



**UNIVERSITY OF MINES AND TECHNOLOGY, TARKWA**  
**SECOND SEMESTER EXAMINATIONS, MAY 2018**

**COURSE NO:** PE 280

**COURSE NAME:** Properties of Reservoir Rocks and Fluids

**CLASS:** PE 2016

**TIME:** THREE (3) HOURS

Name: \_\_\_\_\_ Index Number: \_\_\_\_\_

**ANSWER ANY THREE (3) QUESTIONS**

**Q1.** Given the following gas:

Component	Weight Fraction
C <sub>1</sub>	0.65
C <sub>2</sub>	0.15
C <sub>3</sub>	0.10
n-C <sub>4</sub>	0.06
n-C <sub>5</sub>	0.04

- A.** By assuming an ideal gas behavior, calculate the
- Mole fraction of the gas
  - Apparent molecular weight
  - Specific gravity
  - Specific volume at 300 psia and 120°F

**[8 MARKS]**

- B.** By assuming real gas behavior with compressibility factor 0.85, calculate:
- Gas density at 2,000 psia and 150°F
  - Specific volume at 2,000 psia and 150°F
  - Gas formation volume factor in scf/ft<sup>3</sup>

**[8 MARKS]**

- C.** Calculate the initial oil-in-place (N) of an oil. Given that a reservoir has an area,  $A = 1,600$  acres,  $h = 42$  ft,  $\phi = 26\%$ ,  $S_{iw} = 24\%$ , and  $B_{oi} = 1.63$  bbl/STB. Calculate the initial oil-in-place (N) at the: \_\_\_\_\_ the: \_\_\_\_\_
- Reservoir pressure and temperature conditions
  - Stock tank conditions
  - \_\_\_\_\_

**[4 MARKS]**

**Q2. A.** Given the following gas composition:

<b>Component</b>	<b>Weight Fraction</b>
CO <sub>2</sub>	0.06
N <sub>2</sub>	0.03
C <sub>1</sub>	0.75
C <sub>2</sub>	0.07
C <sub>3</sub>	0.04
n-C <sub>4</sub>	0.03
n-C <sub>5</sub>	0.02

If the reservoir pressure and temperature are 2,500 psia and 175°F, respectively and the specific gravity of the gas is 0.7, calculate:

- I. Gas density by accounting for the presence of nonhydrocarbon components by using the:
  - a. Wichert-Aziz method
  - b. Carr-Kobayashi-Burrows method
- II. Gas viscosity by using the:
  - a. Standing method
  - b. Lee-Gonzales-Eakin method

**[15 MARKS]**

**B.** Differentiate between dry gas and wet gas using their phase diagrams

**[5 MARKS]**

**Q3. A.** A clean and dry core sample weighing 415 g was 100% saturated with a 1.07 specific gravity ( $\gamma$ ) brine. The new weight is 443 g. The core sample is 13 cm long and 5 cm in diameter. Calculate the porosity of the rock sample.

**[3 MARKS]**

**B.** A gas well is producing at a rate of 15,000 ft<sup>3</sup>/day from a gas reservoir at an average pressure of 2,000 psia and a temperature of 120°F. The specific gravity is 0.72. Calculate the gas flow rate in scf/day.

**[5 MARKS]**

**C.** A crude oil system exists at an initial reservoir pressure of 4500 psi and 85°F. The bubble-point pressure is estimated at 2109 psi. The oil properties at the bubble-point pressure are as follows:

$$B_{ob} = 1.406 \text{ bbl/STB}$$

$$R_{sb} = 692 \text{ scf/STB}$$

$$\gamma_g = 0.876$$

$$\text{API} = 41.9^\circ$$

Calculate:

- i. Oil density at the bubble-point pressure
- ii. Oil density at 4,500 psi
- iii. The formation volume factor ( $B_o$ ) at 4500 psi

[8 MARKS]

D. Briefly explain the term the following terms as applied to reservoir rocks:

- i. Fractional wettability

Mixed wettability

[4 MARKS]

Q4. A. The following experimental PVT data on six different crude oil systems are available. Results are based on two-stage surface separation.

Oil #	T	$p_b$	$R_s$	$B_o$	$\rho_o$	$c_o$ at $p > p_b$	$p_{sep}$	$T_{sep}$	API	$\gamma_g$
1	250	2377	751	1.528	38.13	$22.14 \times 10^{-6}$ at 2689	150	60	47.1	0.851
2	220	2620	768	1.474	40.95	$18.75 \times 10^{-6}$ at 2810	100	75	40.7	0.855
3	260	2051	693	1.529	37.37	$22.69 \times 10^{-6}$ at 2526	100	72	48.6	0.911
4	237	2884	968	1.619	38.92	$21.51 \times 10^{-6}$ at 2942	60	120	40.5	0.898
5	218	3065	943	1.570	37.70	$24.16 \times 10^{-6}$ at 3273	200	60	44.2	0.781
6	180	4239	807	1.385	46.79	$11.65 \times 10^{-6}$ at 4370	85	173	27.3	0.848

