

PHASE EQUILIBRIUM (K-values)

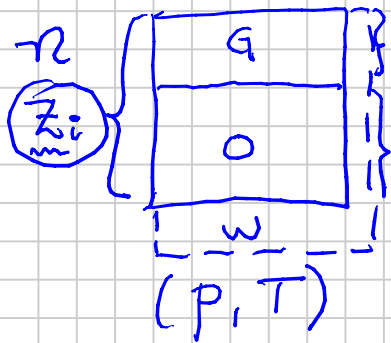
K_i Equilibrium Ratios

Note Title

2013-09-06

GAS-OIL

Molar Compositions



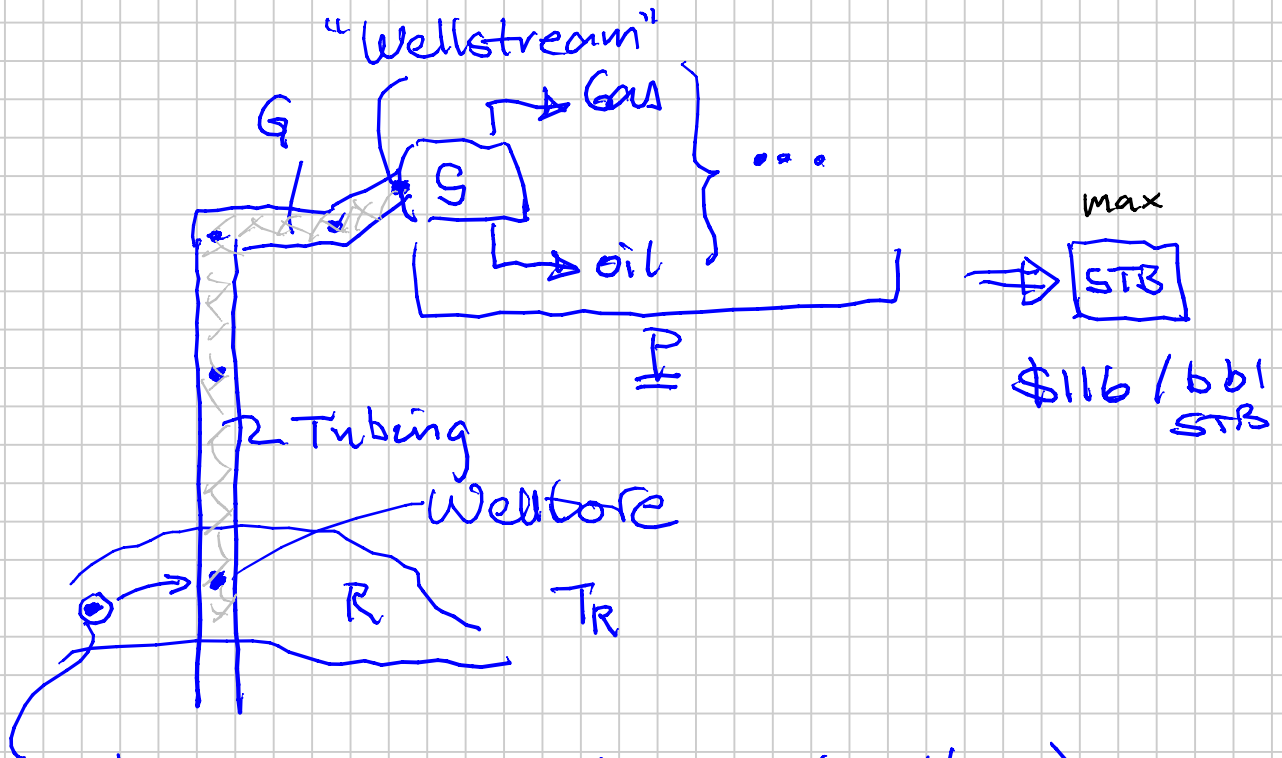
$$y_i = \frac{n_{ig}}{n_g}$$

$$x_i = \frac{n_{io}}{n_o}$$

$$K_i \equiv \frac{y_i}{x_i}$$

$$K_i(P, T, \bar{z})$$

Know @ Reservoir, Production Pipe, Surface Gathering Lines, Separator Unit



In-Situ Reservoir \neq Wellstream (Wellbore)

