Lecture General Chemistry
Winter Term 2022/23

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- Website (Slides, Excercises):
- http://www.chemie.uni-siegen.de/pc/lehre/nanoscitec/

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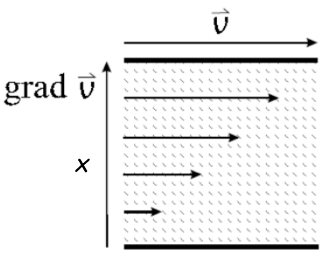
Viscosity



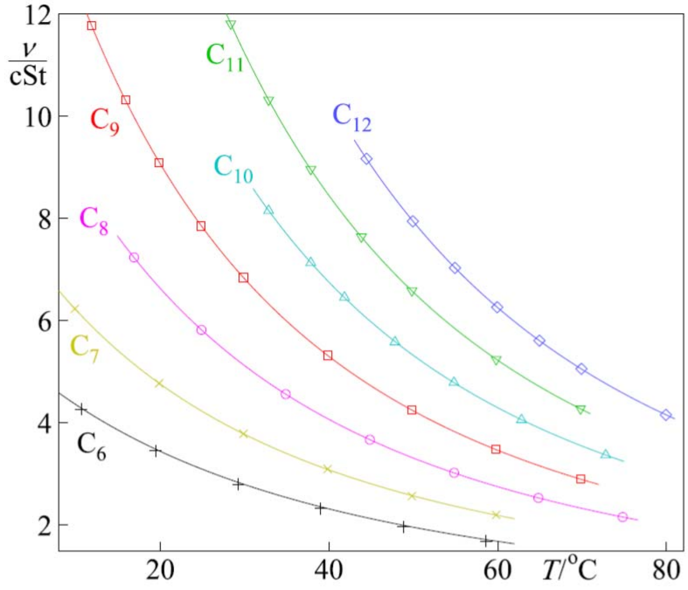
2 Planes, in between: liquid

$$\text{Force} \propto \text{area} \cdot \frac{dv}{dx}$$

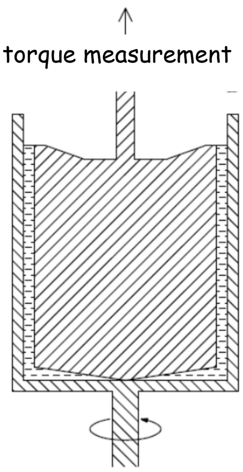
strong dependence on temperature!

Grease, motor oil, general: lubricants

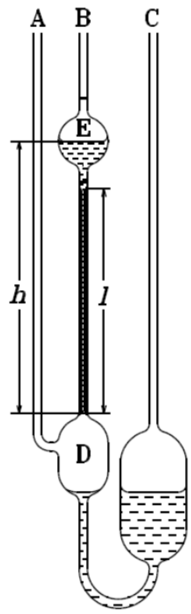
Improvement of lubrication at high temperatur via polymers that swell at high temperatures



kinematic viscosity for n-alcylic acids



Couette-Viscosimetre



Ubbelohde-Viscosimetre

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Solutions

- in solvent H_2O, there are soluble
  - solids: NaCl
  - liquids: Ethanol
  - gases: CO_2

more than one solute can be in the same solution

extreme differences of solubility in water

Examples: solubility in water

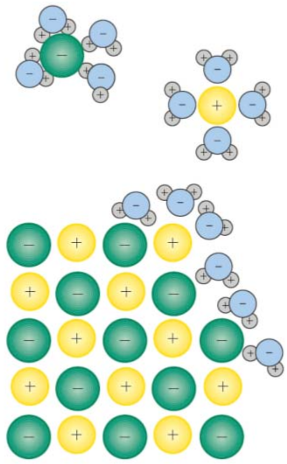
- inorganic solids
  - $BaSO_4$ 0,002 g in 1 kg, 25 °C
  - NH_4NO_3 2100 g in 1 kg, 25 °C
- organic solids
  - urea 790 g per ℓ, 5 °C
    1200 g per ℓ, 25 °C
  - Paraffine --- (nothing)
- organic liquids
  - Methanol, Ethanol, Acetone: miscible
  - Octanol 0,3g per ℓ, 20 °C
- gases
  - Ammonia 702 ℓ per ℓ, 20 °C
  - Nitrogen 0,0162 ℓ per ℓ, 20 °C and 1,013 bar

reasons for different solubilities?

