Reservoarfluider og Strømning
Reservoir Fluids and Flow
Course TPG 4145

Homework Problem 1

Handed Out: Jan. 12, 2018
Due Date: One week after handed out
Hand in on Blackboard as a single Excel file.
File Naming (mandatory!!!): LastName-Problem-1-Solution.xlsx

Problem 1 – **CO2-H2O Mixture Recovery Calculations**

Consider a 25 L (liter) container filled with sand with porosity of 20%. A saturated CO2-H2O mixture is injected at 100 bara[1] (bar absolute) and 20^{o}C.

Known:
Properties and compositions of saturated gas and saturated liquid (i.e. gas and liquid in equilibrium) at 100 bara and 20^{o}C, and at 1 bara and 20^{o}C based on the SRK EOS (with zero binary interaction parameters[2]).

Give results for the two cases:

1. Filling the tank with H2O liquid saturated with CO2.
2. Filling the tank with CO2 "gas"[3] saturated with H2O.

To be calculated after removing fluid from the tank until pressure reaches 1 bara:

(a) Recovery of surface products "gas" and "liquid"[4], removing fluids from top of tank.
(b) Recovery of surface products "gas" and "liquid", removing fluids from bottom of tank.

Solution Tips:

1. Case 1 with initial reservoir liquid, a component material balance will help solve the problem giving surface gas moles and surface liquid moles, then converting surface product moles into surface product volumes.
2. Case 2 for initial reservoir gas can be solved using the same method as Case 1, but the trick is to understand the meaning of the calculated surface liquid moles.

[1] "bara" is the pressure unit bar (10^5 Pa) "absolute". Another pressure type is used in petroleum applications, "barg", which is absolute pressure in bar (i.e. bara) minus atmospheric pressure of 1.0135 bara (1 atm). For example, 100 bara = 99 barg and 1 bara = 0 barg.
[2] BIPs (binary interaction parameters, see Ch. 4) for a mixture containing H2O should be non-zero to ensure accurate estimate of mole fractions in the aqueous and non-aqueous phases.
[3] Note that CO2-dominant phase (e.g. pure CO2 or H2O-saturated CO2) at 100 bara at 20^{o}C "behaves" like a liquid in terms of density. But don't let this affect the way you solve the problem, i.e. treat the CO2-dominant phase in Case 2 as if it is a gas phase (in fact it is!).
[4] The surface "gas" product is primarily CO2 but still contains some H2O in solution (just like air at standard conditions). The surface "liquid" product is primarily H2O but still contains some CO2 in solution (just like "dead" soda water which isn't quite dead!).

TABLE 1 – CO2-H2O saturated mixture properties.

CO2-H2O saturated mixture at 100 bara and 20 C									
SRK EOS									
Temp	Pres	Liquid Density	Gas Density	Liquid	Gas	CO2 y	H2O y	CO2 x	H2O x
(C)	(bar)	kg/m3	kg/m3	MW	MW	mol frac	mol frac	mol frac	mol frac
20	100	1005.2	850.157	18.078	43.774	9.9091E-01	9.0880E-03	2.4323E-03	9.9757E-01
20	1	1001.6	1.797	18.017	43.560	9.8269E-01	1.7308E-02	5.9069E-05	9.9994E-01