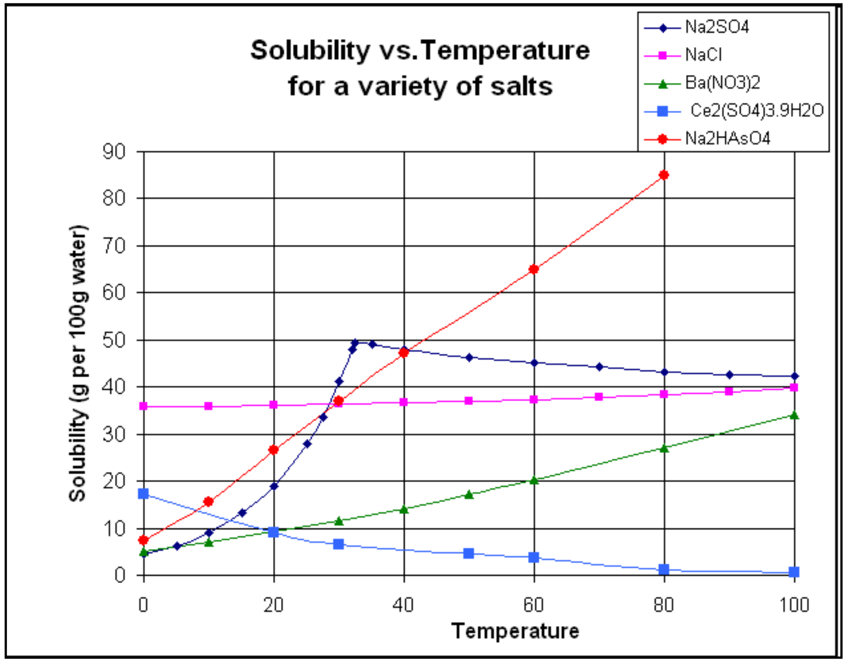
famous rule of thumb "similia similibus solvuntur" ("like dissolves like")



- **Solubility (grams per 100 mL) for soluble compounds**
- **Solubility product for sparsely soluble compounds**







$$M_xA_y(s) \dashrightarrow x\,M^{y+}(aq) + y\,A^{x-}(aq)$$

$$K_c = [M^{y+}]^x[A^{x-}]^y$$

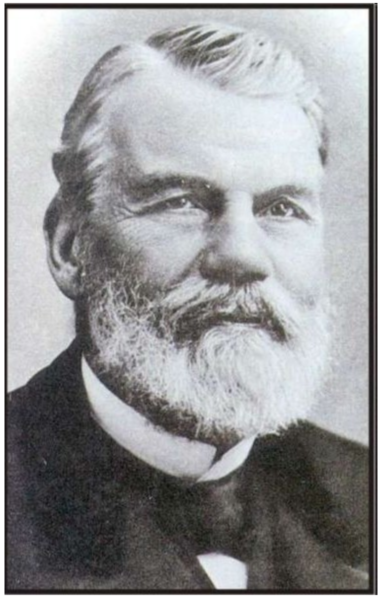
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Colligative phenomena

Properties that do not depend on the quality of dissolved substance, but only on its amount (number of particles)

- **Lowering of the vapor pressure (Raoult's law)**
- **Elevation of the boiling point ("ebulioscopy")**
- **Depression of the freezing point ("cryoscopy")**
- **Osmotic pressure**

Raoult's law



The vapor pressure of an ideal solution is dependent on the vapor pressure of each chemical component and the mole fraction of the component present in the solution

$$p = \sum_i p_i \chi_i$$

For the solution of one non-volatile component *B* dissolved in solvent A the total vapour pressure is:

$$p = p_A \chi_A$$

Assuming that $\chi_B = 1 - \chi_A$ **we obtain after rearrangement:**

$$\frac{p_A - p}{p_A} = \chi_B$$

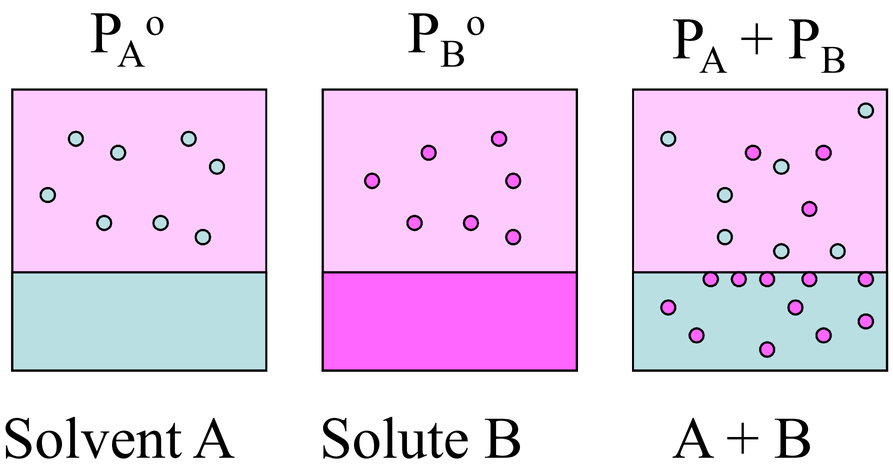
Due to decreased vapour tension over solution:

