

Exam Petroleum Engineering (TA3440)

3 APRIL 2008 9:00 – 12:00

Instructions

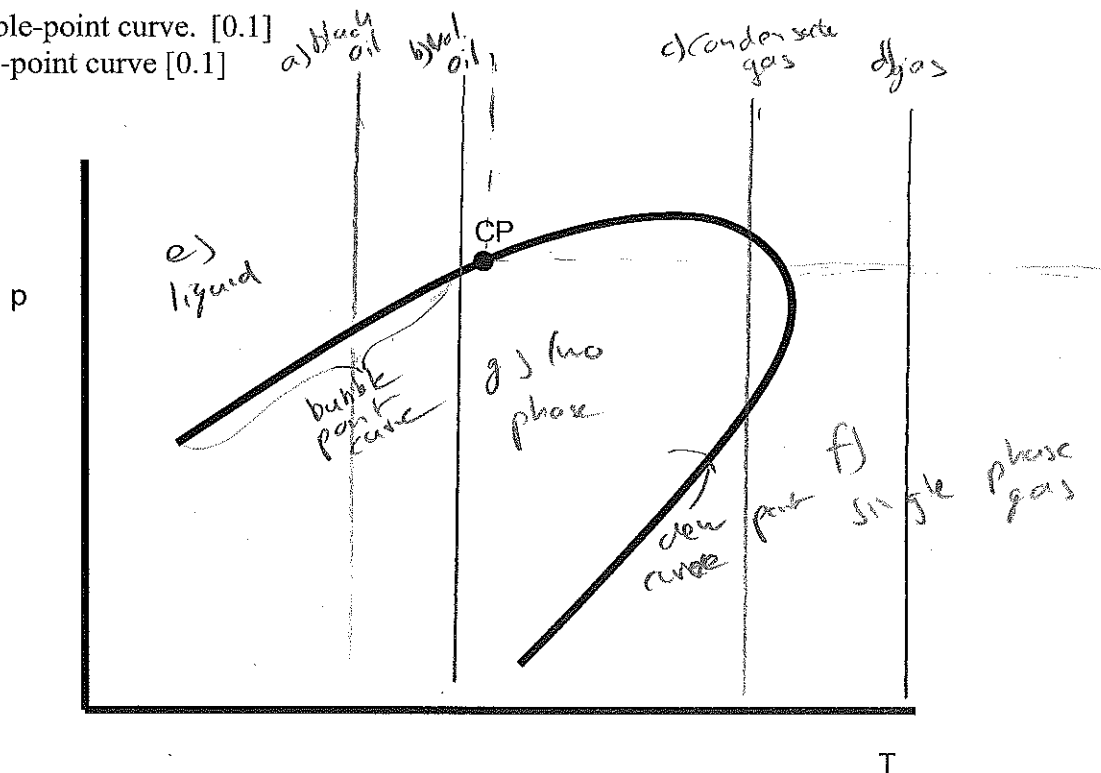
- This exam consists of 10 questions, some of which are divided in subquestions. The rating of each question is indicated behind the question in brackets. In total 10 points can be earned.
- If you cannot answer a sub-question and can therefore not proceed to the next sub-question, guess the answer and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

Questions

1. Consider the phase diagram given below (Figure 1). Indicate in the diagram the following kinds of reservoirs:
 - a. Black oil [0.1]
 - b. Volatile oil. [0.1]
 - c. Condensate gas [0.1]
 - d. Gas. [0.1]

Further indicate the following regions or lines in the graph:

- e. Single phase region liquid [0.1]
- f. Single phase region gas [0.1]
- g. Two phase region [0.1]
- h. Bubble-point curve. [0.1]
- i. Dew-point curve [0.1]



2.