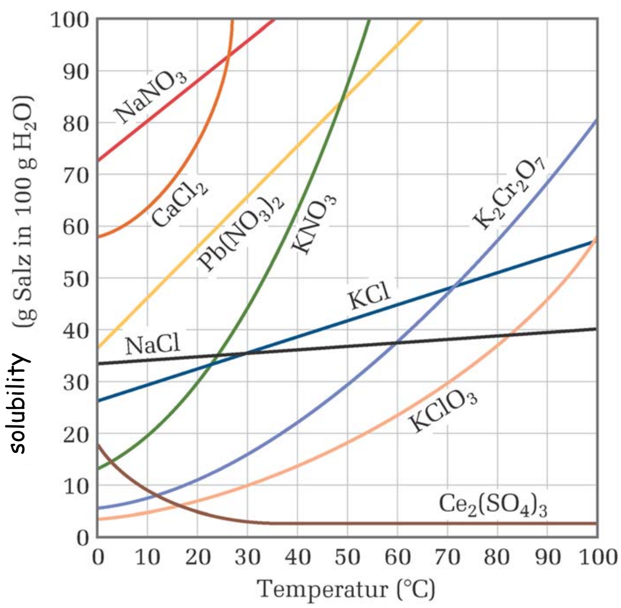
forces between particles:
solvent, solute

in water: polar Substances or Substances capable of hydrogen-bridging dissolve well. Hydration!

Similar compounds mix well, dissimilar compounds do not.



temperature dependency of solubilities



temperature dependency of solubilities of solids

what do we want: c_i or $x_i = f(T)$

Le Chatelier's principle

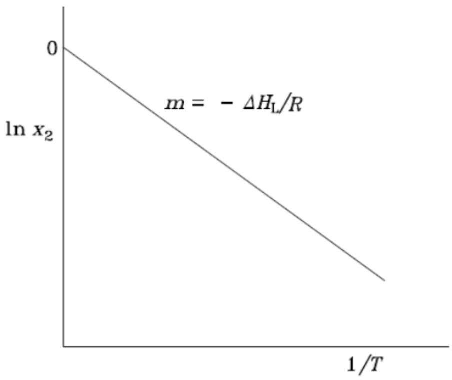
H_L: enthalpy of solution

$\Delta H_L > 0$: solubility rises with T

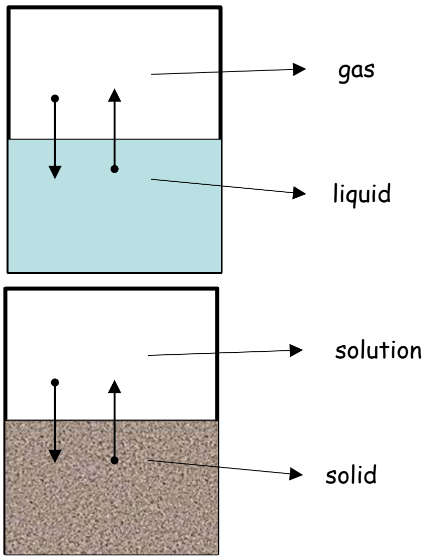
$\Delta H_L < 0$: solubility lowers with T

$\Delta H_L \approx 0$: solubility $\neq f(T)$

$$\ln x_i = -\frac{\Delta H_L}{R} \cdot \frac{1}{T} + C$$

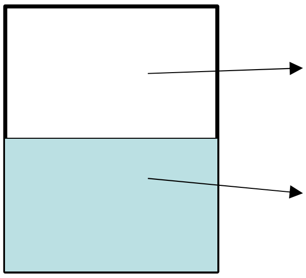


Analogy: dissolving -- evaporation



similar processes,
similar laws

solubility of gases

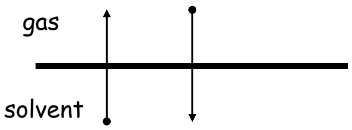


Experiment: <u>solubility of ammonia in water</u>

strong interactions between solvent and gas: good solubility
here: 702 ℓ NH_3 in 1 ℓ H_2O bei 20 °C
(that is: 29 mol in 55 mol)
„water absorbs ammonia"

not our topic here. We will describe poor solubility of gases.