Estimate the undersaturated oil compressibility coefficient by using the: Vasquez-Beggs correlation

- i. Petrosky-Farshad correlation.
- ii. Calculate the Absolute Average Error (AAE)

[16 MARKS]

**B.** State four (4) factors each that control the magnitude of the following rock properties

- i. Permeability
- ii. Porosity

[4 MARKS]

**Equations and Charts:**

$$\gamma_g = \frac{M_a}{M_{air}} = \frac{M_a}{28.96}$$

$$v = \frac{V}{m} = \frac{RT}{p M_a} = \frac{1}{\rho_g}$$

$$B_g = 0.02827 \frac{zT}{p}$$

$$E_g = 35.37 \frac{p}{zT}, \text{ scf/ft}^3$$

$$V_p = \frac{1}{\gamma} (V_{wet} - V_{dry})$$

$$N = 7,758 \frac{A_s h \phi (1 - S_{iw})}{B_{oi}}$$

$$T_{pc} = 187 + 330 \gamma_g - 71.5 \gamma_g^2$$

$$p_{pc} = 706 - 51.7 \gamma_g - 11.1 \gamma_g^2$$

**Gas Viscosity Correlations:**

$$\mu_g = 10^{-4} K \exp \left[ X \left( \frac{\rho_g}{62.4} \right)^Y \right]$$

where

$$K = \frac{(9.4 + 0.02 M_a) T^{1.5}}{209 + 19 M_a + T}$$

$$X = 3.5 + \frac{986}{T} + 0.01 M_a$$

$$Y = 2.4 - 0.2 X$$

$$\mu_1 = (\mu_1)_{\text{uncorrected}} + (\Delta\mu)_{\text{CO}_2} + (\Delta\mu)_{\text{H}_2\text{S}} + (\Delta\mu)_{\text{N}_2}$$

where:

$$(\mu_1)_{\text{uncorrected}} = [1.709 (10^{-5} - 2.062 \cdot 10^{-6} \gamma_g) + 8.118 (10^{-3}) - 6.15 (10^{-3}) \log (\gamma_g)]$$

$$(\Delta\mu)_{\text{CO}_2} = y_{\text{CO}_2} [(9.08 \times 10^{-3}) \log \gamma_g + (6.24 \times 10^{-3})]$$

$$(\Delta\mu)_{\text{N}_2} = y_{\text{N}_2} [8.48 (10^{-3}) \log (\gamma_g) + 9.59 (10^{-3})]$$

$$(\Delta\mu)_{\text{H}_2\text{S}} = y_{\text{H}_2\text{S}} [8.49 (10^{-3}) \log (\gamma_g) + 3.73 (10^{-3})]$$

$$T'_{\text{pc}} = T_{\text{pc}} - \varepsilon$$

$$P'_{\text{pc}} = \frac{P_{\text{pc}} T'_{\text{pc}}}{T_{\text{pc}} + B (1 - B) \varepsilon}$$

$$\varepsilon = 120 [A^{0.9} - A^{1.6}] + 15 (B^{0.5} - B^{4.0})$$

$$A = y_{\text{H}_2\text{S}} + y_{\text{CO}_2}$$

$$T'_{\text{pc}} = T_{\text{pc}} - 80 y_{\text{CO}_2} + 130 y_{\text{H}_2\text{S}} - 250 y_{\text{N}_2}$$

$$P'_{\text{pc}} = P_{\text{pc}} + 440 y_{\text{CO}_2} + 600 y_{\text{H}_2\text{S}} - 170 y_{\text{N}_2}$$

### Crude Oil Correlations:

$$\rho_o = \frac{62.4 \gamma_o + 0.0136 R_s \gamma_g}{B_o}$$

where  $\gamma_o$  = specific gravity of the stock-tank oil  
 $R_s$  = gas solubility, scf/STB  
 $\rho_o$  = oil density, lb/ft<sup>3</sup>

$$\rho_o = \frac{62.4 \gamma_o + 0.0136 R_s \gamma_g}{0.972 + 0.000147 \left[ R_s \left( \frac{\gamma_g}{\gamma_o} \right)^5 + 1.25 (T - 460) \right]^{1.175}}$$

where  $T$  = system temperature, °R  
 $\gamma_o$  = specific gravity of the stock-tank oil

$$\beta_o = 0.9759 + 0.000120 \left[ R_s \left( \frac{\gamma_g}{\gamma_o} \right)^{0.5} + 1.25 (T - 460) \right]^{1.2}$$

where  $T$  = temperature, °R  
 $\gamma_o$  = specific gravity of the stock-tank oil  
 $\gamma_g$  = specific gravity of the solution gas

$$c_o = \frac{-1,433 + 5R_{sb} + 17.2(T - 460) - 1,180 \gamma_{gs} + 12.61^\circ}{10^5 p}$$