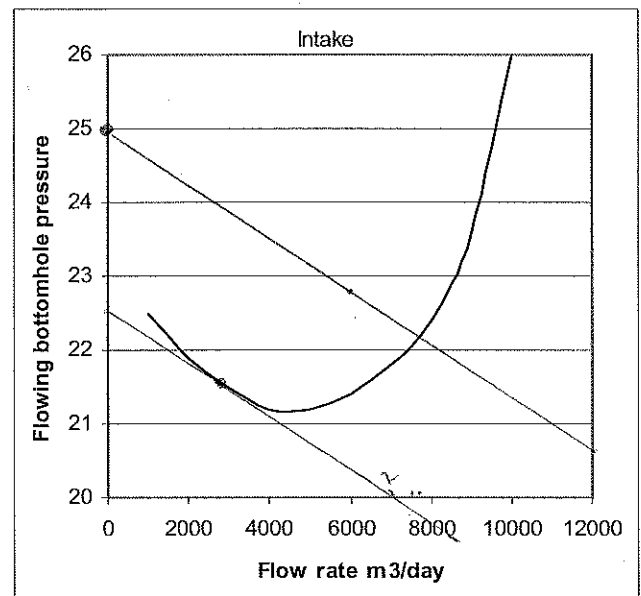
- a. Describe two functions of the drilling mud. How does the mud reach the bottom of the well, and how does it return to the surface? [0.5]
- b. If you are drilling into the top of a reservoir at 3000 m depth, containing a 300 m gas cap above a hydrostatically pressured aquifer, what is the minimum mud weight (in kg/m^3) you need to avoid an influx? Assume that the gas pressure gradient is 2 kPa/m and the water gradient 10 kPa/m. [0.5]

3.

- a. A new separator system is to be designed. State one main criterion for optimising the composition of the liquid output stream. State one main criterion for optimising the composition of the gas output stream. What is the disadvantage if too many light components are kept in the liquid phase? [0.3]
- b. Give three main factors which determine the size of a separator. [0.3]
- c. Give two reasons for using a vertical separator rather than a horizontal separator. [0.2]

4.

- a. Initially the pressure in a reservoir is 25 MPa. When the well produces 6000 m^3/day , the flowing bottomhole pressure is 22.8 MPa. What is the Productivity Index? [0.2]
- b. The intake pressure curve for the well is shown in the figure. What is the initial production rate? [0.2]
- c. If the PI stays constant, as the reservoir pressure drops, what is the lowest reservoir pressure at which the well will flow? [0.2]
- d. Explain what formation damage is ("skin"). How can skin be detected in the well? Indicate three causes of formation damage? [0.5]



5. Is the formation volume factor for oil typically
 - a. much smaller than 1
 - b. a little smaller than 1
 - c. 1
 - d. a little larger than 1,
 - e. much larger than 1?Why does it have this magnitude? [0.9]

6. Is the formation volume factor for gas typically
- much smaller than 1
 - a little smaller than 1
 - 1
 - a little larger than 1,
 - much larger than 1?

Why does it have this magnitude? [0.9]

7. Explain the following concepts in one sound bite and give ranges of typical values, e.g., $0.1 < S_{wc} < 0.3$:
- connate water saturation (S_{wc}) [0.2],
 - residual oil saturation (S_{or}) [0.2],
 - end point water relative permeability (k'_{rw}) [0.2],
 - end point oil relative permeability (k'_{ro}) [0.2],
 - water viscosity μ_w [0.2],
 - oil viscosity μ_o [0.2] and
 - fractional flow function f_w [0.2].

8.

Derive or give the numerical upstream weighting scheme for water displacing oil from left to right in a porous medium in the form of $S_w(t+\Delta t) = S_w(t) + etc.$

Give the scheme in terms of:

- the water flowing in over the west-boundary and leaving over the east boundary,
- of the total Darcy velocity u ,
- the fractional flow function f_w ,
- the porosity ϕ and
- the space step Δx and time step Δt .

Use the grid cell configuration W-P-E, where W is the centre of the left cell, P is centre of the middle cell, and E is the centre of the right cell. The distance between cells is Δx .

[1.0]

9. What is the definition of “risk” (as covered during the lectures on HSE management) and how is this concept used in the “risk matrix”? [1.0]

10. What is the NPV of the following cash flow at discount rates of 0 and 15%? [1.0]

Table 1: Undiscounted cash flow						
Time (year)	1	2	3	4	5	6
Cash flow (10^6 \$)	-9.3	-4.2	3.8	4.9	3.5	2.4