Exam Petroleum Engineering (TA3440)

11 APRIL 2011 9:00 – 12:00

Instructions

- This exam consists of 10 questions, some of which are divided in sub-questions. The rating of each question is indicated behind the question in brackets. In total 13.5 points can be earned.
- If you cannot answer a sub-question and can therefore not proceed to the next sub-question, guess the answer and proceed anyway.
- State your assumptions and explain your answers.
- The exam is 'closed book'.
- **Exams written with pencil cannot be accepted!**

Questions

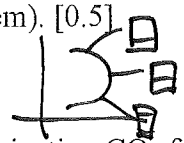
1. Explain the terms primary, secondary and tertiary oil recovery. Give two examples for each of these kinds of oil recovery (thus in total at least 6 examples) and explain them shortly. [1.0]

2. Draw schematically the oil volume formation factor B_o and the solution gas-oil ratio R_s as function of the pressure at a constant temperature? Explain shortly the curves. [1.0]

3.
   a. Explain the following terms: mud pressure and pore-fluid pressure [0.5]
   b. Explain the term formation strength and explain how it is calculated; give the formula. [0.6]
   c. Explain what over-balanced drilling is. [0.4]

4.
   a. Draw schematically in one graph the pressure as function of the depth for respectively water, oil, gas and the rock. Explain why the four pressure gradients in this graph are different. [0.5]
   b. Explain with the help of a graph and some notes how the oil-water contact (OWC) and the gas-water contact (GWC) is determined. [0.5]

5.
   a. After production of the reservoir fluid to the surface, the reservoir fluid is separated into gas, oil and water. Give the requirements for water, gas and oil to be reached by separation. [0.5]
   b. For the design of the vapour-liquid separator, the so-called K-factor is used. Explain the meaning of the K-factor. To illustrate the K-factor use a schematic pressure, composition diagram at constant temperature displaying a vapour-liquid two-phase region (for a binary system). [0.5]



6.
   a. What is the purpose of injecting CO_2 for enhanced oil recovery? That is, how does it influence the oil production? Support your answer. [1.0]
   b. Does CO2 injection increase sweep efficiency, or displacement efficiency, or both? [1.0]

7.

a. Draw schematically the inflow performance curve for a gas and an oil reservoir. Explain the different behaviour. [0.5]
b. Explain the terms damage skin and geometric skin. Illustrate your explanations with a schematic drawing. [0.5]
c. Explain the terms 'coning' and 'cusping'. Give in total four causes for coning and cusping. [0.5]

8. What are the (contractual) reasons why one attempts to establish a long plateau production when producing gas reservoirs? [1.0]

9.

a. Explain the term water-wet, oil-wet and partial wet. Support your answer with schematic drawings. Which property is used for characterisation of wettability? [0.5]
b. Derive the relation between capillary pressure and interfacial tension and the contact angle. [0.5]
c. Explain the term absolute permeability and relative permeability.[0.5]
d. Make a schematic drawing of the relative permeability as function of the saturation of the wetting-phase. Explain the shape of the curves. [0.5]

10. For this question, refer to the figure below, which was discussed in the lecture. For a given waterflood, the superficial velocity u is about 1 m/day (about 10^{-5} m/s in SI units), the interfacial tension σ is 0.03 N/m, and the water viscosity is 1 cp (0.001 Pa s). This leaves behind a waterflood residual oil saturation. The desire is to reduce this to virtually zero, by either increasing the superficial velocity, increasing the viscosity, or reducing the interfacial tension.

a. What viscosity would be needed to achieve this goal by increasing the viscosity? Answer in either cp or Pa s, but make clear which units you are using? [0.5]
b. What would this increase in viscosity do to injectivity? (You don't need to give a number; just give a qualitative answer.) [0.5]
c. Suppose instead the decision is made to reduce interfacial tension. What value of interfacial tension would be needed to achieve the goal of virtually zero residual oil saturation? Answer in units of N/m. [0.5]