National Exams December 2014

98-Pet-A2, Petroleum Reservoir Fluids

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is a CLOSED BOOK exam.
3. **Only A Casio or Sharp approved calculator models are permitted.**
4. FIVE (5) questions constitute a complete exam paper.
5. The first five questions as they appear in the answer book will be marked.
6. All questions are of equal value unless otherwise stated and all parts in a multipart question have equal weight.
7. Clarity and organization of your answers are important, clearly explain your logic.
8. Pay close attention to units, some questions involve oilfield units, and these should be answered in the field units. Questions that are set in other units should be answered in the corresponding units.
9. A formula sheet is provided at the end of questions

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Question 1 (20 Marks)

Describe the following black oil PVT experiments.

a) Black oil flash vaporization or flash liberation test
b) Black oil differential liberation or differential expansion test.

Question 2 (20 Marks)

Natural gas composition from a gas well producing from a dry gas reservoir is given in the following. Calculate the real gas density and the gas formation volume factor at 95 °F and 1200 psia.

Component	Mole percent	Molecular Weight (lb_{mass}/lb_{mole})	P_c (psia)	T_c (°R)
Methane	96	16.04	666.4	343.33
Ethane	3.5	30.07	706.5	549.92
Propane	0.3	44.11	616.0	666.06
i-Butane	0.06	58.123	527.9	734.46
n-Butane	0.015	58.123	550.6	765.62
Hexane	0.055	86.177	436.9	913.6
Heptanes plus	0.07	128.00	372.0	1100.6

Question 3 (20 Marks)

Separator and laboratory tests have been conducted on a wellstream fluid and the following data were collected.

Separator producing gas-oil ratio, GOR	50000 SCF/STB
Separator oil formation volume factor, B_o	1.3 separator bbl/STB
Separator oil density, ρ,	40 lb_{mass}/separator ft^3
Separator oil molecular weight, M	90 lb_{mass}/lb_{mole}

Use the given data to calculate the mole of gas per mole of liquid required for recombination of the collected oil and gas samples.
Assume volume of one mole of gas at standard conditions is 379.4 SCF.

Question 4 (20 Marks)

The following PVT data for an oil sample is given in the following table.
Use these data to find

a) The bubble point pressure
b) The total formation volume factor, B_t at bubble point pressure in bbl/STB.
c) The coefficient of isothermal compressibility of the oil at 4000 psia.
d) The total formation volume factor, B_t at 2000 psia in bbl/STB.

Pressure p(psia)	Oil formation volume factor Bo (bb//STB)	Gas formation volume factor B_g (ft^3/SCF)	Solution gas-oil ratio Rs (SCF//STB)
4500	1.31	0.0034831	950
4000	1.32	0.0037471	950
3500	1.33	0.0041198	950
3000	1.30	0.0046765	810
2500	1.27	0.005553	700
2000	1.23	0.0070185	550
1500	1.20	0.0096796	450
1000	1.17	0.0153007	300

Question 5 (20 Marks)

A binary mixture of 40 mole percent of component A and 60 mole percent of component B is placed in a laboratory cell and brought to the equilibrium conditions of 500 psia and 100 °F. The mixture forms a two-phase system. The equilibrium constants (*K*-values) for components A and B are estimated to be 10 and 0.04, respectively. Determine the equilibrium phase fraction (L and V) and the corresponding composition (mole fractions, x_A, x_B, y_A, y_B) of gas and liquid phases in the cell.

Question 6 (20 Marks)

A volumetric (means volume is constant) dry gas reservoir has an initial pressure of 2000 psia and a constant temperature of 120 °F. The reservoir pressure drops to 1125 psia after half of the moles of the gas in the reservoir are produced. The gas compressibility factor, Z was 0.80 at 2000 psia. What is the gas compressibility factor at 1000 psia? Estimate the coefficient of gas isothermal compressibility, c_g in 1/psi and 1125 psia?

Question 7 (20 Marks)

Draw pressure – temperature (PT) diagram(s) of hydrocarbon systems and determine/locate the following:

a) Reservoir and production pressure – temperature (PT) path for dry gas, wet gas, and retrograde gas condensate reservoirs;
b) Critical point, cricondenbar, and cricondentherm;
c) Quality lines, dew point, and bubble point curves;
d) Undersaturated oil reservoirs, saturated oil reservoirs and retrograde region.

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Formula Sheet

Average molecular weight: $M_{av} = \sum y_i M_i$

Pseudo critical Temperature: $T_{pc} = \sum y_i T_{pc_i}$

Reduced temperature: $T_r = \dfrac{T}{T_c}$

Pseudo critical pressure: $p_{pc} = \sum y_i p_{pc_i}$

Reduced pressure: $p_r = \dfrac{p}{p_c}$

Gas density: $\rho = \dfrac{pM}{ZRT}$

where ρ is gas density in lb_{mass}/ft^3, p in psia, T in R, M is in lb_{mass}/lb_{mole}, R=10.732 psi-$ft^3/(lb_{mol}$-°R)

Gas formation volume factor, $B_g = 0.02827\dfrac{ZT}{p}$ in $\dfrac{ft^3}{SCF}$, where p in psia, T in °R.