Microscopic view: solubility of gases in liquids



$$\dot{n}_{\downarrow} \propto p$$

$$\dot{n}_{\uparrow} \propto x$$

In equilibrium:

$$\dot{n}_{\uparrow} = \dot{n}_{\downarrow}$$

In equilibrium: $p \propto x$

$p = kx$ Henry's Law

$p_i = k_i x_i$ Henry-Dalton's law for gas mixtures

The indices i denominate different gases. Each gas obeys Henry's law as if no other gas were present. (only true for nonreactive gases)

Example: solubility of N_2 and O_2 in water

at 20 °C and 1,013 bar

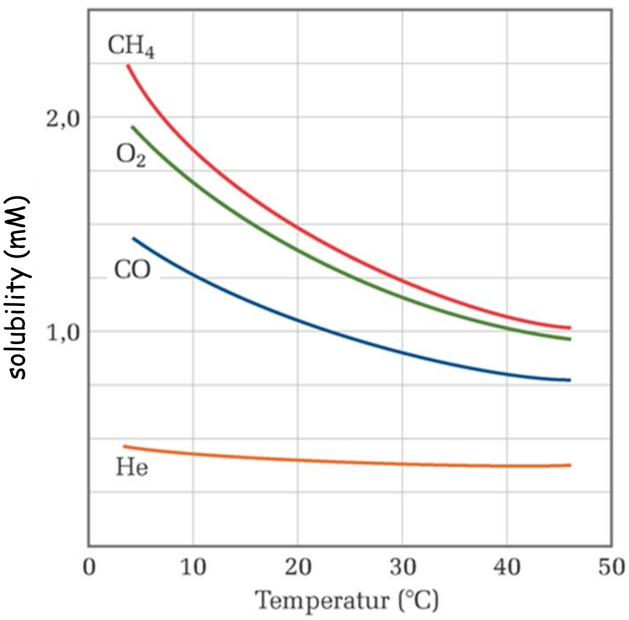
$$O_2 : x_{O_2} = 2,5 \cdot 10^{-5}$$

$$N_2 : x_{N_2} = 1,3 \cdot 10^{-5}$$

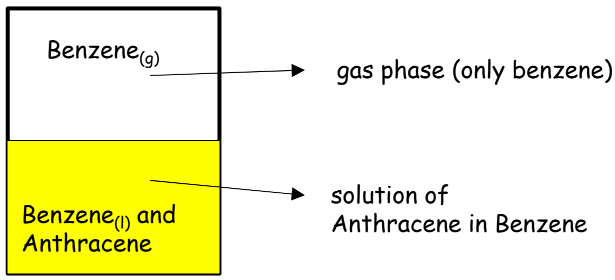
$$k_{O_2} : \frac{p_{O_2}}{x_{O_2}} = \frac{1,013\,\text{bar}}{2,5 \cdot 10^{-5}} = 4,1 \cdot 10^{4}\,\text{bar}$$

important in industry: washing (purifying) gases,
Technological use: gas scrubbing, eg removing hydrogen sulfide from coke oven gas

coke from coal: *CO*, H_2, CH_4, H_2S form in the process
removing H_2S by weak aquous base solution



vapour pressure of solutions

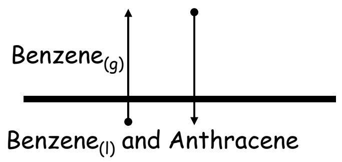


difference to former problem?

former problem: gas (some other compound) above solvent with dissolved gas

now: solvent in the gas phase

Microscopic view: vapour pressure of solutions



$\dot{n}_{\downarrow} \propto p$

$\dot{n}_{\uparrow} \propto x_1$ Index 1: Benzol

In equilibrium:

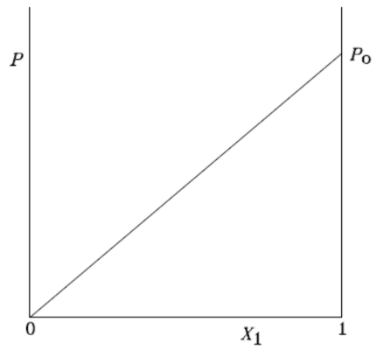
$$\dot{n}_{\uparrow} = \dot{n}_{\downarrow}$$