Behavior of K_i

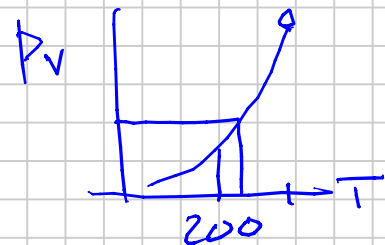
K_i represents (in lay terms) the relative preference of component i to "be" in the gas phase or oil phase:

$$K_i > 1$$

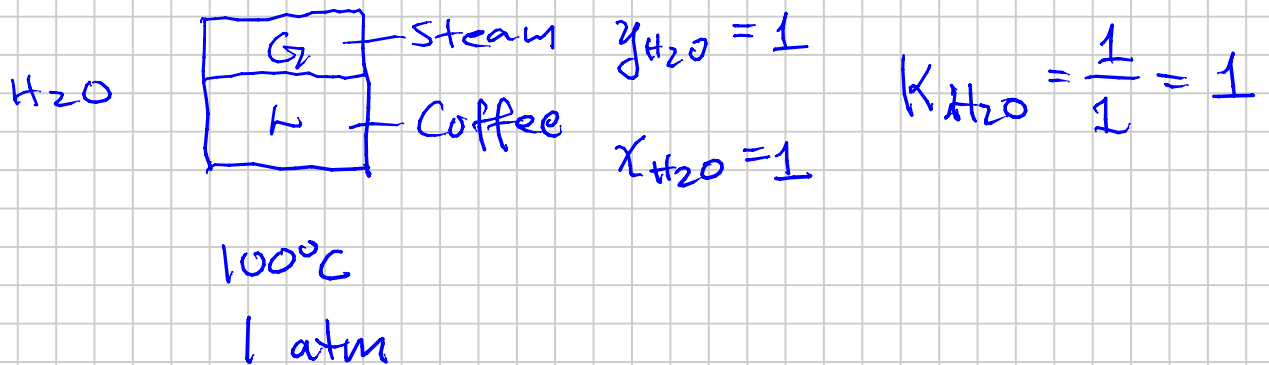
$$K_i < 1$$

We can make more money by selling component i as part of the liquid phase (ultimate processed surface)

