Fundamentals on Petroleum and Gas Engineering
(석유가스공학통론) (G17674)

- 2023 Midterm Examination -

Student ID: **Name:**

Notice

- Fill your name in the following:
  "I, ________________, swear I solve all problems by myself in this midterm examination.
  I will take any disadvantages if any dishonesty such as cheating is acted on my solution."
  <u>5 points will be deducted from your total score if you do not fill in your name above.</u>
- **<u>You MUST solve each problem by hand.</u>**
- Submission Deadline: 6:30 PM, April 25, 2023.

Problem 1.

The following data are available for a newly discovered gas reservoir:

GWC = 9,700 ft, Centroid depth = 9,537 ft, Net bulk volume (V) = 1.776×10^{10} ft^3

$\varphi = 0.19$, $S_{wc} = 0\ 20$, $\gamma_g = 0.85$

Although a gas sample was collected during a brief production test the reservoir pressure was not recorded because of tool failure. It is known, however, that the water pressure regime in the locality is

$$p_w = 0.441D + 31 \text{ psia}$$

and that the temperature gradient is 1.258°F/100 ft, with ambient surface temperature 80°F.

1-1. Calculate the volume of the GIIP. Assume that $Z_{\text{GWC}} = 0.888$ and $\mathrm{d}P/\mathrm{d}D = 0.117$ psi/ft. [10 pts.]

1-2. It is intended to enter a gas sales contract in which the following two points a) and b) have been stipulated by the purchaser. Can this latter requirement be fulfilled?

a) During the first two years, a production rate build-up from zero to 100 MMscf/d (million) must be achieved while developing the field. [5 pts.]

b) The plateau rate must be continued for 15 years at a sales point delivery pressure which corresponds to a minimum reservoir pressure of 1,200 psia. [5 pts.]

You may use the following assumptions:

- The aquifer is small so that the depletion material balance equation can be used.
- $Z = 0.832$ when $P = 1{,}200$ psia.

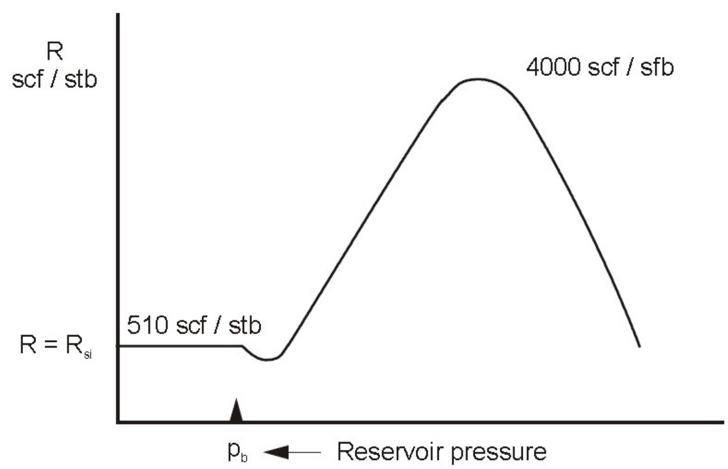
Problem 2.

Compare phase behaviors of five hydrocarbon types: black oil, volatile oil, retrograde liquid condensate, wet gas, and dry gas. [10 pts.]

Problem 3.

3-1. Define the following three PVT parameters: R_s, B_o, and B_g. Explain each PVT parameter with a graph as a function of pressure. [15 pts.]

3-2. Below is the graph that depicts the producing gas oil ratio (R) as a function of the average reservoir pressure for a typical solution gas drive reservoir. Explain why R slightly decreases when the average reservoir pressure gets smaller than the bubble point pressure (P_b). [5 pts.]



Problem 4.

Derive the general expression for the material balance equation with consideration for a) expansion of oil plus originally dissolved gas, b) expansion of the gascap gas, c) change in the hydrocarbon pore volume (HCPV) due to the connate water expansion and pore volume (PV), underground withdrawal, and the net water influx into the reservoir. [15 pts.]

Problem 5.

Prove that 1 Darcy (1 D) equals 9.869E-13 m^2. [10 pts.]

Problem 6.

Provide the full Darcy's equation with the skin factor S for the radial flow of an incompressible fluid in field units. [10 pts.]

Problem 7.

7-1. Define the mobility λ [2 pts.].

7-2. Define the mobility ratio M [3 pts.].

7-3. Explain the significance of mobility control on improved oil recovery (IOR) [10 pts.].

-------------------- This is the End of the Midterm Examination --------------------

[Backup]

Problem 3.

What is the conversion factor between k, expressed in Darcies, and in cm^2 and $metre^2$, respectively? [10 pts.]

Problem 5.

5-1. Derive the basic equation for the radial flow of a fluid in a homogeneous porous medium

$$\frac{1}{r}\frac{\partial}{\partial r}\left(\frac{k\rho}{\mu} r \frac{\partial P}{\partial r}\right) = \phi c \rho \frac{\partial P}{\partial t}$$

from

$$q = -\frac{k}{\mu}\frac{\partial \psi}{\partial l},$$

which is the Darcy's law. [5 pts.]

5-2. Derive the radial diffusivity equation. [10 pts.]

5-3. Compare the three most common conditions for which the constant terminal rate solution is sought: transient, semi-steady state, and steady state. [5 pts.]

Problem 6.

A homogeneous formation has an average effective permeability k_e. The effective permeability out to a radius r_a from the well has been altered (damage/stimulation) so that its average value in this region is k_a. Show that, for this situation, the skin factor may be expressed as

$$S = \frac{k_e - k_a}{k_a} \ln \frac{r_a}{r_w}$$

where r_w is the wellbore radius. Assume that for $r < r_a$, the flow can be approximately described under steady state conditions and that for $r > r_a$, semi-steady state. [10 pts.]