NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF PETROLEUM ENGINEERING
AND APPLIED GEOPHYSICS

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Exam results are due in week X, 2012
Sensur faller i uke X, 2012

EXAM IN COURSE TPG4145 RESERVOIR FLUIDS
EKSAMEN I EMNE TPG 4145 RESERVOARFLUIDER

Monday December 19, 2011
Mandag 19. desember 2011

Time/Tid: 0900 – 1300

Permitted aids/Tillatte hjelpemidler:
C:
ONLY (1) SPE *Phase Behavior* monograph volume 20 in original book form; handwritten notes written within the original book allowed, and (2) Good Oil Well #4 PVT Lab report.
NTNU allowed calculator.

Hjelpemidler:
C:
KUN (1) SPE *Phase Behavior* monograph volume 20 i original bokform og Good Oil Well #4 PVT Lab Rapport; håndskrevende notater skrevet inni den originale boken er tillatt..

General

Fig. 1 illustrates the geologic setting assumed for the Good Oil Well #4, with an overlying oil sand and underlying gas sand that is separated from the oil sand by a sealing shale.

The oil well sample collected and reported in the Good Oil Well #4 laboratory report is the only fluid sample collected from the well. All questions in the exam refer to this well and the two reservoirs which it penetrates.

Assume initial reservoir pressure and temperature are the same in both gas and oil sands (taken from PVT report).

Other relevant properties are given in Table 1. Some properties you may need to assume, and if so, state these assumptions clearly in your answers.

Problem 1: Gas Sand.

The interpretation of pressure-depth data through the gas sand suggested a reservoir gas specific gravity of 0.60 (air=1).

A. Assuming the gas sand consists only of methane and ethane, estimate the gas-sand composition.
B. Calculate initial gas density, and express it as a pressure gradient (psi/ft or bar/m).
C. Calculate initial gas in place.
D. Calculate the kg-moles of initial reservoir gas.
E. How long will it take to produce 50% of the initial gas in place if the producing rate is maintained constant at 5.0E6 scf/D (1.416E5 Sm^3/d)?
F. What is the average reservoir pressure after having produced 50% of the initial gas in place?
G. What is the flowing bottomhole pressure after having produced 50% of the initial gas in place?

Use the straight-line gas material balance, and assume the pressure-squared reservoir rate equation is valid. On part F, to get an exact answer, tedious trial-and-error is required; you only need to give an approximate estimate based on two Z-factor calculations, plotting p vs p/Z.

Problem 2: Oil Sand.

Prior to the bottomhole sampling and laboratory PVT study, a short production test gave the following data: total producing gas-oil ratio of 504 scf/STB, 43 ^{o}API stocktank oil gravity, and average separator gas gravity of 0.91. Use these production test data to solve part A. Use the laboratory PVT report to solve all other parts of this problem.

A. Estimate from correlations the oil viscosity (at reservoir temperature) and at (i) initial pressure, (ii) bubblepoint pressure, and (iii) 1 atm. Compare and discuss briefly these values with laboratory PVT report oil viscosities measured on the bottomhole sample.
B. Calculate the oil-gas viscosity ratio μ_o/μ_g in the oil sand when the reservoir pressure is 650 psig.
C. What is the most efficient of two-stage separation processes given on Page 6.
D. Calculate initial oil in place assuming the most efficient two-stage separation.
E. Calculate initial solution gas in place assuming the most efficient two-stage separation processes.
F. Calculate the kg-moles of initial reservoir oil.

Recommended correlations for oil viscosity include Figs. 3.20, 3.22 and Eqs. 3.117, 3.123-3.124, and Eq. 3.130. Charts, if available, are good enough for exam usage.

Problem 3: Gas and Oil Sand Commingled Production.

This problem considers the situation where Good Oil Well #4 is perforated not only in the oil sand but also in the gas sand, with both zones being open to flow. During a production test with both sands producing, surface samples were collected.

A. Calculate the mole fraction $f_{gi} \equiv n_{gi}/(n_{gi}+n_{oi})$, where n_{gi} and n_{oi} represent gas-sand and oil-sand initial moles in place.
B. For methane, ethane and C_{7+} only, calculate the total molar composition of the "field" oil sand + gas sand – (z_{C1}, z_{C2}, z_{C7+}).
C. The producing wellstream mixture composition is estimated to be given by z_i in part (B). The separator samples were brought to a laboratory; the physically-recombined mixture was equilibrated at initial reservoir conditions. The equilibrium vapor mole fraction f_V was found to be close to f_{gi} (part A). Calculate the equilibrium gas and equilibrium oil compositions of methane and ethane: y_{C1}, y_{C2}, x_{C1}, and x_{C2}. Use equilibrium ratio estimates for methane and ethane of K_{C1}=2.0 and K_{C2}=0.75 at initial reservoir conditions.
D. Estimate the percent of oil in the PVT cell from part C, at initial reservoir conditions.

TABLE 1 – RESERVOIR DATA FOR OIL SAND AND GAS SAND RESERVOIRS PENETRATED BY GOOD OIL WELL #4.

	Oil Sand	Gas Sand	Units	Oil Sand	Gas Sand	Units
Bulk Volume (Ah)	2800	19200	acre-ft	3.46E+06	2.37E+07	m3
Average Thickness (h)	10	30	ft	3.05	9.15	m
Average Porosity (ϕ)	0.21	0.26		0.21	0.26	
Average Water Saturation (Sw)	0.32	0.22		0.32	0.22	
Average Permeability (k)	30	50	md	30	50	md

Fig. 1 – Schematic of Oil Sand and Gas Sand Reservoirs penetrated by Good Oil Well #4.