Exam ta3440 Petroleum Engineering

22 March 2004

Instructions

- This exam consists of 8 questions, some of which are divided in subquestions. The rating of each question is indicated behind the question in brackets.
- Duration: 3 hours.
- 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.

Questions

1. A project team has developed the following two offshore scenarios for a new satelite development from an existing production platform in 70 m waterdepth.

   1a) Which scenario would you recommend at an oil price of 23 $/bbl, and a discount rate of 15%? Use a 40% royalty, a variable Opex of 0.80 $/bbl and neglect fixed opex and taxes. (1 point)

   1b) Both scenarios have the same number of wells, which can all be drilled using a jack-up rig. What may cause the difference in well costs? (½ point)

Table 1: Sub-sea development scenario

Time (year)	*Drilling costs ($)*	*S/S wellheads ($)*	*Production (bbl/d)*
1	*86*	*20*	*10,000*
2	*124*	*34*	*30,000*
3			*28,000*
4			*21,000*
5			*15,000*
6			*10,000*
7			*6,000*

Table 2: Wellhead platform development scenario

Time (year)	*Drilling costs ($)*	*Platform ($)*	*Production (bbl/d)*
1		*54*	
2	*44*		*10,000*
3	*62*		*30,000*
4			*28,000*
5			*21,000*
6			*15,000*
7			*10,000*
8			*6,000*

2. Consider a well in the centre of a square reservoir and one in the centre of a circular reservoir. Except for their areal shape the reservoirs share the same parameters, including total area. Which well has the highest Productivity Index (P.I.) and why? (½ point).
3. When producing a gas reservoir at a constant bottom hole pressure the rate decreases approximately exponentially. Explain this behaviour. (1 point)
4. Table 3 gives part of a survey file of a deviated well at a point where the drill string is in tension.

   4.a) Calculate the dogleg severity for the two hole sections in Table 3. (½ point)

   4.b) In which section do you expect the highest contact forces? Explain your answer. (½ point)

Table 3: Survey file segment for two hole sections.

Inclination (deg) α	*Azimuth (deg)* β	*AHD (m)*	*N (m)*	*E (m)*	*TVD (m)*
47.47	143.37	2001.31	3006.34	-459.23	1900.12
49.96	145.54	2031.74			
50.23	147.91	2060.89			

5. Figure 1 is a generic representation of the oil formation volume factor as a function of pressure. Explain the shape of the curve. (1 point)

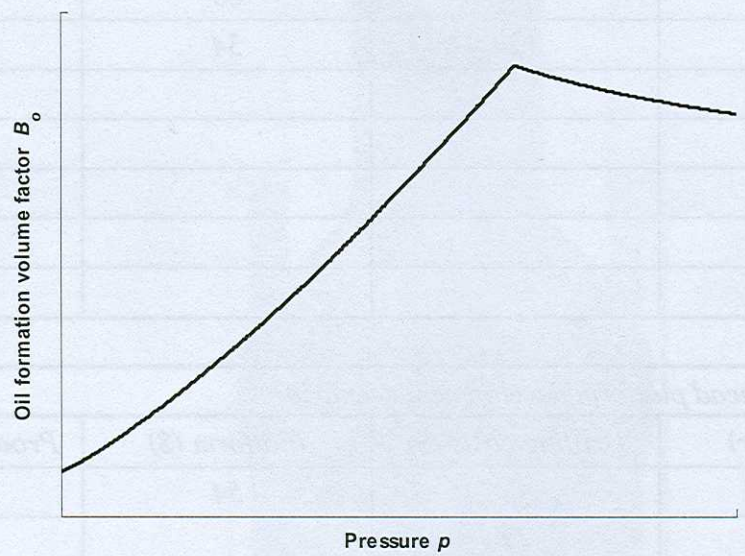

Figure 1: Oil FVF as function of pressure at constant temperature.