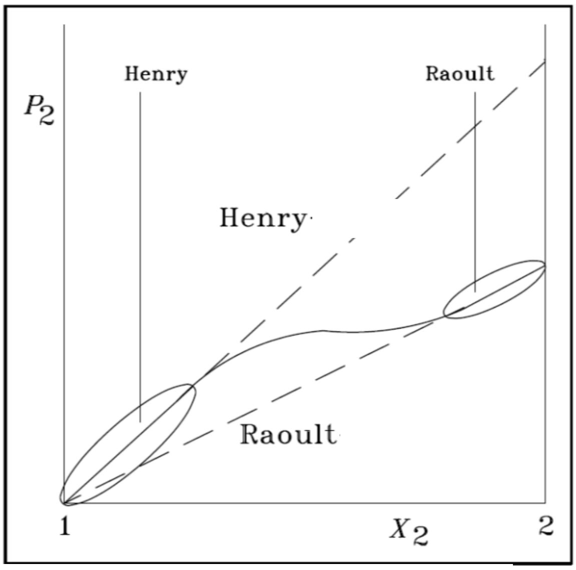
In equilibrium: $p \propto x_1$

$$p = ax_1$$

Therefore: $a = p_0$
(p_0 : vapour pressure of pure benzene)

$p_1 = p_0 x_1$ Raoult's Law





Properties of solutions

- Solubility of solids
- Solubility of gases
- Vapor pressure of solutions
- distillation
- boiling point elevation
- freezing point depression
- Stability condition of phases

Diagram for Raoult for T = const. and variable p

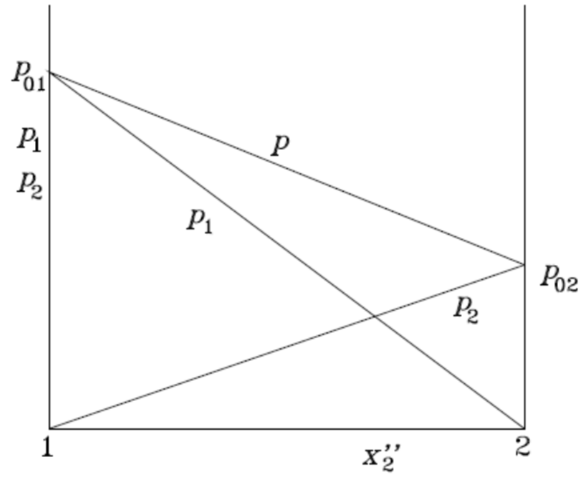


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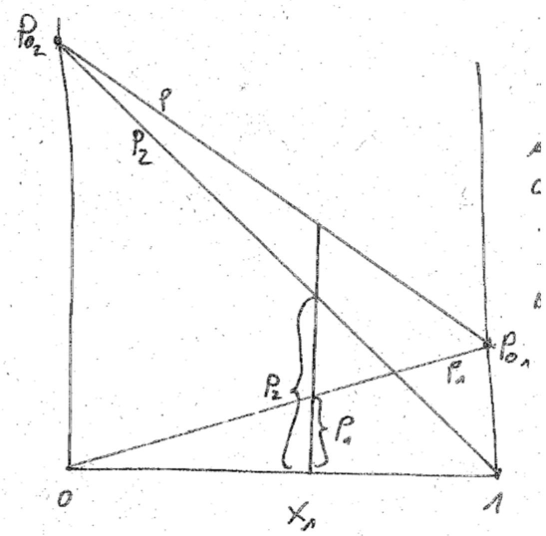
Diagram for T = const. und variable p