5-10 times the value

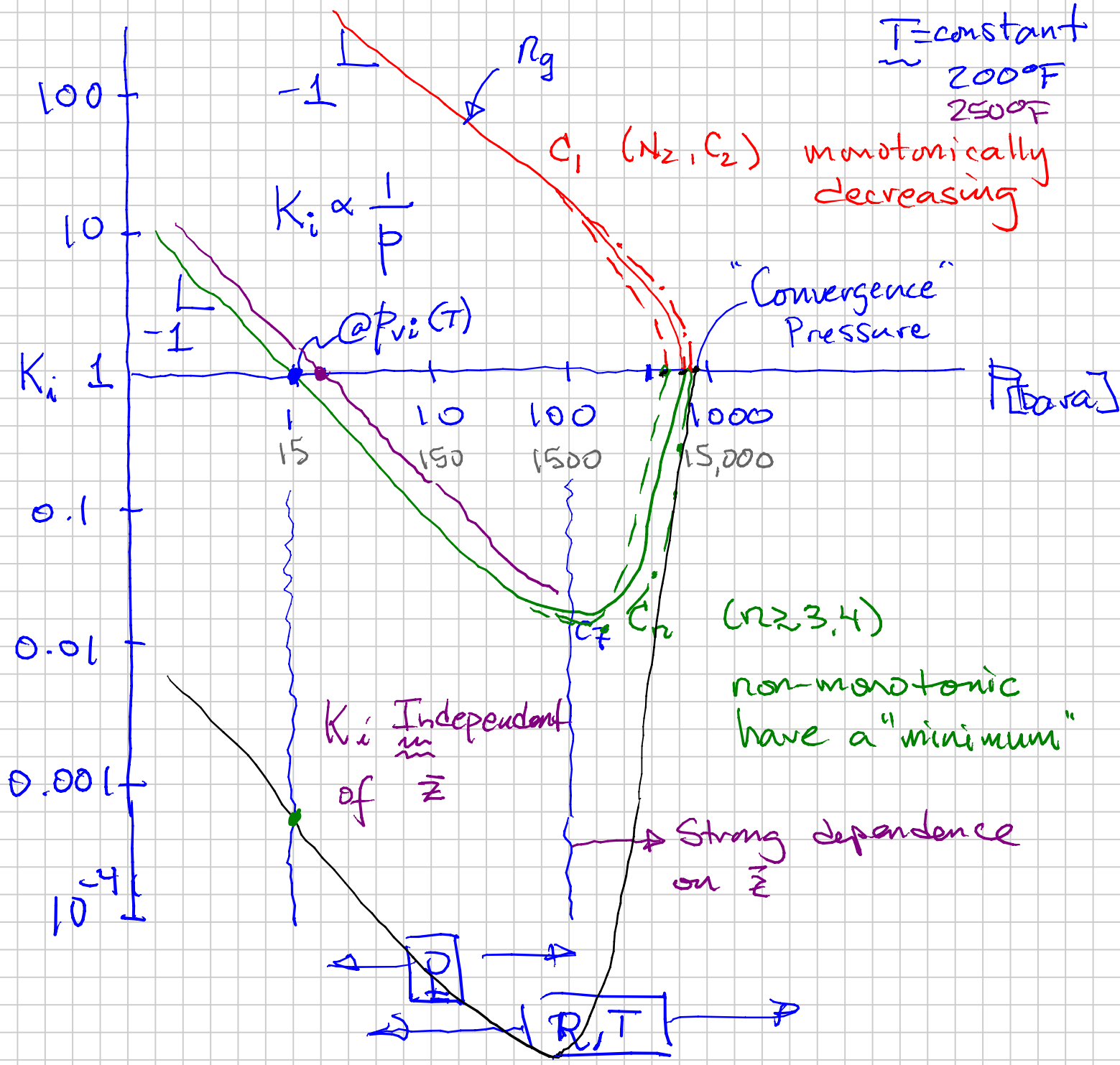


@ $P_v(T)$

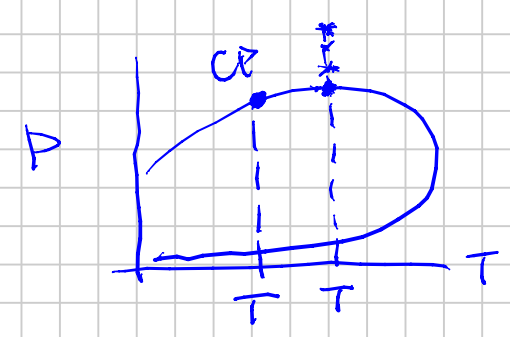


$$P_{vi}(T) \Rightarrow K_i (P \leq 100 \text{ bara}, T)$$

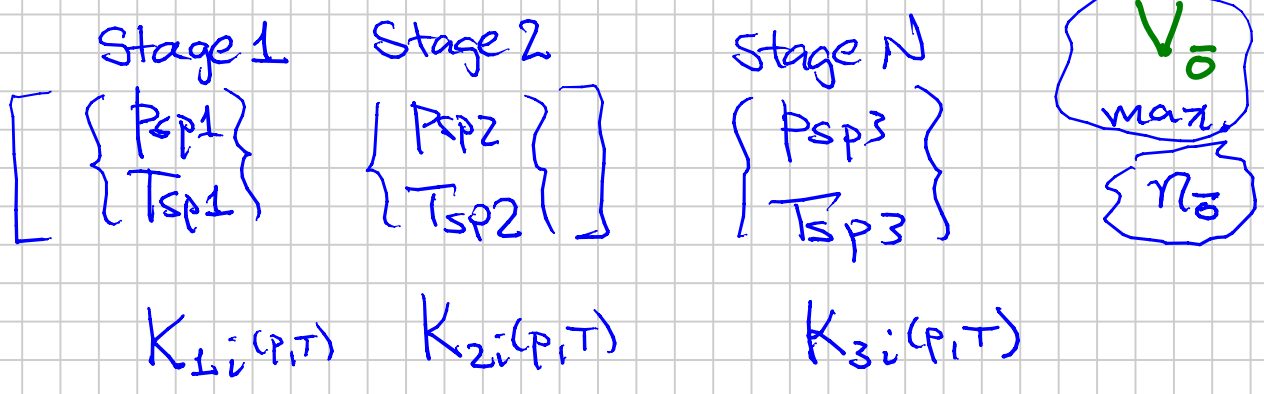
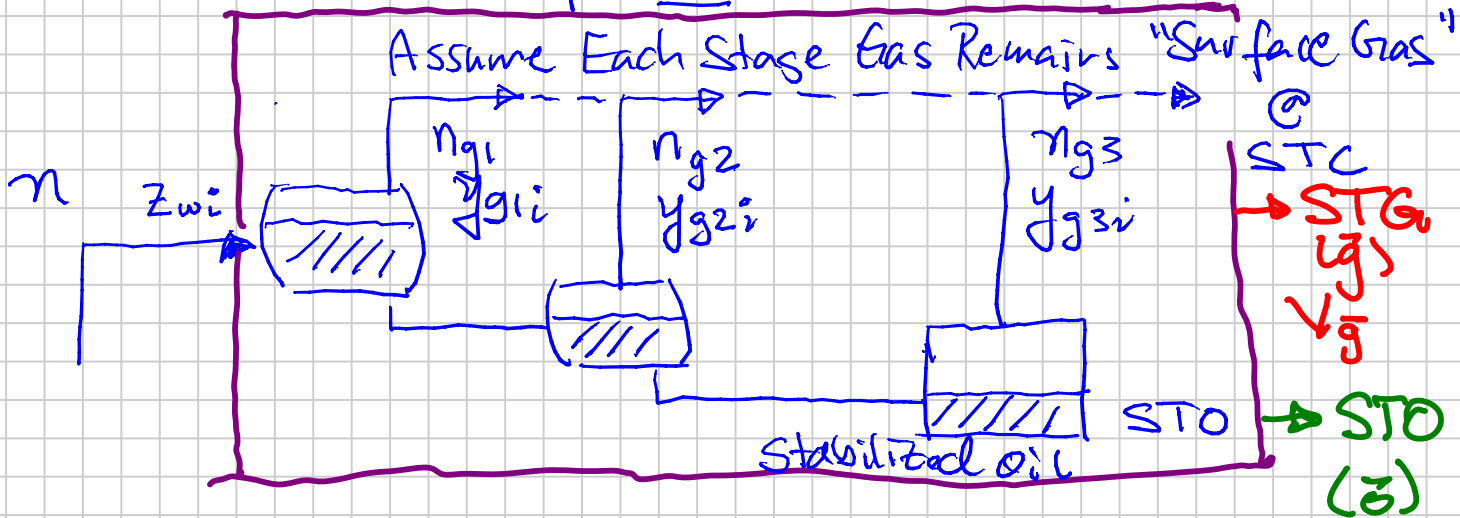
$$K_i = \frac{P_{vi}(T)}{P}$$