6. Figure 2 displays the pressure intake curves of a production well for two different tubing sizes.

   6a) Initially the pressure in a reservoir is 25 MPa. When the well produces 1000 m^3/day, the flowing bottomhole pressure is 24 MPa. What is the Productivity Index? (½ point)

6b) The intake pressure curve for the well is shown in the figure, for two tubing sizes (4 ½ and 5 ½ inch). Estimate the initial production rate for each size of tubing? (½ point)

6c) It is expected that the pressure in the reservoir will decrease quickly with time. Which size tubing would you choose to install? (½ point)

6d) If the PI stays constant, as the reservoir pressure drops, what is the lowest reservoir pressure at which the well will flow, with the chosen size of tubing? (½ point)

6e) Give a reason why installing a smaller size tubing can sometimes give a higher flow rate in a well. (½ point)

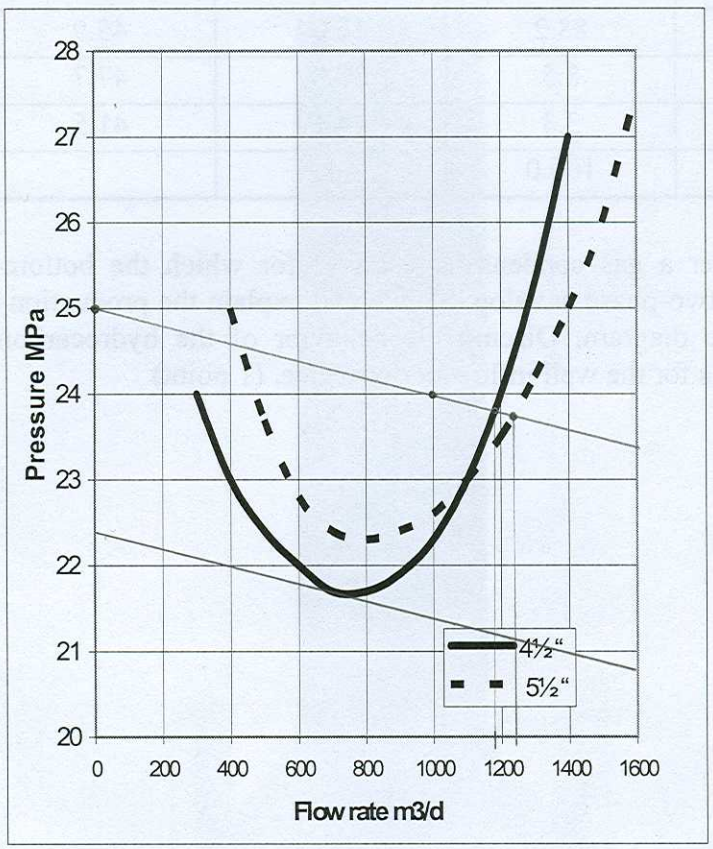

Figure 2: Pressure intake curves.

7. Natural gas with the composition given in Table 4 is produced from a reservoir at a pressure p_1 = 1470 psia and temperature T = 95 °F. The gas is stored at a surface storage tank at p_2 = 2940 psia. The surface and reservoir temperatures are nearly the same.

   7a) Determine the Z factors of the gas under both reservoir and storage tank conditions. Discuss briefly the physical meaning of the change in the Z-factor. (1 point)

   Note: If a mixture consists of m components with mole fractions y_i, we can use the following relationships, known as Kay's mixing rules, to obtain the pseudo properties of the mixture:

$$p_{pc} = \sum_{i=1}^{m} y_i p_{c,i} \text{ and } T_{pc,abs} = \sum_{i=1}^{m} y_i T_{c,i,abs} .$$

7b) Compute the work needed to bring the gas from the reservoir to the storage tank conditions assuming a linear relationship between the Z-factor and the pressure in the interval p_1–p_2. (½ point)

Table 4: Gas properties.

Hydrocarbon	*Weight %*	*M (g/mole)*	*Critical Pressure (Bar)*	*Critical Temperature (K)*
methane	88.2	16.04	45.9	191
ethane	8.5	30.07	47.7	305
propane	3.3	44.10	41.5	370
total	100.0			

8. We consider a gas condensate reservoir for which the bottom-hole pressure falls within the two-phase envelop. Sketch and explain the production path in the pressure temperature diagram. Discuss the behavior of the hydrocarbons and the possible implications for the well inflow performance. (1 point)