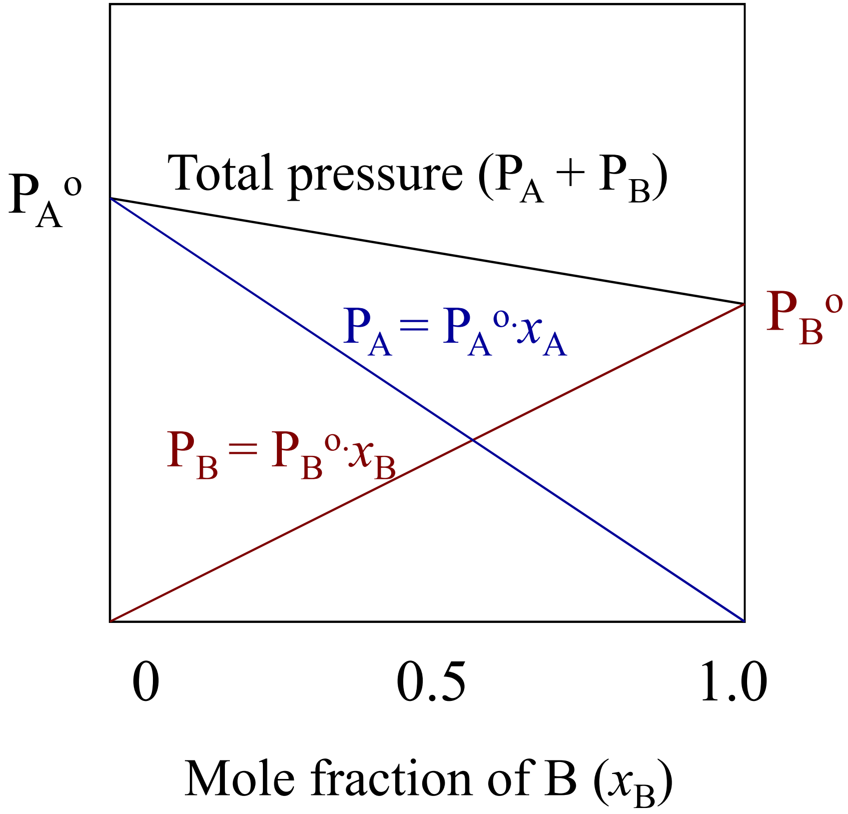
- **boiling point is higher (ebulioscopic effect)**
- **freezing point is lowered (cryoscopic effect)**

Raoult's law

Raoult's law suggests that partial pressure of the component is proportional to its molar fraction in the solution.

That means that when a pure solvent is mixed with a solute the solvent vapor pressure is lowered. It easy to understand if one takes into account that addition of solute leads to dilution of the solvent. As a result less molecules of the solvent become available for evaporation on the surface of the solution and vapor pressure of the solvent decreases.

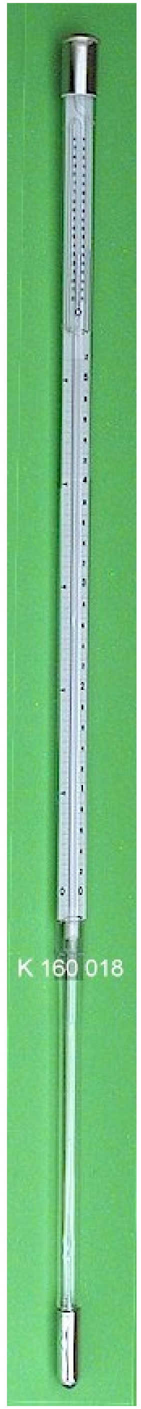




Ebulioscopy and cryoscopy

Used for molecular weight determination

As a result of dilution of the solvent by the solute there are less molecules of the solvent available for freezing or boiling in a given volume. Therefore, lower temperatures are needed for freezing and higher temperatures are needed for boiling



Beckmann thermometer

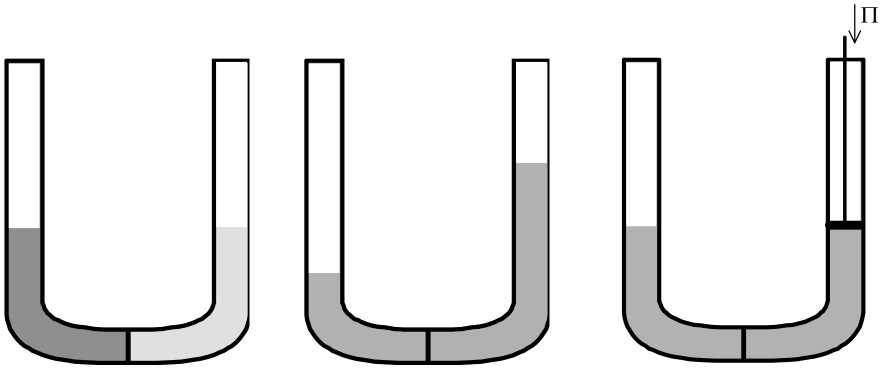
Freezing point depression $\Delta T_f = K_f \cdot c_{solute}(mole/L)$

