H-12

Problem 1

A bottom hole sample of a reservoir fluid undergoes a single flash to standard conditions. Compositional analysis of STO and gas is performed for the following components:

C_1, C_2, C_3, i-C_4, n-C_4, i-C_5, n-C_5, C_6, C_7, C8, C_9, C_{10+}

PS! In the following calculations, the components are numbered in the same order, i. e. totally 12 components.

The following data are given:
GOR = 5000 Sm^3/Sm^3

Molefraction of gas:	y_i, (i=1-12)
Molefraction of STO:	x_i, (i=1-12)

M_{STO} = 200kg/kgmol
$\gamma_g = 0.70$
ρ_{STO} = 800 kg/m^3

It is supposed that the reservoir is "closed", and the following data are given:

T_{res} = 400 K
P_i = 400 bar
P_d = 300 bar at T_{res}

Bulk volume:	10^6 m^3
Porosity:	Φ=0.2
Residual water saturation:	S_{wr}=0.2

Compressibility factors:
- Z_i at P_i and T_{res}
- Z_d at P_d and T_{res}

a.
1. Characterize the reservoir fluid by a PT-diagram.
2. Give a short description of the experimental principles for determining:
   a. M_{STO} (use formula)
   b. ρ_{STO}

b.
The composition of STO is determined by GC-analysis, and the following data are given:

Mass of STO:	10 g	
Mass of standard:	1.0 g	
Area of standard:	A_s	
Area of comp. C_1-C_9:	A_i,	(i=1-11)
Mole weight of comp. C_1-C_9:	M_i,	(i=1-11)
Density of comp. C_1-C_9:	ρ_i, (kg/m^3)	(i=1-11)

1. Give a short description of the principles for the GC-analysis regarding:
    a. Standard used
    b. Detector (properties)
    c. How the components are quantified (give formula, response factor, etc.)
2. Derive a formula for the weight % of the components C_1-C_9, $(w\%)_i = f(A_i, A_s)$; (i=1-11).
3. Give a formula for weight% of C_{10+}, $(w\%)_{C10+} = f(A_i, A_s)$.
4. Derive a formula for M_{C10+}, $M_{C10+} = f((w\%)_{C10+}, (w\%)_i, M_i)$; (i=1-11)
5. Derive a formula for mole fraction of each component, $x_i = f((w\%)_i, M_i)$; (i=1-12).
6. Derive a formula for ρ_{C10+}(kg/m^3), $\rho_{C10+} = f(x_i, M_i, \rho_i)$.
   For x_i and M_i; (i=1-12), and for ρ_i; (i=1-11).

c.

The composition of the reservoir fluid, z_i as mole fraction, is determined by a mathematical recombination of the composition of STO and gas. Determine a formula showing $z_i = f(x_i, y_i)$.

d.

Calculate initial oil and gas in place, IOIP and IGIP = $f(Z_i)$ as Sm^3.

Addition 1.
Important formula/correlations in PVT-Analysis.

Temperature:

$^oK = 273.15 + {}^oC$
$^oF = 1.8 \times {}^oC + 32$
$^oR = {}^oF + 459.69$

Pressure:

1atm = 1013.250 mBar = 1.013250 bar = 101.3250 kPa = 0.1013250 MPa = 14.69595 psia
psia = 14.69595 + psig
1 atm = 760.002 mmHg at 0 ^oC

Density:

1 g/cm^3 = 62.43 lb/ft^3 = 350.54 lb/bbl
1 lb/ft^3 = 16.0185 kg/m^3
$\rho_w = 0.999015$ g/cm^3 (60 ^oF, 1 atm)
$\rho_w = 0.9991$ g/cm^3 (15 ^oC, 1 atm)

Specific density:

For liquids: Determined relative to water at sc.
For gases: Determined relative to air at sc.

$$\gamma_o = \frac{\rho_o}{\rho_w} = \frac{141.5}{131.5 + {}^oAPI}$$

$$^oAPI = \frac{141.5}{\gamma_o} - 131.5$$

Cragoe`s formula (empirical formula giving molecular weight of hydrocarbons):

$$M_o = \frac{6084}{^oAPI - 5.9}$$

$$\gamma_g = \frac{M_g}{M_{air}} = \frac{M_g}{28.96}$$

Volume:

1 bbl = 5.615 ft^3 = 0.15898 m^3
1 ft^3 = 0.0283 m^3
1 US Gallon = 3.785 litre
1 Imp. Gallon = 4.546 litre
Molar volume of gas at standard conditions:
V_m = 379.51 SCF/lb mole (60 ^oF and 14.69595 psia)
V_m = 23644.7 cm^3/g mole = 23.6447 m^3/kg mole (15 ^oC and 101.3250 kPa)

Air:

$Z_{air} = 0.9959$ (60 ^oF, 14.69595 psia)
$M_{air} = 28.96$

Gas constant:

R = 10.732 (psia, ft^3, ^oR, lb mole)
R = 0.082054 (atm, litre, ^oK, g mole)
R = 8.3145 (kPa, m^3, ^oK, kg mole)