PE 120 Fundamentals of Petroleum Engineering

Final exam 2002

Part A: Quick questions

- 1. Oil, water and gas are present in a reservoir rock. Which of these do you expect to fill the largest pores? Explain.
- 2. a) Explain what is relative permeability.
 - b) Suppose that oil and water are both present in an oil-wet rock. In one figure, sketch typical relative permeability curves for the oil and the water as function of the water saturation. Comment on your drawing.
- 3. Explain what is meant by the instantaneous gas-oil ratio. Why can this gas-oil ratio be large if the reservoir pressure is below bubble point?
- 4. Explain what is retrograde condensation. When can retrograde condensation have an adverse effect on production?
- 5. How many pounds does one barrel of 40° API gravity oil weigh?

Part B

IF YOU USE GRAPHS TO ANSWER ANY OF THE QUESTIONS IN PART B, PLEASE INDICATE WHICH GRAPHS YOU USED. ALWAYS EXPLAIN YOUR COMPUTATIONS, **DO NOT JUST GIVE THE SOLUTIONS**.

Questions marked with (*) are considered a little challenging.

- 1. In the notes, we derived an equation for the volumetric flow rate for radial flow near a well.
 - a) Find an expression for the flux velocity in radial flows.
 - b) What happens to the flux velocity as the radius r goes to 0? Did you expect this? Explain.
 - c) (*) How could you deal with the behavior found in b) in a reservoir flow simulator?
- 2. Water and oil flow simultaneously in a horizontal core (k=100 md) of length 10 cm and diameter 4 cm. The inlet pressure is 4 atm and the outlet pressure is 1 atm. We define the total flow rate as the sum of water flow rate and oil flow rate in the core. Assume the water viscosity is 1.0 cp and the oil viscosity = 4.0 cp. The relative permeabilities are given by the formulae

$$k_{\rm rw} = 0.4 \left(\frac{S_{\rm w} - 0.2}{0.6}\right)^2,$$

$$k_{\rm ro} = 0.8 \left(\frac{0.8 - S_{\rm w}}{0.6}\right)^2$$

The corresponding curves are shown in the picture below.

- a) Determine the minimum and maximum total flow rates and the corresponding water saturations.
- b) What would the answers be for part a) if the core was vertical instead of horizontal?
- c) Is this rock water-wet or oil-wet? Explain.
- d) (*) If a gas was introduced in this core, would the gas relative permeability depend on the water saturation, the oil saturation or both? Explain your answer clearly.



3. a) A gas has the following composition:

y _i (mole	fraction)
0.8	
0.1	

C3 0.1

C1 C2

- (i) What is the molecular weight of this gas?
- (ii) What is the gas gravity of this gas?
- (iii) What is the density of this gas at a pressure of 3224 psia and temperature of 123° F?

b) A petroleum reservoir produces a fluid from a reservoir at 2000 psia and 150°F. The fluid has the following composition:

C1	0.3406	n-C5	0.0311
C2	0.0655	C6	0.0298
C3	0.0984	C7+	0.3881
n-C4	0.0465		

Determine whether the reservoir is two-phase, single phase gas or single phase liquid. You may use K-factors of C8 for the C7+.

4. The following PVT data are available for a reservoir. The reservoir is assumed to have 275 MM STB of oil in place initially. There is no free gas. The original pressure was 3600 psia. The current pressure is 3400 psia, and 732,800 STB have been produced.

pressure (psia)	Solution gas-oil ratio (SCF/STB)	Formation volume factor (bbl/STB)
3600	567	1.310
3200	567	1.317
2800	567	1.325
2500	567	1.333
2400	554	1.310
1800	434	1.263
1200	337	1.210
600	223	1.140
200	143	1.070

- a) Explain why the formation volume factor first increases and then decreases as the pressure decreases. What causes the initial increase in formation volume factor? At the current conditions, is the reservoir saturated or under-saturated?
- b) Compute the current N_p. Is water influx a contributing factor to the production of this reservoir? Explain why or why not.
- c) How much oil will have been produced by the time the reservoir pressure is 2700 psia?