Boiling point elevation $\Delta T_b = K_b \cdot c_{solute}(mole/L)$

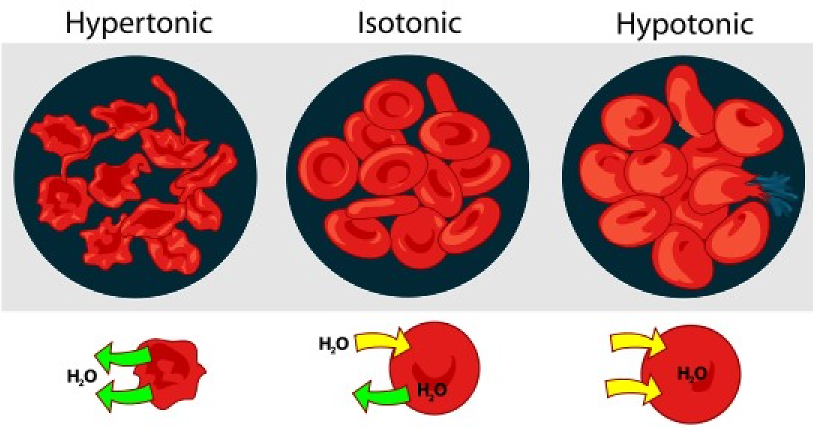
K_f - “cryoscopic constant” or “molar depression constant” {^{o}C/M}

Osmotic pressure

Semipermeable membrane = permeable for solvent but not for solute

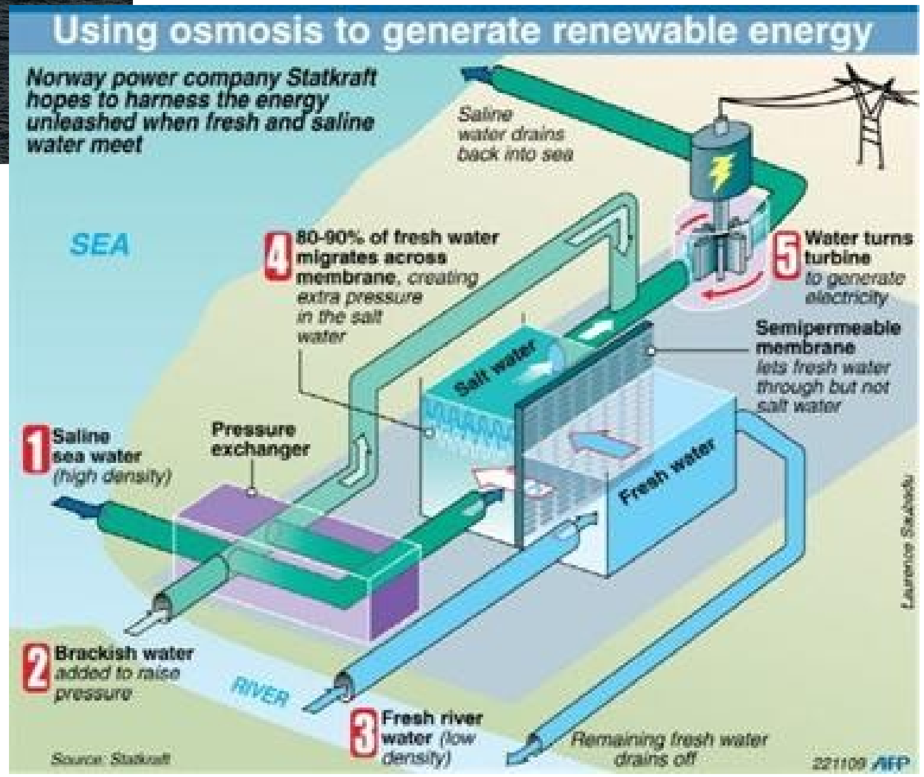


Van't Hoff equation: $\Pi = cRT$



Osmotic pressure

Statkraft (Norway) osmotic power plant



- 24th Nov 2009 in Tofte on the Oslo Fjord
- 1 Watt per square meter using polyimide membrane
- 2-4kW of electricity, hoped that by 2015 the total output will have reached 25 MW :]

evropský
sociální
fond v ČR

EVROPSKÁ UNIE

MINISTERSTVO ŠKOLSTVÍ,
MLÁDEŽE A TĚLOVÝCHOVY

OP Vzdělávání
pro konkurenceschopnost

INVESTICE
DO ROZVOJE
VZDĚLÁVÁNÍ