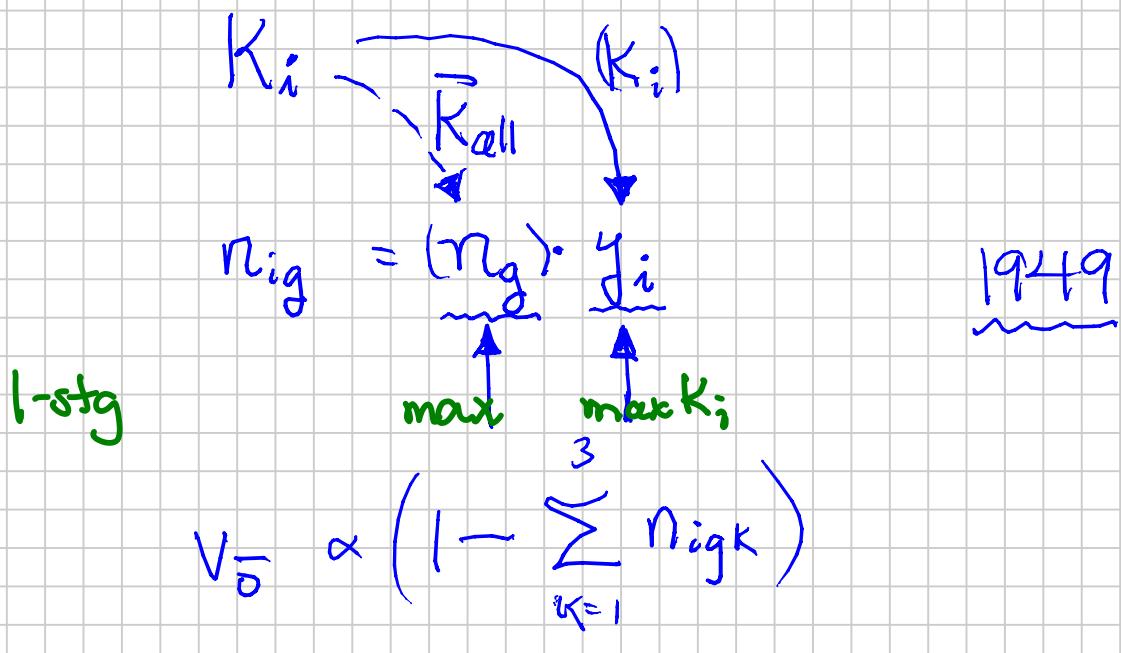
$K_{i \text{ min}}$ @ $\sim 50-120$ bara

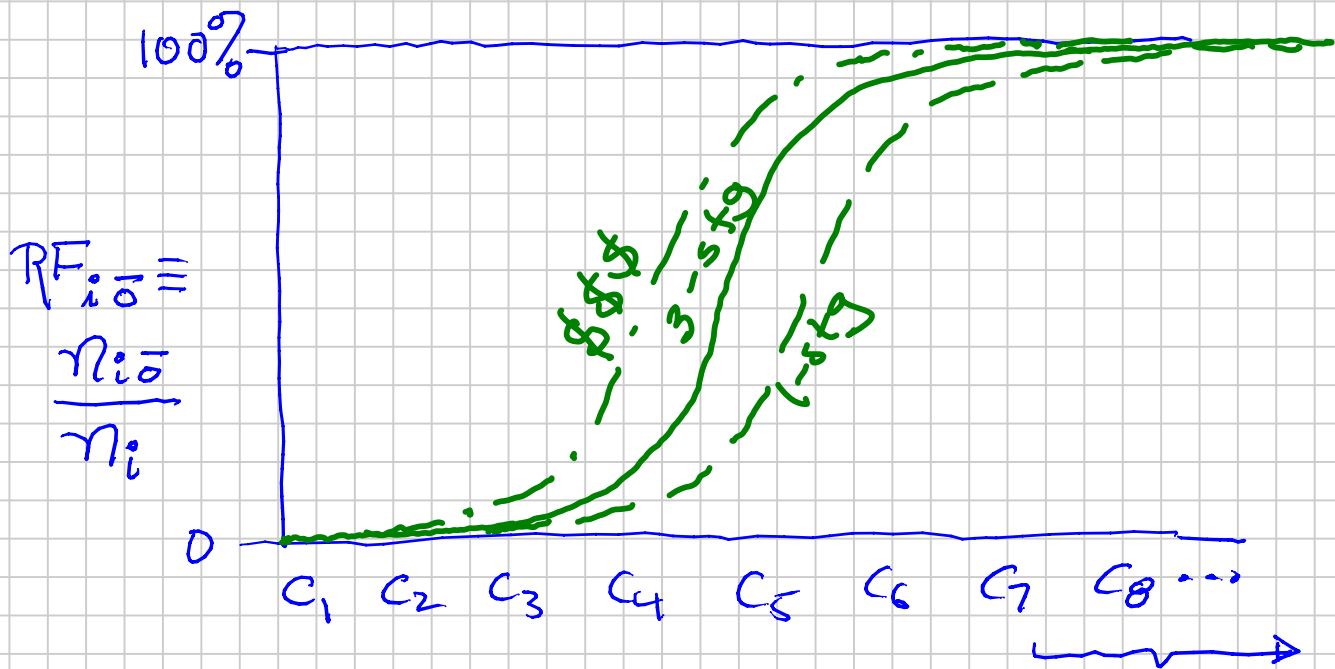


SURFACE PROCESSING "P"