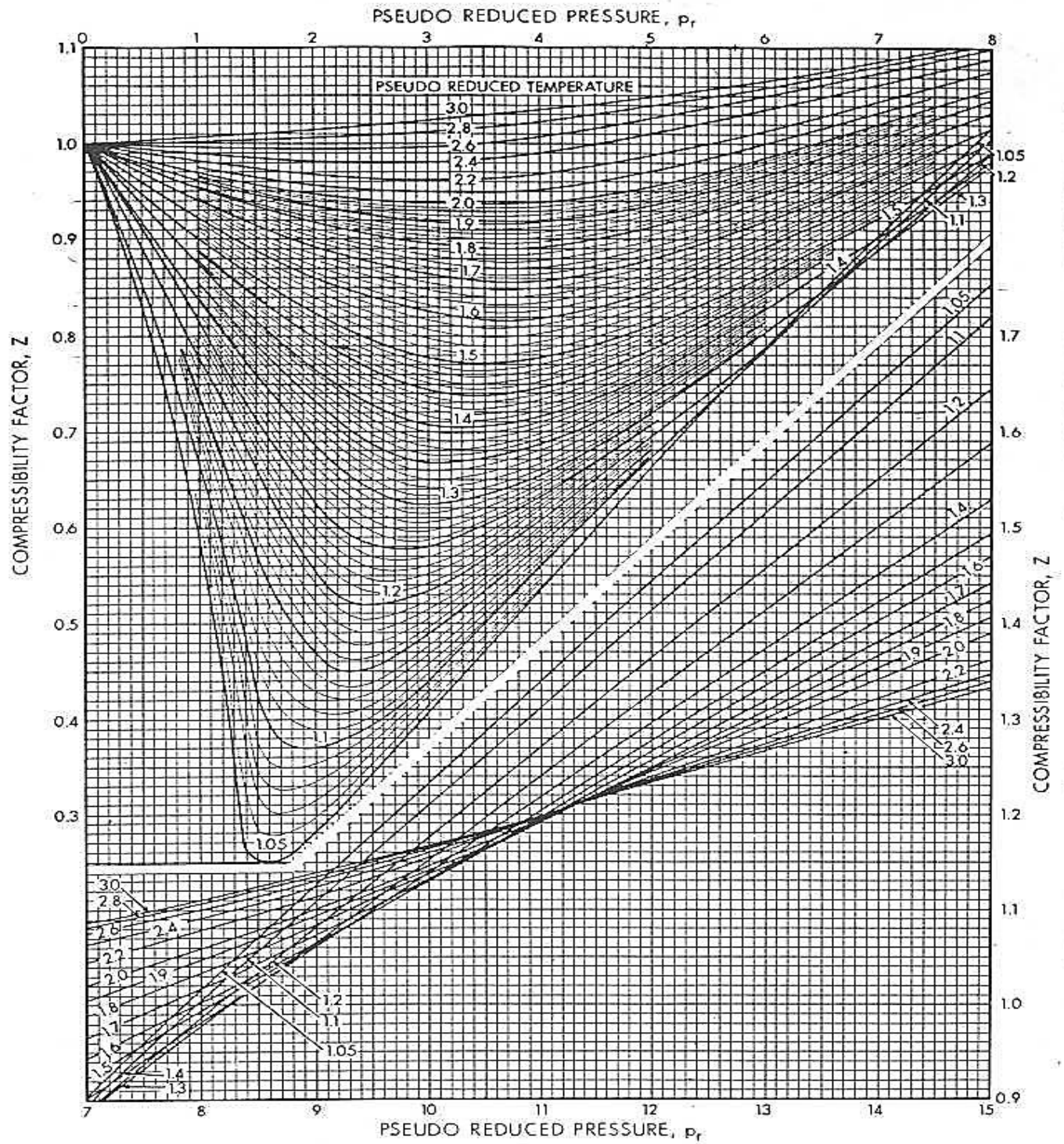
where T = temperature, °R  
 p = pressure above the bubble-point pressure, ps  
 R<sub>sb</sub> = gas solubility at the bubble-point pressure  
 γ<sub>gs</sub> = corrected gas gravity as defined by Equation

$$\gamma_{gs} = \gamma_g \left[ 1 + 5.912 (10^{-5}) (API) (T_{sep} - 460) \log \left( \frac{P_{sep}}{114.7} \right) \right]$$

where γ<sub>gs</sub> = gas gravity at the reference separator pressure  
 γ<sub>g</sub> = gas gravity at the actual separator conditions of p<sub>sep</sub> a  
 p<sub>sep</sub> = actual separator pressure, psia  
 T<sub>sep</sub> = actual separator temperature, °R

$$c_o = 1.705 \times 10^{-7} R_{sb}^{0.69357} \gamma_g^{0.1885} API^{0.3272} (T - 460)^{0.6729} P^{-0.5906}$$

where T = temperature, °R  
 R<sub>sb</sub> = gas solubility at the bubble-point pressure, scf/STB



**Figure 1 Standing and Katz Compressibility Factors Chart**

**Dr S. A. Marfo/ Mr E. M. Amarfio**