$$p_1 = p_{0_1} x_1$$

$$p_2 = p_{0_2} x_2$$

$$p = p_1 + p_2$$

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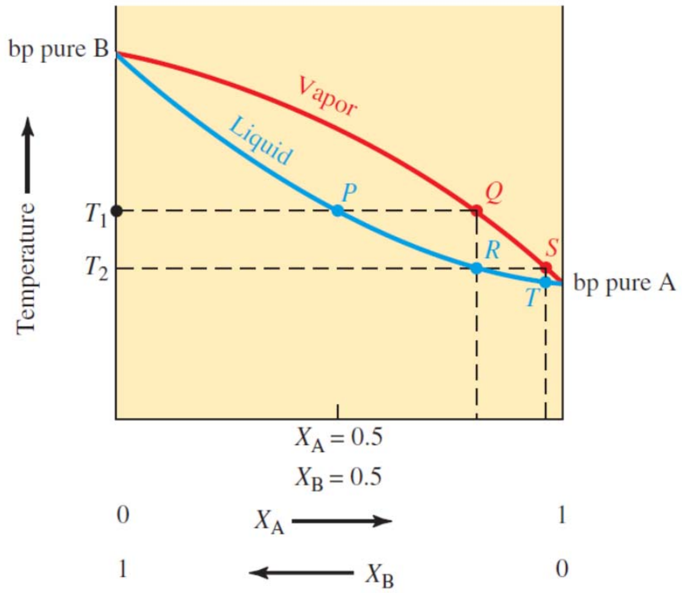
better: Diagram for p = const. und variable T



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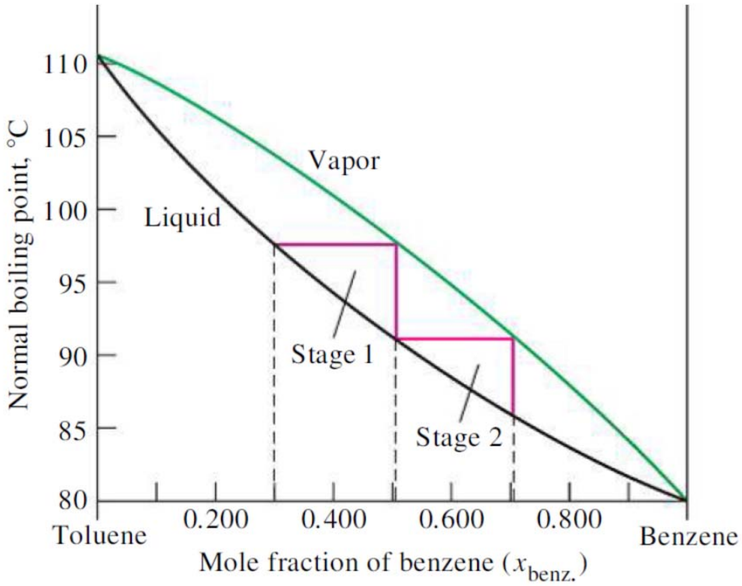

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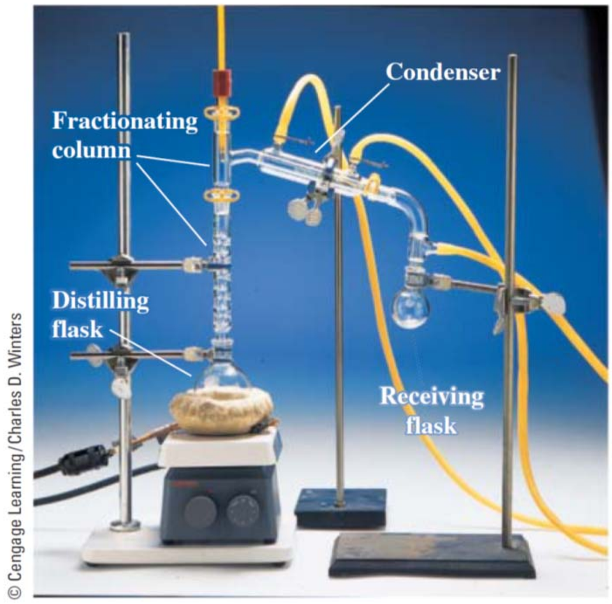
Distillation apparatus



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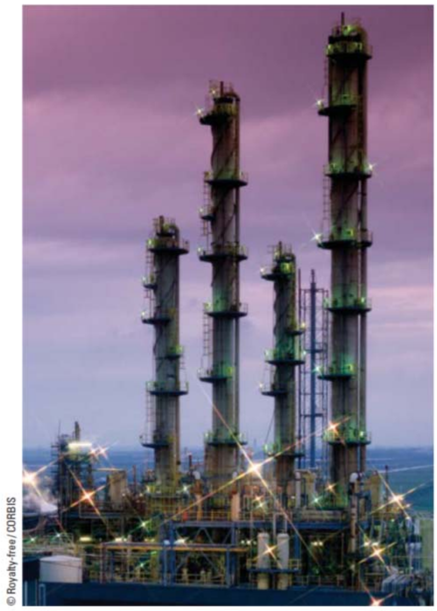

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