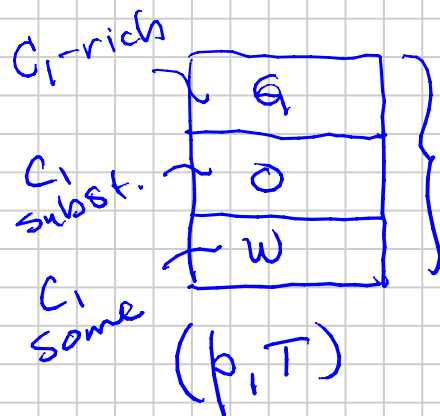


Controls the ultimate MOLES of $i \Rightarrow$ STO





Water - Gas - Oil Phase Equilibria



N₂
CO₂
C₁
C₂
C₃
⋮
C₇
⋮
C₂₀
⋮
C₃₆₊
H₂O

- Pore In-Situ
- Production Pipes
- Separator
- Ocean (Leakage Blowout)

In general

Rigorous

$$\text{Gas-Oil } K_i(p, T, \bar{z}) \approx K_i(p, T, \bar{z}^*)$$

↑
No H₂O

↑
H₂O
Included

Engineering Guideline

⇒ We can ignore H₂O component and aqueous phase when doing gas-oil phase equilibria calculations.

$$K_{wgi} \equiv \frac{y_i}{x_{wi}} \gg 1$$

$$K_{woi} \equiv \frac{x_i}{x_{wi}} \gg 1$$

all i except H₂O
Limited Solubility
in the Aqueous Phase

$\ll 1$ for H₂O \Rightarrow

$$K_{wgc_1} < K_{wgc_2}$$

CO₂

Methane

⋮

HCS

Decreasing
Solubility
↓

H₂O-G-O

When is solubility important?

① Gas production \Rightarrow water production

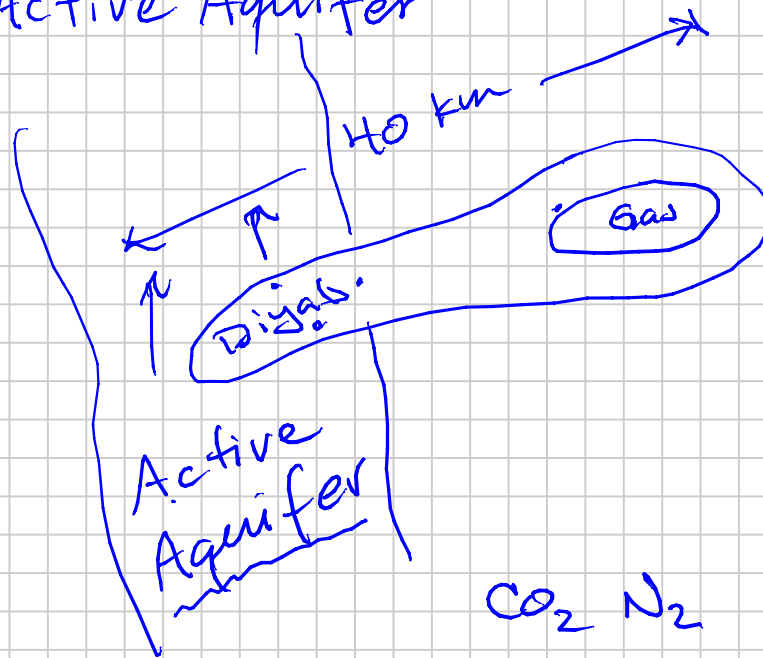
0.1-5 mol-% wellstream H₂O

- $T_R > 200^\circ\text{F}$
- $P_{wg} < 500 \text{ psia}$

② When oil & gas "sees" (mixes) with larger amounts of water that has not yet equilibrated ("seen") oil & gas yet.

- Injecting water (water flood)
- Offshore blowout situation

• Active Aquifer



Dakham

Gaseous Components (CO_2 , N_2 , C_1 , C_2 , C_3 ; Aromatics)