Total or two-phase formation volume factor: $B_t = B_o + B_g\left(R_{sob} - R_{so}\right)$

Coefficient of isothermal oil compressibility: $c = -\dfrac{1}{B_{ob}}\left(\dfrac{dB_o}{dP}\right)_T$

Phase equilibrium relations:

$$\begin{cases} \sum_i \dfrac{z_i}{1+V(K_i-1)} = 1, & x_i = \dfrac{z_i}{1+V(K_i-1)}, \quad \sum_i x_i = 1, \\ \sum_i y_i = 1, & \sum_i z_i = 1, \quad K_i = \dfrac{y_i}{x_i}, \quad L+V=1 \end{cases}$$

Coefficient of isothermal oil compressibility: $c_g = \dfrac{1}{p} - \dfrac{1}{Z}\left(\dfrac{dZ}{dP}\right)_T$

Conversion Factors

1 m^3 = 6.28981 bbl =35.3147 ft^3

1 atm =14.6959488 psi =101.32500 kPa=1.01325 bar

1 m = 3.28084 ft = 39.3701 inch

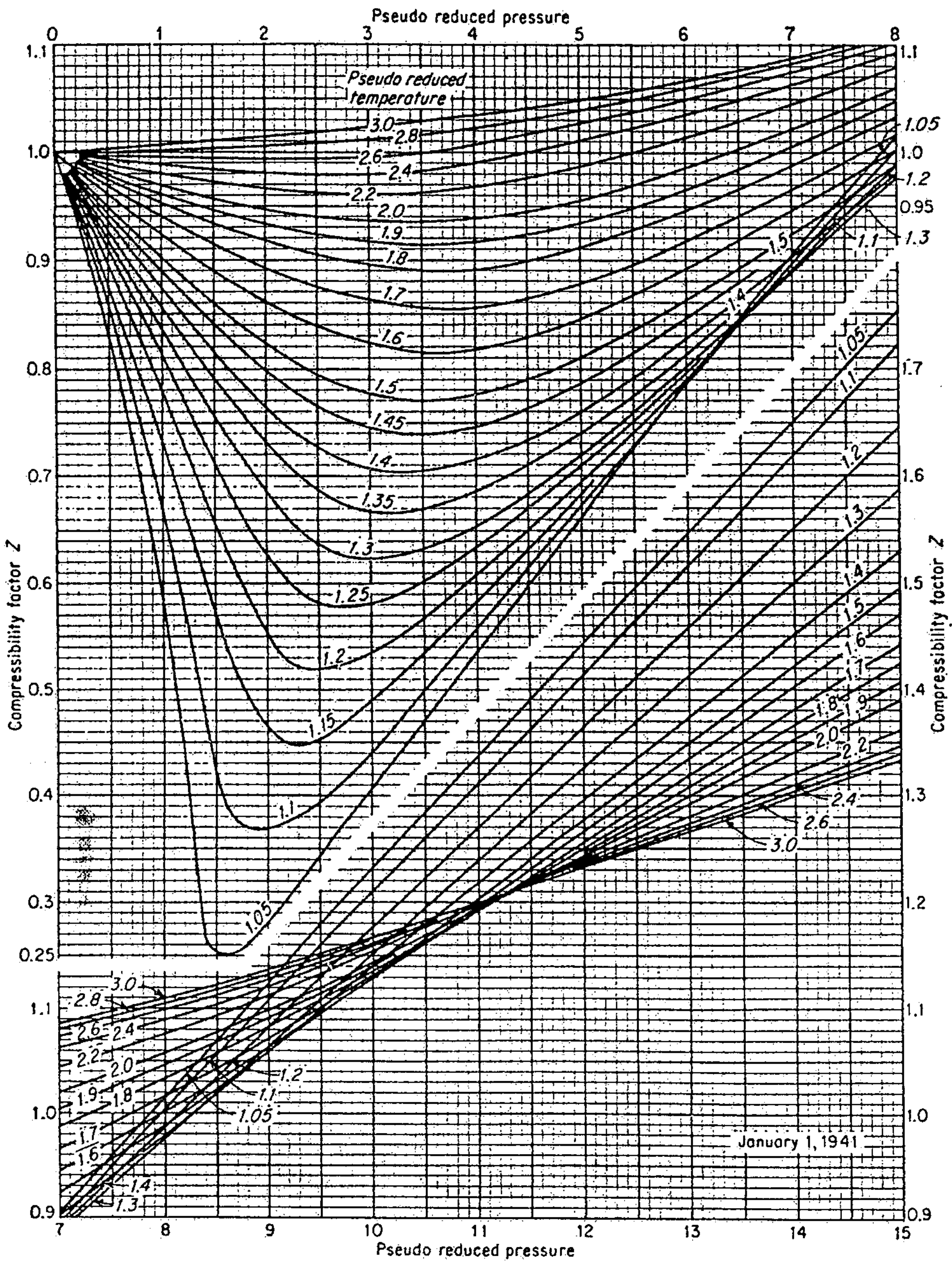

Fig. 4-16. Compressibility factor for natural gases. *(Standing and Katz, 4-87. Courtesy AIME.)*