ASSIGNED READINGS:

TODAY'S CLASS: Ch.14: section 14.3

NEXT CLASS: finish Ch.14
(14.5 – detergents only – Lect.07)

(1)

How much solute is dissolved?
Qualitative terminology…

▪ **Saturated solution** = contains maximum concentration of solute that will dissolve in that solvent at that temperature

   NOTE: in a sat'd sol'n, have equal rates of dissolving and precipitating (an equilibrium situation…)

▪ **Solubility** = the quantity of solute dissolved in a saturated sol'n
   (often expressed as: g solute per 100mL water)

▪ **Unsaturated solution**: concentration less than saturated… more solute can dissolve

▪ **Supersaturated solution** (see Closer Look p.563)
   = a metastable state where too much solute is dissolved…
   …any disturbance ⇨ solute will precipitate suddenly

(2)

14.3 Environmental factors affecting solubility: temperature (T) & pressure (P)

Important for dissolving solids, liquids & gases

Important for dissolving gaseous solutes only

- **Is the dissolution process enthalpically favourable?** *(requires heat, or not?)*

  entropically favourable? *(will ↑T make ΔG ↑ or ↓?)*

- **Partial pressure of gas** determines frequency of collisions between gas & solution's surface

  ⇨ determines [gas] at which have balance of rates of gas dissolving & leaving solution

  = a saturated sol'n, at eqm, where [gas] = "solubility"

Entropic thinking important here...

(3)

Effect of Temperature	↑T ⇨ ↑ **Rate** of dissolution *(always)* ↑ **Solubility?** *...not always!*

TRENDS FOR <u>AQUEOUS</u> SOL'NS: for most cases...

Dissolved solids: solubility ↑ with ↑ T
- WHY? Dissolving is entropically favourable...
- Thus: $\Delta G_{dissolution}$ becomes more –ve as T ↑
- *So: To crystallize out solutes: cool down*

Exceptions: sodium sulfate, cerium sulfate

Dissolved gases: solubility ↓ with ↑ T
- WHY? Dissolving gas is entropically unfavourable...
- *Thus: To release gas (entropically favourable): warm up*

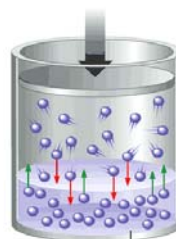<u>**To predict effect of T case by case:**</u> consider **both** ΔH & ΔS...
- *textbook discusses enthalpy only, because it's only Ch.14*
- *you should use Ch.19's entropy thinking - other way isn't always right!*

(4)

Effect of pressure: on gas solubility

- Pressure related to # gas molecules per unit volume
- higher P ⇨ more COLLISIONS with liquid
  - ⇨ ↑ rate of entry of gas into solvent
    exit unaffected

↑ P: ↑ Solubility

Henry's law: $C = k_H P$
concentration of dissolved gas
IS DIRECTLY PROPORTIONAL TO
partial P of that gas above the solution

In Kotz textbook, written:

$$S_g = k_H P_g$$

↑
Solubility: conc. of gas
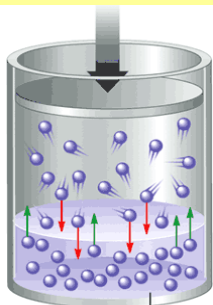in a sol'n saturated with
that gas at a given T & P

Gas	k_H (M/mm Hg)
Table 14.3 • Henry's Law Constants (25 °C)	
N_2	8.42×10^{-7}
O_2	1.66×10^{-6}
CO_2	4.48×10^{-5}

**IMPORTANT: ** unit analysis crucial here, especially P units! **
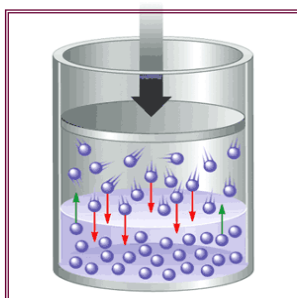often given solubility data at given partial P of gas (calculate own k_H)

Zumdahl's
Figure 11.5

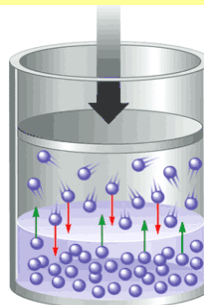## GASES DISSOLVE BECAUSE MOLECULES COLLIDE WITH THE LIQUID'S SURFACE...

SOLUTION AT EQUILIBRIUM

Balance between gas molecules entering (*dissolving*) & escaping from solution

CHANGE:
   ↑ PRESSURE
⇨ ↑ collisions
   with surface
⇨ ↑ rate of
   dissolution

RESULT:
   ↑ [dissolved gas]
⇨ ↑ rate of escape
⇨ new equilibrium
   reached

(6)

Example: supersaturated solutions containing GAS

Sudden $\downarrow$ in pressure $\Rightarrow$ gas <u>erupts</u> from solution!

Tragedy at Lake Nyos, Cameroon (K&T p.556)

- Lake in deep volcanic crater
  $\Rightarrow$ active vents beneath, emitting $CO_2(g)$

- Poor turnover of water
  $\Rightarrow$ depths sat'd with $CO_2(g)$ at high P_{CO_2}

> Aug. 21, 1986: Tremor? Δ in temperature?
> $\Rightarrow$ sudden turnover of water in lake
> $\Rightarrow$ high-$[CO_2]$ water now seeing low $P\textbf{CO}_2$ of air
> - 260 ft geyser of CO_2
> - dense gas cloud hugged ground; 45 mph
> - 1700 people died, 12 miles away
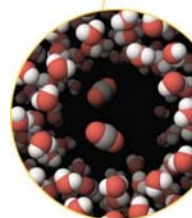
Now: PREVENTION: 200 m pipes <u>vent</u> depths

(7)

Example: CO_2 in your soda pop (from an old exam)

The solubility of gaseous CO_2 in water at 10°C is 0.240 g per 100.0 mL, under a pressure of 1.0 atm of carbon dioxide. During manufacturing, a soft drink at 10.0°C is saturated with CO_2 under a pressure ($P\, CO_2$) of 4.0 atm, and then sealed.

a) What mass of CO_2 is dissolved in a 355mL can of this drink?

> Ans: k = 0.0024 g/(mL·atm)
> m_{CO2} = 3.4 g dissolved

b) Imagine you open a can of this beverage and leave it open to the atmosphere (P_{TOTAL} = 1 atm) at 10°C to go "flat".
    [Air is ~ 0.031% CO_2 by mole; thus, P_{CO_2} = ...]
    What volume of CO_2 will be released from the beverage?

> Ans: $m_{CO2-dissolved}$ = 0.000264 g
> $m_{CO2-released}$ = 3.4077 g (all...)
> V_{CO2} at 1 atm = 1.8 L

(8)

ASSIGNED READINGS:

BEFORE NEXT CLASS:

Read: rest of Ch.14

Practice: Converting between concentration units
& solving gas solubility problems

Next class: finish Ch.14

(9)